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ABSTRACT

Eye movements of 18 male and seven female dyslexic children and 10 normal children were evaluated to determine if eye movement disorders may be the cause of some of the symptoms associated with dyslexia. Data on eye movements were collected while Ss moved their eyes from one fixation point to another in a nonreading situation. Errors in vertical eye movements significantly differentiated between normal and dyslexic children. Within the dyslexic group, children who showed large vertical eye movement errors were also the ones whose reading problems included skipping or repeating lines and losing the place. It is concluded that eye movement disorders are probably the cause of reading problems for a subgroup of dyslexic children. (Author/DB)

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EYE MOVEMENT DISORDERS IN DYSLEXIA

Leon Festinger, Edward M. Brussell and Saulo Sirigatti

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Contents

Summary

The idea that disorders of eye movements can, in part, be the cause of some symptoms associated with dyslexia has been largely rejected by experts in the field. There are, however, very few data to support this judgment and the data that do exist on eye movements in dyslexic children were collected while the children were reading. The present study collected data on eye movements of dyslexic and normal children who had the simple task of moving their eyes from one fixation point to another. Errors in vertical eye movements significantly differentiated between dyslexic children and normal readers. Within the dyslexic group, those who showed large vertical eye movement errors were also the ones whose reading problems included skipping or repeating lines and losing their places. It is concluded that eye movement problems are probably the cause of reading problems for a subgroup of dyslexic children.

Eye Movement Disorders in Dyslexia

by

Leon Festinger, Edward M. Brussell and Saulo Sirigatti

Introduction:

There are many children who have difficulty learning to read and the reasons for these difficulties are numerous and varied. Among them, however, is a group whose reading problems seem inexplicable in ordinary terms. The term "dyslexia", which means literally a disturbance in the ability to read, has been used increasingly in recent years to label this disorder. The syndrome has been defined more in terms of what it excludes than what it includes. Thus, Critchley (1970) reports that in 1968 the Research Group on Developmental Dyslexia of the World Federation of Neurology defined specific developmental dyslexia as "A disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence, and socio-cultural opportunity. It is dependent upon fundamental cognitive disabilities which are frequently of constitutional origin."

Critchley (1970) himself attempted a more detailed definition together with a summary of the main known characteristics of dyslexics:

> "Within the heterogeneous community of poor readers [slow readers, retarded readers] there exists a syndrome comprising a specific difficulty in learning the conventional meaning of verbal symbols, and also in correlating sound with symbol in the appropriate fashion. Such cases ..... are said to be 'pure' in that the victims are free from mental defect, serious primary neurotic traits and gross neurological deficits. This syndrome of developmental dyslexia is of constitutional and not of environmental origin, and it may well be genetically determined. It is unlikely to be the product of damage to the brain at birth, even of a minor degree. It is independent of the factor of intelligence, and consequently it may appear in children of normal I.Q., and it stands out conspicuously in those who are in the above-average brackets. ..... The syndrome occurs more often in boys. The difficulty in learning to read is not due to simple perceptual or acoustico-visual anomalies, but represents a higher level or cognitive defect - an asymbolia, in other words." (p. 24)

With definitions primarily centering on "what it is not," in practice, the term becomes very imprecise. Thus Martin (1971) complains that "The use of the term dyslexia is disputed, its definition is unclear, and continues to vary with different experts in the field and it is of little use to the classroom teacher or the child's physician." With such ambiguity about who is, and who is not, to be included in the category of dyslexia, it is also not surprising that the research literature is replete with controversy and inconsistent findings. We will not attempt to review this literature in any detail. We will, however, discuss the major attempt at theoretical explanations of the disorder.

It is widely believed (Crosby, 1968; Kirk, 1962; Cohn, 1964; Vernon, 1957; Critchley, 1970) that there is a neurological basis for dyslexia. It is also widely held that this neurological basis is genetically or congenitally transmitted and this opinion is supported by studies that have shown a large percentage of dyslexic children to come from families with a history of dyslexia (Hallgren, 1950; Kägen, 1943). There is little agreement, however, on the exact nature of the neurological misfunction. The major hypothesis, originally proposed in detail by Orton (1925), was based on the observation that many dyslexic children were not dominantly right-handed. This led him to propose that the reading problem arose because of a lack of strong left cerebral dominance.

