

THE EFFECTS OF DIFFERENT COLORED DEVELOPMENTAL EYE MOVEMENT
TESTS ON CHILDREN'S PERFORMANCE

by

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This paper is submitted in partial fulfillment of the
requirements for the degree of

Doctor of Optometry

Ferris State University
Michigan College of Optometry

May, 2007

ABSTRACT

Background: Traditionally Developmental Eye Movement (DEM) tests are done on white paper and are intended for use in diagnosing oculomotor dysfunction. Those students with oculomotor dysfunction tend to be poorer readers. We would like to see if test performance results will differ when the test is repeated on yellow and blue paper.

Methods: Three DEM tests were performed consecutively, in a randomized order, on white, yellow and blue paper on forty-one third grade human subjects at an elementary school. The order of testing was predetermined based on a random number scale. At the conclusion of testing, the classroom teacher rated each student's reading ability based on a set classification of 1-5, with 1 being the lowest level and 5 being the highest level reader. *Results:* The data was analyzed by JMP 5.0 software by SAS, and it was determined that there was no correlation between reading level and performance on the DEM. Also, no statistical evidence showed that a specific colored paper influenced performance on the DEM. However, it was determined that the students performed better on each consecutive test regardless of the color of paper. This brings into question the test-retest reliability of the DEM. *Conclusions:* Performance on the DEM is not related to reading ability. Also, no evidence was found that the use of blue or yellow paper will increase speed and accuracy on the test. Although it is a quick and inexpensive test, the DEM may be of limited usefulness in evaluating for reading difficulties.

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Introduction

The Developmental Eye Movement (DEM) test is a commonly used assessment of oculomotor abilities, specifically in school-aged children. It is a visual-verbal skill test that includes rapid automatized naming of numbers. The DEM consists of two timed vertical number test groups with 40 single-digit numbers each, and one timed horizontal test group of 80 single-digit numbers randomly spaced in 16 rows. The timed scores for both vertical test groups are added together. The horizontal timed score is adjusted for omissions and additions that occur while reading the numbers aloud. The ratio calculated from the adjusted horizontal time to the total vertical time can be compared to age-related normals. The percentile rank can help to determine whether or not the subject has accurate oculomotor skills. Presumably, the faster a student completes the DEM, the better their oculomotor skills, so therefore they are more developed readers. Conversely, those at lower reading levels will demonstrate a slower DEM performance.¹ Therefore, this test can be used by optometrists to determine if a student's oculomotor dysfunction (OMD) may be affecting their reading abilities. By doing the DEM on different colored paper, this research is intended to determine if colored paper will remediate reading difficulties.

Other research has been conducted to determine if colored overlays may help improve visual perception and, therefore, reading ability. One study showed that of all the children who used colored overlays for three months while reading, eighty-eight percent had improvement in their DEM scores.² Another study proved that children who continually used a colored overlay while reading, had an increase in their rate of reading. This occurred after experience of working with the overlays and was evaluated by the

Rate of Reading test. This test is much like the DEM, however it requires the child to read aloud randomly ordered common words.³ Additional research has specifically demonstrated a connection between wavelength of light and reading comprehension since blue filters significantly improved eye movement efficiency in subjects with poor reading abilities.⁴ The purpose in testing on blue, yellow and white DEM tests is to find evidence that children's performance with certain oculomotor tasks can improve depending on the colored background of the text. This may show that the DEM could potentially be a convenient and efficient way for clinicians to screen patients who may benefit from the use of these overlays.

The DEM was chosen for this research because of its supposed good intra-subject test-retest reliability for all four of its scores. Specifications for reliability include the test's ability to produce the same results if given to the same subject in the same environment. This is important to the research since the same test is given three different times, each on a different color paper. The DEM has also been proven to show consistency when determining pass/fail criteria of OMD.¹

Methods

Our testing population consisted of forty-one, third grade students from two separate classrooms at a public elementary school in Michigan. This project was approved by the Human Subject Review Committee of Ferris State University. Parental permission was obtained from each subject who participated in the study prior to testing (Appendix A). No predetermined selection criteria were involved other than classroom attendance on testing day.

