

THE POSSIBLE EFFECT OF ATTENTION ON THE DEVELOPMENTAL EYE MOVEMENT (DEM) TEST

A PILOT STUDY

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Abstract

There is an established association between reading and eye movements. The Developmental Eye Movement (DEM) test is used to evaluate eye movements in school-age children. The purpose of this study was to investigate whether attention would influence the results of the DEM test if it were read in a reversed format, since attention has been shown to affect the results of this test in its standard format. Eighteen 10-11 year old females participated in this study. They were divided into two groups: one group read the test in the standard format (ABC), while the other read it in the reversed format (CAB). The test was repeated a week later with each of the two groups reading the test in the same format were not significantly different from one week to the next, indicating a lack of learning effect. However, there was a statistically significant difference in performance when the subjects took the CAB format as compared to the ABC format. Subjects did better when reading the test in the CAB than in the ABC format. Our findings support the proposition of Coulter and Shallo-Hoffmann that attention may have influenced the results.

Key Words

attention, developmental eye movement (DEM) test, reading, saccades

INTRODUCTION

The demands on the visual system during reading are numerous and complex. One of the most important skills that is vital for fast and efficient reading is the ability to execute saccadic eye movements. These movements must be precise and quick in order to effectively derive information from the written text. A deficiency in the oculomotor system could lead to abnormal eye movements, which often result in frequent regressions and loss of place in the text being read.^{1,2}

A deficiency in ocular motility may manifest as an increase in the number of saccadic eye movements, as well as increasing difficulty in performing these movements. Patients who suffer from such a deficiency often complain of losing their place when reading, of slow reading, and of poor comprehension. Common symptoms include excessive head movements while reading, word omissions, and skipping or rereading lines. Some try to avoid these symptoms by using their finger to lead the eyes along the line of the text.^{1,2}

Some authors have attributed these difficulties with saccadic eye movements to a deficiency in the transient visual processing system.^{3,4} This system is linked to the magnocellular (M) neural network; this system is most sensitive to visual information that is of high temporal frequencies (motion) and low and middle spatial frequencies (detail). It is accompanied by the sustained visual processing system, which is linked to the parvocellular (P) neural network. The latter is most sensitive to visual information that is of low temporal and high spatial

frequencies. Both M and P cells are present in the macular region. Thus, in reading, it is proposed that the M cells provide information from the right of fixation, which in turn guides the next saccade so that the P cells can derive the detail of the text.⁵

The Developmental Eye Movement Test (DEM)^a is a popular clinical method to evaluate both visual-verbal automaticity and saccadic eye movements.⁶ It provides a practical and inexpensive quantitative method in these regards. In addition to a pre-test card, there are two subtests. The first (Test A and B) consists of 80 numbers divided into two groups of 40 numbers on separate cards, arranged in two vertical columns each. This subtest does not require the subject to make horizontal eye movements. Performance on this subtest is thought to be a measure of visual-verbal automaticity. The second subtest (Test C) requires the use of horizontal eye movements; the subject calls out eighty numbers, printed on a card, that are presented in a horizontal array of 16 rows of five numbers each. The numbers are randomly arranged in each of the 16 rows. This subtest is a measure of both visual-verbal automaticity and horizontal saccades.

As the subject calls out the numbers on each of the subtests, the examiner records the time and the number of errors (omissions, additions, transpositions, or substitutions). The times required to perform Test A and Test B are added to obtain a total time for this subtest. The various errors are included in a formula to obtain a corrected total time. The horizontal time (Test C) divided by the vertical time (Test

A and B) yields a ratio that represents the comparison of visual- verbal automaticity (vertical) to the oculomotor plus visual-verbal automaticity (horizontal) performance level. An ideal ratio would be the number one. Thus, the closer the ratio is to the ideal, the better the overall performance. The total time for each subtest, the ratio and number of errors in Test C, all have normative tables according to age.