The observation that a high incidence of mixed dominance is found among dyslexic children has been confirmed, by and large, in the research literature (Granjon-Galifret and Ajuriaguerra, 1951; Ettlinger and Jackson, 1955; Harris, 1957). The question of how and why mixed dominance should lead to reading problems is, however, less clear. Both Gates and Bond (1936) and Vernon (1957) argue that there is no clear theoretical connection between the two phenomena. Nevertheless, although some writers argue for dyslexia being due to neurophysiological maturational lags (Drew, 1956; Bender, 1957; Birch, 1962) and some still argue for dyslexia being a learned disorder (Mosse and Daniels, 1959), the hypothesis concerning mixed cerebral dominance is more widely accepted than any other.

The Role of Eye Movements:

It has been a rather common observation that the eye movements of dyslexic children differ from those of normal readers. Mosse and Daniels (1959), for example, note that "they move their eyes back to the left in a searching, uneven, and unsteady movement and then frequently miss the beginning of the next line." Ajuriaguerra, et al. (1968) describe the eye movements of dyslexics as showing "oculomotor irregularity during the reading act, forcing the movement to become jerky, slowing progress and reducing the sweep." In addition to this kind of common observation, one of the frequently noted difficulties in reading shown by dyslexic children seems plausibly related to eye movements. Critchley (1970) lists this difficulty, or set of difficulties, as items 4 and 5 in his list of 18 symptoms shown by dyslexics:

"4. Difficulty in keeping track of the correct place while reading."

"5. Perplexity in switching accurately from the right hand extremity of one line of print to the beginning of the next line on the left."

It is not unexpected, therefore, that writers in the field would have commented on the relationship between these reading difficulties and eye movements. What is, perhaps, surprising is the unanimity with which they reject the idea that faulty eye movement control may cause reading problems. Critchley (1970) states: "Faulty eye movements must be regarded as the outcome of a difficulty in reading, and not its cause." The same views are expressed by Taylor (1965), Ajuriaguerra, et al. (1968) and Smith (1969). The only exception to this view that we have found is that stated by Mosse and Daniels (1959) who unequivocally state that faulty eye movements are the cause of the symptoms listed above. They also believe these faulty eye movements are learned through bad eye movement practices, particularly through reading comic books.

The basis for the nearly unanimous rejection of the possible importance of eye movements is far from clear. Usually no supporting data are mentioned at all and, indeed, there are very few systematic studies of the matter in the literature. We have found only three studies that are empirically relevant. Goldberg (1970) measured the eye movements of 25 dyslexic children while reading slightly difficult, and then extremely difficult, material. He also measured their eye movements on the same two pieces while an adult read out loud along with the child, and again after the child had been tutored on the difficult words in the passages. He reports that abnormalities of ocular movements were found to increase with the difficulty of the material when the child read alone. When an adult read out loud along with them the eye movements became more "stable". After having been tutored on the difficult words "the graph showed definite improvement over previous untutored graph recordings." The author concludes that it is "the degree of comprehension that produces the type of ocular movement." Rémond and Lesèvre (1958) compared eye movements while reading of adult dyslexics and normal readers. They report that the dyslexics show a great number of eye movements back over words that they had already read. Lesèvre (1964, reported by Critchley, 1970) recorded eye movements of dyslexic and normal children while reading, and reports that the dyslexic children showed slower oculomotor reaction times, a greater number of short pauses and many useless ocular movements.

None of these studies seems very convincing one way or another. It is not surprising that eye movements will be slower for someone who has difficulty reading or that the eyes will move back to look again at a word that was not really comprehended. It is also not surprising that if an adult reads out loud along with the child, making it less necessary for the child to read, the eye movements of the child will not go back to difficult words. The question of whether or not there is an inherent problem of oculomotor control that produces, or helps to produce, the reading problem for some of these dyslexic children remains unanswered. Indeed, the question probably cannot be answered by measuring the eye movements while reading since under these conditions causes and effects are difficult to disentangle. To answer the question it would seem desirable to measure eye movements, not while the dyslexic child is reading, but in an utterly simple task in which comprehension plays no part and in which any emotional problems the child may have about reading also are absent. If, for example, a child is simply asked to move his eye from one spot of light to another that appears within his visual field, no reading problem should affect his eye movement. If one found that dyslexic children showed disturbances in eye movements under such simple task conditions, then one would have evidence for the assertion that, perhaps, oculomotor control problems produced the reading problem. Perhaps, at least in some who are called dyslexic, the neurological difficulty is concerned with oculomotor control and not with any cognitive process. We collected data to explore this issue.