It was predetermined that the DEM would be administered on white, blue and yellow paper in a randomized order. The white paper was assigned the number one, while blue was assigned number two, and yellow was assigned to number three. Using a random number table, the order of testing for students 1-41 was established.

On testing day, the subjects were randomly removed from the classroom on an individual basis to complete the task. Each subject was tested in the same controlled environment. The same instructions were given to each subject prior to testing (Figure 1). The subjects were timed using a standard stopwatch. All three colors were given to each subject consecutively. Completion of all three colored DEM tests was required for inclusion in the results. No compensation was awarded to any of the subjects during the testing process.

“I’d like you to read some numbers on these next few pages. The object is to read them correctly and as fast as you can. You cannot use your finger to keep your place. Let’s begin....

Test A: The numbers on this page are in 2 columns. I’d like you to start at the top of the first column, read to the bottom and then go back to the top of the second column and read down. Read it correctly and as fast as you can.

Test B: Read these the same way that you did on the previous page. Remember to read it correctly and as fast as you can.

Test C: For this section, I’d like you to read the numbers from left to right. When you finish reading the first line, go to the second line and so on. Read the numbers correctly and as fast as you can.”

Figure 1: Instructions read to subjects prior to DEM administration.

After testing was completed, classroom teachers were asked to rate each student’s reading ability on a scale of 1-5, with 5 being the highest reading level. This number was used to compare the individual’s score on each DEM in order to determine if colored paper has an effect on the test performance. The compiled results were analyzed with JMP 5.0 software by SAS.

Results

Each DEM was individually scored and compared to the age-related normal tables given in the DEM test booklet. One subject was unable to complete the testing; therefore the subject pool was based on 40 participants. Tables 1-6 represent the data analysis performed by the JMP 5.0 software by SAS.

Table 1. Mean and standard deviation results of each DEM and reading level

	Mean	Standard Deviation
Reading Level	3.575	1.394
White DEM	1.517	0.704
Yellow DEM	1.438	0.605
Blue DEM	1.412	0.422
First DEM	1.648	0.688
Second DEM	1.458	0.650
Third DEM	1.262	0.271

Table 2. Matched pairs analysis of the colors used

	Correlation ¹	Probability ¹
White with yellow	0.766	0.282
White with blue	0.461	0.302
Yellow with blue	0.440	0.777

Table 3. Matched pairs analysis between first, second and third test

	Correlation ¹	Probability <t ¹
First with second	0.847	0.001

First with third	0.587	<0.001
Second with third	0.696	0.009

Table 4. Oneway ANOVA of color by reading

	F Ratio ¹	Probability ¹
White by reading	2.516	0.059
Yellow by reading	1.112	0.366
Blue by reading	1.371	0.264

Table 5. Matched pair analysis of high readers (rated 4 and 5 by teachers)

	Correlation ¹	Probability ¹
White with yellow	0.119	0.496
White with blue	0.721	0.798
Yellow with blue	0.343	0.406

Table 6. Matched pair analysis of low readers (rated 1-3 by teachers)

	Correlation ¹	Probability ¹
White with yellow	0.851	0.449
White with blue	0.443	0.246
Yellow with blue	0.607	0.348

¹This data is based solely on the calculated DEM ratios

Discussion

After analysis of the calculated data, numerous conclusions were drawn in regards to the repeatability of the DEM, how a student's reading ability correlates to their performance on the test and whether the color of the DEM affects the outcome.

The DEM was given on white, blue and yellow paper to determine if one color would improve test performance. This component of the collected data was designed to represent how colored overlays, placed over text, are used to improve reading speed and decrease visual stress. Although other research supports the use of various colored overlays to improve reading speed after ten minutes of continuous reading⁵, these statistics show that there was no significant correlation between the three colors of paper used and the DEM ratio performance.