Coulter and Shallo-Hoffmann⁷ investigated children's performance on Test C over time, by dividing it into two equal parts and comparing the number of errors found in reading the two parts. The children consisted of two groups: one had previously been found to have abnormal DEM test results and another control group who had normal DEM test results. They found that the first group of subjects made more errors in the second part than in the first part of Test C. They attributed these results to the presumed influence of attention and not to fatigue because the difference in performance did not occur in the control group of subjects.

PURPOSE

To further study the role of attention, we investigated whether the format of the DEM test could affect the results; would children obtain different results if they read the horizontal subtest (Test C) before the vertical subtest (Test A and B) and would the results be due to fatigue or attention?

SUBJECTS

Twenty-six subjects attending the third grade of a local Primary all-girl School were asked to participate in the study. Nineteen subjects returned the parent consent form, and one more was not included since she appeared for only one of the two sessions of the study. The subjects (N=18; mean age 10.72; SD 0.35) wore their present corrective lenses, if indicated. All subjects were free of binocular vision anomalies or amblyopia. Permission to conduct the study had also been granted by the school.

METHODS

The subjects took the DEM test in different formats on two occasions, one week apart. One format was the standard protocol, i.e., test A and B precede test C (referred to as ABC). The other format reversed the order of the tests so that Test C was taken first (referred to as CAB). During the first session, 12 subjects

(Group 1) took the DEM in the ABC format, and 6 (Group 2) were given the CAB format. Inclusion into the particular group was randomly determined by a coin toss. During the second session, subjects who previously had been tested in the ABC format were tested in the CAB format and vice versa. The two sessions were taken a week apart to mitigate any learning effect. For each subject and in each format a ratio was calculated and the number of errors recorded. The DEM ratio was obtained by dividing the horizontal adjusted time by the total completion time for the two vertical tests. All testing was carried out by two of the authors (NV and EO).

RESULTS

The results for each subject in the two sessions are presented in Table 1. The difference in performance (based on the ratios) between Group 1 (taking the ABC format in the first session) and Group 2 (taking the ABC format in the second session) is not statistically significant (t= 0.33; p>0.25). The difference in performance between Group 2 (taking the CAB format in the first session) and Group 1 (taking the CAB format in the second session) is not statistically significant (t= 0.75; p>0.1). These results indicate that a learning effect was unlikely to have occurred from the first session to the second session.

The performance of all the subjects (N=18) who took the usual format (ABC), either during the first or second session, were in accord with the norms for this age group; the mean ratio was 1.356 (+0.229). The mean ratio for all subjects taking the CAB format either during the first or second session was 1.134 (+0.189). This difference is statistically significant (t = 3.09; p<0.01, two-tailed). Thus, when subjects read the Test C first (CAB format), they achieved, on average, better results than when they read Test C last (ABC format). This indicates that the order of presentation of the Tests has an effect on the results of the DEM. We also noted that the total number of errors for all subjects is greater in ABC format (27) than in CAB format (18), but this lack of accuracy is only confined to 7 out of the 18 subjects. Test-retest reliability was not assessed in this pilot study. However, it has usually been found to be high: Garzia et al⁶ obtained reliability coefficients approaching 0.90 for vertical and horizontal

TABLE 1.
DEM ratios obtained by each subject in both formats and in each session.

Subject	ABC Ratio	Subject	CAB Ratio
First Session			
Group 1		Group 2	
1	1.3	13	1.09
2	1.58	14	1.22
3	1.53	15	1.15
4	1.64	16	1.25
5	1.25	17	1.0
6	1.06	18	1.38
7	1.25		
8	1.82		
9	1.53		
10	0.93		
11	1.31		
12	1.23		

Second Session			
Group 2		Group 1	
13	1.06	1	1.07
14	1.22	2	1.40
15	1.3	3	1.23
16	1.44	4	1.15
17	1.61	5	1.03
18	1.38	6	0.90
		7	0.69
		8	1.10
		9	1.06
		10	0.97
		11	1.47
		12	1.25

N=18	ABC mean (SD)	1.356 (0.229)	
	CAD mean (SD)	1.134 (0.189)	

times in subjects tested one week apart. The error scores reliability coefficient on the other hand was much lower and not significant, in accord with the evaluation of total errors in our study.