Methodology:

Apparatus was constructed to permit rapid and easy changes of a fixation target from one position to another. To do this, 13 circular apertures, 1.3 cm. in diameter, were cut into the black metal front of a 116 by 116 cm. light-tight box. The placement of the apertures is shown in Figure 1. As illustrated on the figure, vertical and horizontal distances between neighboring apertures were all 10 degrees of visual angle. Oblique distances between neighboring apertures were all $\sqrt{50}$ degrees. Behind each aperture was a projector which could display, in the aperture, any one of three sizes of Landolt C's (7.6, 5.6, or 3.4 minutes of arc in diameter) in any one of four orientations (the gap in the C up, down, left or right). The luminance of the displayed C's was 1.3 Ft. L.

Subjects were seated in an adjustable chair so that their eyes were 286 cm. from the display board and directly in front, and at the height of, the central aperture. A rear head rest and a cushioned forehead rest held the subject's head in position. Horizontal and vertical components of eye movements were measured electro-oculographically. Two Beckman biopotential electrodes mounted on the temples provided information about horizontal eye movements. Four electrodes, one above each eye and one below each eye, measured vertical eye movements. A reference electrode was placed behind the ear. D.C. recording was used throughout since we wanted to know the exact eye position at all times. A Grass Model 7 polygraph recorder was used to record the two components of eye position and also to indicate the exact time, on the moving paper tape, that the fixation target changed position.

The sequence of fixation target changes, and the length of time each target remained exposed was controlled by a specially built processor which read information punched on paper tape and automatically ran off the designated sequence. Exposure durations for any given target