It was thought that more developed readers would excel on the DEM because those students tend to have more advanced oculomotor skills compared to poorer readers. When comparing the DEM ratio performance to the classroom reading level, assigned by the teacher, there was no significant association. In this case, those students labeled as having a lower reading ability did just as well as those who were considered to be the best readers in the class.

Based on previous research, it was hypothesized that poorer readers may benefit more from using different colored test papers in comparison to more experienced readers, because the colors act to relax the eyes, decreasing the visual strain caused by overaccommodating or overconverging the eyes during extended reading. The statistics showed that there was still no significant correlation between the color of paper and the DEM ratio performance. Those with a level 1-3 reading ability did not favor any

particular color. In a school study conducted in 2002, 37.5% of students with diagnosed dyslexia showed improved reading skills when using a colored overlay of their choice, as compared to 25% of students with average reading skills.⁵

One aspect of the results that demonstrated a significant difference was the order of the tests, regardless of the colors. The DEM ratios dramatically improved with each additional DEM given. The DEM was used because of its supposed high test-retest reliability, however the results question whether this is an accurate 'description' of the test. There are two primary reasons as to why the ratios improved with repeated testing. First, the vertical times slowed significantly from the first to the third test and secondly, the adjusted horizontal times significantly improved from first to third tests. The decrease in vertical times and improvement in horizontal times resulted in a dramatic reduction of the overall ratio, indicating an improvement in performance.

Much research has been conducted in the test-retest reliability of the DEM test, however, there has not been a definitive answer as to whether or not true reliability exists. Research conducted at the Southern California College of Optometry showed that third grade students performed better on the second DEM test given two weeks after the first test. Six out of the 30 student sample size initially failed the DEM, however all six students passed the second time. This suggests that diagnostic errors can be made in identifying suspected oculomotor dysfunction if only tested one time.⁶ On the contrary, other research conducted on 53 students during examination at a private optometric practice, as well as 13 students at a local school, was the first to show good to excellent test-retest reliability on two DEM tests given one to four weeks apart. The student's age

ranged from seven to fourteen years old. However, those students tested at the private practice showed the best test-retest correlation.¹

Conclusion

This research was designed to determine if the DEM could accurately determine a high level reader from a lower level reader, as well as determine if the use of colored paper would increase the performance of poorer readers.

Our results indicate that there is no correlation between the DEM test performances when tested on yellow, white or blue paper. The reading level of the child tested had no influence on the DEM test results, and no particular color DEM test improved the performance of those with lower reading abilities. There was a significant improvement with each successive DEM given, regardless of the color, which goes to question whether the DEM has acceptable test-retest reliability.

The DEM test is currently used by practitioners to assess the oculomotor function of school-aged children. Based on the above research, the results from the DEM test should not be the only data used when making assessments in regards to a child's reading ability.

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APPENDIX A

Permission Slip

Dear Parent or Guardian:

We are third year optometry students at the Michigan College of Optometry at Ferris State University, and are conducting a research project at your child's school. This letter is to notify you of our desire to have your child participate in this study in the coming weeks.

This study involves performing three variations of one test that correlate to your child's reading ability. This test is non-invasive and will take approximately ten minutes per student. This test is routinely performed during comprehensive vision examinations on children with reading difficulties. Your child's individual privacy will be protected because no names will be used in the final report. No diagnoses, recommendations or treatments will be assigned to any individual participating.

The purpose of this research is to determine if there is a correlation between reading performance and the color of testing material used. We hope this research will benefit optometry by providing a better method to diagnose reading dysfunction in children.

If you **do not** wish for your child to participate in this project, please sign the form below and return it to your child's teacher within the next week. Any questions about this project may be directed to Dr. Michael Cron at 231-591-2171.

Thank you for your time and consideration.

Sincerely,

Kelly C. Kobus
Optometry Intern

Lindsey Stull
Optometry Intern

Michael T. Cron, O.D.
Faculty Advisor

I do not wish for my child to participate in the vision research project.

Parent's Signature

Child's Name