DISCUSSION

This study demonstrates that when the DEM test is taken in a reversed order, i.e. reading the horizontal arrays before the vertical columns, the subjects performed significantly better (based on the ratios) than when taking the test in its standard format. If these results had been affected by oculomotor dysfunction, the order of the presentation of the subtests should not have mattered, since the results would have been equally affected. If learning had played a role the results would be significantly better in the second session than in the first, which was not the case.

Thus, we agree with the proposal made by Coulter and Shallo-Hoffmann,⁷ that attention may affect the results of the

DEM test. By beginning the DEM test with Test C, which is more visually demanding and takes more time to read the same number of digits in Test A and B,⁶ the attention mechanisms of the child are aroused. The child then performs better in the CAB presentation and the ratio is smaller than in the ABC presentation.

Although fatigue could account for part of the results, Garzia et al⁶ carried out an analysis of the errors obtained in Test C and found no more errors at the end of the test than at the beginning. Coulter and Shallo-Hoffmann⁷ also dismissed fatigue as a principal factor in testing children of about the same age as in our study. It would seem to us more likely, in agreement with Coulter and Shallo-Hoffmann and some optometrists⁸ that attention could have played the largest role in the results. It is a common observation of parents and teachers that most children have a short attention span.⁹ Thus, it is possible that after performing Test C, our subjects' level of attention lessened when reading Test A and B: If the initial level of attention had persisted our subjects would have read Test A and B more quickly, yielding a larger ratio, which was not the case (see Table 1). Nevertheless, we cannot exclude the possibility that fatigue could, to some extent, have contributed to the results. Further research with more subjects is needed to confirm the results and implications regarding the role of attention that we have presented in this pilot study.

At least several studies support the idea that attention affects the speed and accuracy of eye movements in reading; they further propose that attentional shifts are dominated by the M pathway.¹⁰⁻¹³ Various areas of the brain (parietal, pulvinar of the thalamus and superior colliculus) have been found to be involved in the complex process of attention. This was established through the use of lesion techniques in animal studies and using magnetic resonance imaging or positron emission imaging.¹⁴ Moreover, Kowler et al¹⁵ have found that perceptual attention plays an important and necessary role in the performance of accurate saccades. Further, Kustov and Robinson¹⁶ have identified neurons in the intermediate layers of the superior colliculus that displayed increased activity during the preparation period of saccadic eye movements.

In the present study, attention is more likely to be of a reflexive or stimulus-in-

duced nature, than of a voluntary nature, since the subjects were not in any way requested to behave differently in performing the DEM test, whether in one format or the other.¹⁷

It is important to note the subjects of our study do not represent a sample with any specifically known attention deficit. Visual attention appears to be the main component responsible for the different results obtained when the DEM test is presented in a reversed order. Although our sample does not necessarily reflect the population of children between 10 and 11 years, since it consists of females only, we would not expect the results to be any different with male subjects, as the norms of the DEM test are not gender specific. Nevertheless, additional research on male samples of this age group is needed to confirm our results and conclusions.

It is possible that if the format of the DEM test was changed and Test C was carried out before Test B, i.e., following the sequence ACB, valuable information could be obtained. If the total time were to be significantly longer in Test B compared to Test A, it is probable that attention and/or fatigue would have affected the results. However, if both Test A and Test B revealed almost identical results, even though Test A had been taken first and Test B last, the DEM test could indicate the presence or absence of oculomotor dysfunction. Such a change would necessitate a new set of norms, since the original set was created on the basis of the original format (ABC). Furthermore, additional research would be needed to determine if our results hold true for all ages included in the DEM'S normative data.

The DEM test is a frequently used and effective means of assessing ocular motility in optometric practice.¹⁸ Therefore, more research is needed to establish the influence of the various factors which may influence the performance of this test.

Disclosure

None of the authors has any commercial or financial interest in the product used in this study.

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