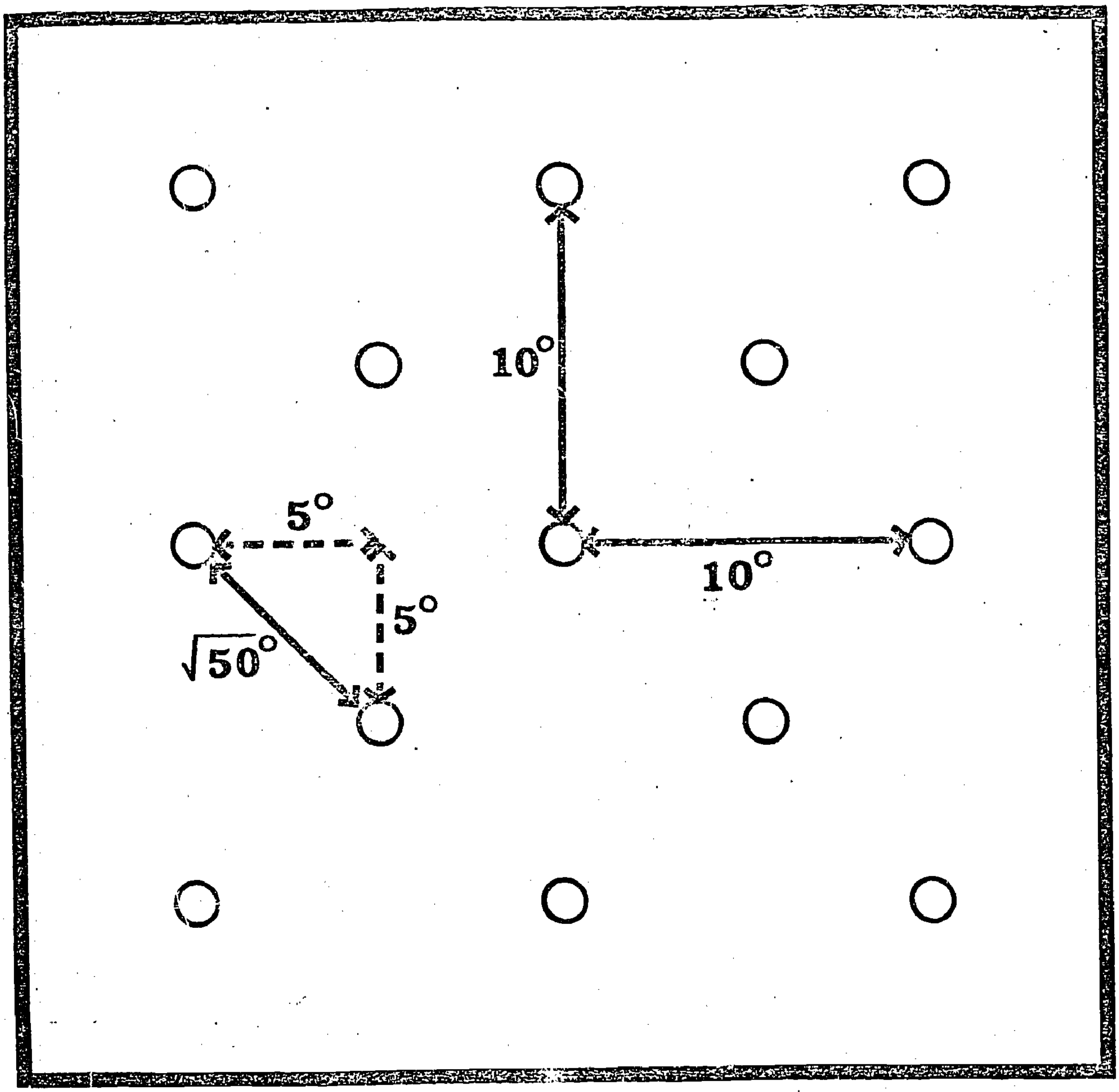

Fig. 1. Schematic Diagram of Display Board

position were 2.0, 2.5, 3.0, 3.5 or 4.0 seconds. Within any sequence of target changes, these exposure durations were randomized so that the subject could not anticipate when the target would change position. Data were collected on eye movements during four different sequences of target position changes. Each of the four sequences started with the target in the central position. Change of target position was always either 10 degrees to the left, right, up or down or $\sqrt{50}$ degrees in either of four diagonal directions. The direction of change of the target position was randomized so that the subject could not anticipate where the target would move next. This randomization was restricted by the following conditions, however. Within each of the four sequences, each target position was to appear at least 4 times and each of the eight directions of change of position was to occur equally often. Each of the four sequences contained 64 target position changes and took about 3-1/2 to 4 minutes to run through.

The dyslexic children who participated in the study were referred to us by the Optometric Center of New York, The Teachers College Reading Center and the Cornell University Medical School. Because of the ambiguity of the term "dyslexia" we attempted to specify, to each of these cooperating institutions, what kind of children we did, and did not, want for the study. We did not want children with clear neurological impairment, children of low I.Q. for whom the reading disability might simply reflect general intellectual deficit, or children with very serious behavioral or emotional problems that could well be the cause of the reading problem. We did want children for whom the reading problem was very specific, who performed well intellectually otherwise and who showed the kinds of specific reading problem usually associated with dyslexia.

Thirty-three dyslexic children were referred to us by the cooperating institutions. We were unable to obtain adequate eye movement records from eight of these children. Our final sample of 25 dyslexic children included 18 boys and 7 girls. We also tested a sample of normal children for comparison with the dyslexic children. Of 16 children who came for testing we were unable to obtain adequate eye movement records from 6. We were thus left with ten children in the sample of normal readers, five boys and five girls. The parents of all the children were completely informed of the purposes and procedures of the study before they agreed to bring their children to the laboratory. The children were paid two dollars an hour for their participation. Table 1 shows the age distribution in our two samples.

Table 1

Age Distribution of Samples of Dyslexic and Normal Children

Age	Dyslexics	Normals
7, 8	6	1
9, 10	12	7
11, 12	6	2
12+	1	0

The first step in the procedure, when the child came for testing, was to place the EOG electrodes. A clear plastic template was used to insure orthogonal placement of the "vertical component" and the "horizontal component" electrodes. A minimum of fifteen minutes were allowed to pass, after placing the electrodes, before any data were collected. This was done to minimize drift due to polarization in the recording of the eye movements. During this waiting period the chair was adjusted to its proper position for the child. The child was also asked to identify the orientation of the gap in the various sizes of Landolt C's. The smallest size of C for which the child had no difficulty in identifying the gap orientation was chosen for use with that child. The waiting period also provided time for the child's eyes to adapt to the dim level of illumination in the room before testing began.

The child was told that a C would appear and that he was to look at it, identifying to himself the orientation of the gap, until it went off and another C appeared in another position. He was then to immediately look at the new one and so on. The child was not asked to verbally report the orientation of the C because such vocalization produced artifacts in the eye movement recordings. The child was also asked to try to sit rather still during a sequence. He was told that each sequence would last less than four minutes and there would be rest periods in which he could move around between sequences. The first sequence was a very short one with the target moving back and forth between two positions horizontally and then vertically, pausing for appreciable durations at each position, so that the eye movement measures could be calibrated. When the calibration was completed the child was given a rest period. The four test sequences were then run off with rest periods between each. Instructions were repeated before each sequence. At the conclusion of the testing session another calibration sequence was run to determine whether or not any changes in DC gain had occurred.

With the sample of dyslexic children, after the electrodes had been removed, the mother and child were interviewed in another room to obtain as much information as possible about the specifics of the child's reading difficulty. The mothers of the dyslexic children were also asked if they would sign release forms which we could use to request information from the child's school and clinic. Twenty-three of the parents agr... to this. Schools and clinics for each of these twenty-three ch... contacted but we obtained information only from 12 schoo... s.

... ye movement records were analyzed in great detail to determine whether there were, or were not, significant differences between normal readers and dyslexic children. The specifics of the analysis, together with the problems of the analysis, will be presented in the next section on results.

Results and Discussion:

It will be recalled that we attempted to obtain a sample of children who, in our terms, were "pure dyslexic". In other words we wanted children whose disability was very specific to reading and not part of a general academic retardation nor stemming from severe and obvious neurological disorders. Since it was difficult to locate such children, and be certain ahead of time that they fit our criteria, and since many were reluctant to come to our laboratory, we collected eye movement data on any who were recommended as fitting our criteria who were willing to come. We subsequently collected as much data as we could concerning the specifics of the child's reading problem.

It is unfortunate, though not surprising, that with this procedure our sample of 25 "dyslexic" children included some who clearly, on later determination, did not fit our criteria. We excluded from our analysis six children, three from the same family, where it seemed clear that the reading disability was simply one aspect of a generally poor school performance. All six came from underprivileged homes and four of the six had I.Q. scores appreciably below 100. The analysis we will report is based on the remaining 19 cases and, of course, our sample of ten children with no special reading disability.

Comparison of the "normal" and "dyslexic" children. It is clear that if eye movement problems are at all related to the reading problems of dyslexic children we should be able to observe differences in the eye movements between our two samples. On a gross level, we do not find such differences on the average between the two groups. Before we turn to the more detailed examination of eye movement patterns, where we do find some differences, let us summarize the data on the more obvious measures.

It has sometimes been mentioned (Lesèvre, 1964) that the latency for eye movements is longer for dyslexic children, that is, that it takes longer from the onset of a target stimulus to the time that the child begins to move his eye to bring the stimulus to the fovea. These observations, of course, have usually been made in reading situations. In our data we find no such difference. The average latency for eye movements is 320 msec for the dyslexic children and 315 msec for the normal children. The standard deviations are also very similar being, respectively, 62 and 59 msec. Both of these average latencies are long compared to what one finds with adults for whom the average latency for a saccadic eye movement is about

250 msec. To our knowledge, no data exist in the literature concerning saccadic latencies in children and our guess is that these latencies are normally longer for children than for adults. Indeed, in our data there is a consistent tendency for the younger children to have longer latencies than the older ones. Since our two samples are closely equivalent in age, an average of 9.4 years for the normals and 9.5 years for the dyslexics, we may conclude that saccadic latency is not a problem in the reading difficulties of dyslexic children.

We can also examine whether or not there are any differences between the two groups in the accuracy of the saccadic eye movements. A word of caution is necessary here in order not to misinterpret our data. Electro-oculograms are not very accurate. The noise level for horizontal eye movement records is at least half a degree of visual angle and, for vertical movement records, is at least a degree. With young children, who do not sit still for very long, the accuracy of measurement is even less. For these reasons we have taken the average of many measurements but, even so, not too much attention should be paid to the absolute values of errors in eye movements. They may reflect error of recording as much as error of eye movement. We can, however, compare the normals and dyslexics in terms of relative magnitudes since the measurement problems are identical for both groups.

It is quite clear in our data that, again, there is no difference on the average between the normal children and the dyslexic children in the accuracy of the saccadic eye movements. For example, the absolute error for the mean magnitude for each subject of a ten degree leftward eye movement is 0.7 degrees, on the average, for normals and 0.6 degrees for the dyslexics. For movements to the right the comparable numbers are 0.8 and 0.6 degrees. There is clearly no difference between the two groups. The same picture emerges for vertical eye movements. The comparable figures for upward movements are 1.2 and 1.3 degrees and for downward movements they are 1.2 and 1.2 degrees.

With more detailed examination we did, however, find one difference that is large and unequivocal between the normal and the dyslexic children. We were led to look for this because of a general impression from the data that, while there were few differences if any between our two groups on horizontal eye movements, there were many instances in the dyslexic group with extremely inaccurate vertical movements. We were, of course, surprised not to see any difference in accuracy on the average. Closer inspection of the data made us realize that it was not absolute accuracy that was involved but rather questions of symmetry in the vertical movements. For a child in the normal group, if the upward saccade tended to be short (or long) the downward saccades tended, similarly, to be too short (or too long). In the dyslexic group, however, there were many who showed movements that were too long in one direction and too short in the other. The kind of symmetrical errors shown in the normal groups might not even be errors. Such apparent errors could result from the difficulties, with such children, of calibrating the measurement of the exact magnitude of eye movements. Asymmetrical errors must, however, be real errors of eye movements. There would be no reason in our recording and measurement techniques for a movement of the eye in one direction to produce a smaller or larger measurement than a movement of the identical magnitude in the opposite direction.

In order to see whether or not these impressions were real, we calculated, for each child, the difference between the average magnitude of upward movements and the average magnitude of downward movements. Average of the absolute differences between these magnitudes for the normals was 1.3 degrees of visual angle. For the dyslexic children, however, this average is 2.3 degrees, a difference which is rather large and is statistically significant. This difference between the normals and the dyslexics exists only with respect to vertical eye movements and not with horizontal ones. The same calculations for the differences in average magnitude between right and left eye movements yield averages of 0.4 degrees for normals and 0.5 degrees for dyslexics, a trivial and insignificant difference.

Analysis within the dyslexic group of children. Although it is of some value to show that, at least on some measure, there is a difference in eye movement patterns between normal and dyslexic children, it is hardly enough. If the aspects of eye movements that seem to distinguish normals from dyslexics are indeed involved in the reading difficulty, then there should be a clear relationship between the nature of the eye movement difficulty and the specific nature of the reading difficulty. Our analysis within the dyslexic group is oriented toward seeing whether or not such relationships exist.

The data concerning the specifics of the reading problems for the dyslexic children are, unfortunately, uneven. We interviewed the mother of each child and, in addition, obtained whatever reports and records that we could from school, from remedial reading centers and the like. Much of the information we obtained from these sources turned out to have very little bearing on the things in which we were interested. In addition, on many children, we were unable to obtain school records. For our examination of the data we have simply used whatever information we had from whatever sources. We have concentrated on three things that seemed to us to have possible relationships to eye movements, namely, reports of word and phrase reversals during reading, reports of skipping lines or repeating lines during reading, and reports of easily losing one's place or needing to use some marker while reading in order not to lose the place.

One might expect that lack of accurate control over vertical eye movements might result in some very specific problems in reading. When moving from one line to another such inaccuracy could be expected to result in frequent skipping of lines or repeating lines or totally losing one's place. We can, then, look at our data to see if those dyslexic children that show large asymmetrical errors in their vertical eye movements are also reported to have those specific reading problems. Table 2 shows the relevant data. In this table the dyslexic children are divided into three categories: those who have very large vertical asymmetrical errors, those whose asymmetries are moderate, and those who would seem, considering the measurement inaccuracy, not to have such error.

Table 2

Vertical Eye Movement Error and Reported Reading Problem Symptoms

Difference Between Upward and Downward Movements (degrees of visual angle)	Reported Reading Symptoms: Word or phrase reversal	Skipping or repeating lines	Loses place or needs marker
oup Showing Large Vertical Error			
7.6 (downward larger)			X
4.2 (downward larger)	X	X	X
3.4 (downward larger)		X	
3.4 (downward larger)	X	X	
3.2 (downward larger)			X
2.7 (upward larger)	X	X	
2.7 (downward larger)	X	X	
2.5 (downward larger)		X	
Group Showing Moderate Vertical Error			
1.8 (downward larger)	X		X
1.8 (downward larger)			
1.7 (downward larger)		X	
1.5 (downward larger	X		
1.2 (upward larger)	X	X	
Group Showing Negligible Vertical Error			
1.0 (downward larger)	X		
1.0 (upward larger)	X		X
0.9 (downward larger)	X		
0.9 (upward larger)	X		
0.8 (downward larger)	X	X	
0.4 (upward larger)	X		

The first column in the table gives the average difference in degrees of visual angle between upward and downward eye movements for stimulus sequences requiring a ten degree eye movement. Thus, for example, the first child listed in the table (the one who has the largest error of 7.6 degrees) moves his eyes upward only 6.7 degrees, and moves them downwards 14.3 degrees, on the average, when an accurate movement would be 10 degrees in each direction. The next three columns show the incidence of the three specific reported symptoms.

Even a casual inspection of the data in Table 2 reveals that there is, indeed, a rather strong relationship between vertical eye movement error and the type of symptom reported. Every child who showed a large difference between the magnitude of upward and downward eye movements is reported either to skip lines, repeat lines or to lose his place if he doesn't have a marker while reading. In the moderate error group three of the five children are reported as having these symptoms (one child in this group does not have any of the three symptoms), while in the group that has negligible error of vertical eye movements only two out of the six children are reported to have these problems. In this last group they are all reported to have word reversal problems.

The distribution of the magnitude of the difference in upward and downward eye movements in Table 1 is also worth noting. This distribution is essentially bimodal, a gap existing between the smallest error value in the "large error group" (2.5) and the next highest value (1.8). Actually, the gap in the distribution should be viewed as more marked than this. A close inspection of the eye movement records of the child with the difference of 2.5 degrees between upward and downward movements reveals that this does not completely describe the vertical inaccuracy of the eye movements. After a downward saccade this child's eyes typically continued to drift downwards for another two or three degrees before the movement was halted. The bimodal appearance of the distribution strengthens the interpretation that we have located a specific eye movement problem that some children have that is definitely related to specific reading problem symptoms.

It can readily be seen in Table 2 that no such gap exists between the "moderate error group" and the "negligible error group". Here the distribution seems continuous and, indeed, the division between these latter two groups is arbitrary and perhaps artificial. All of these error values are within the range of those measured on our group of normal children. Indeed, the average difference for these two groups thrown together is 1.2 degrees of visual angle, indistinguishable from the average value of 1.3 for the normal children.

Statistically, the relationship between vertical eye movement error and reading problem symptoms is significant. Combining the data for the "moderate" and "negligible" error groups, five of the eleven children have problems of skipping or repeating lines or of losing their place without a marker as compared to eight out of eight with these symptoms for the "large error" group. This difference, tested using the Fisher exact test, yields a p value of less than .02.

One other point is worth noting from Table 2. The direction of the asymmetry of vertical eye movements is not a random affair. Among those who have large errors, seven of the eight have larger downward than upward movements. On the other hand, among those showing negligible error, half show larger downward, and half show larger upward movement. It is unclear to us why this should be the case or what the implications are for interpreting the problem.

<u>General Implications</u>. In our analysis of our data we have found one type of eye movement problem that seems to be strongly related to one of the many symptoms of reading problems that, in general, are characteristic of dyslexia. We have found that those children whose upward and downward

saccades are typically of very different magnitudes also have difficulty keeping their place while reading and also tend to skip or repeat lines. Since fewer than half of the children called dyslexic in our sample showed this eye movement problem, we obviously are dealing here with something that, at best, affects only a modest proportion of dyslexic children. Still, if this proves to be a factor, then something has been learned.

The question must, of course, be raised as to how one should interpret this relationship. Obviously, if there is an eye movement problem, that problem must be symptomatic of some deeper, perhaps neurological, malfunction. What we have learned here is, then, not what causes the problem for these children but rather how the problem that does exist translates itself into a reading problem. It creates a reading problem because it happens to affect eye movements in this particular way.

Any finding about dyslexia, even if it is relevant to only few such children, and even if it is only relevant to a few of the many reading difficulty symptoms they show, should be considered in terms of what should be done about it. Here, of course, the question immediately arises as to whether or not the oculomotor system can be trained to make more accurate and more symmetrical vertical eye movements. It is not at all certain that this could be done. There is almost no relevant literature on the subject. Training procedures, however, could easily be devised for children that have this particular eye movement problem to see if extended training would result in change and if the resultant change would have a significantly beneficial effect on the reading ability.

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