The Relationship between Two Tests of Reading Comprehension Performance with and without Eye Movement Monitoring Analysis (Eye Trac II)

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Introduction

Reading is the foundation for most formal education programs. Because of this, educators are constantly attempting to evaluate children's reading performance and place a grade level on reading ability. As a part of student's academic records, reading grade levels, as determined by subtests of the many types of achievement tests, e.g., the Metropolitan Achievement Test, can be found. More specifically, reading specialists use diagnostic tests designed to evaluate reading capabilities with more preciseness. The Durrell Analysis of Reading Difficulty (Durrell) is one such test.[1]

Besides educators, optometrists interested in vision related learning problems often need to have assess to reading levels and ability to relate to any vision dysfunction.[2] This is often done through the use of eye movement instruments.[3] The EDL/Biometrics Eye Trac II is one such devise. Through the analysis of eye movements (fixations and regressions) the practitioner is able to investigate the efficiency of performance relative to the eye movement patterns.[4]

An area of continual research for optometrists is the relationship between reading and oculomotor function.[5] (Poynter, AAO) However little is known about the validity of the reading level determined with the eye movement analysis (Reading Eye II) as it relates to many of the standard reading tests, which do not use eye movements in their analysis.[6]

Therefore, the primary purpose of this study was to investigate the relationship between two tests of reading comprehension, specifically a standarized series of reading comprehension test, the Durrell Test of Reading Difficulty, which does not measure and integrate quantitative eye movements, e.g.,fixations, regressions

in its scoring of reading performance with one that does, the EDL/ Biometrics Eye Trac II reading series.

Method

Subjects

The subjects for this study were 23 students, from 4th to 6th grade, in a summer program designed for those requiring remedial instruction in mathematics and reading. (They included 1 sixth grade student, 13 fifth grade students and 9 fourth grade students.) All subjects had either recent complete visual examinations or passed a screening conducted by fourth year optometry students from Ferris State College of Optometry.

All the subjects passed a Modified Visual Clinical Screening During the subsequent testing the subjects were required to use any visual correction they had to ensure maximum visual efficiency. The children were of normal intelligence and were enrolled in regular classroom programs. There were 12 males and 11 females.

Test Administration and Scoring

School personnel provided recent reading grade levels for each subject as determined by the Metropolitan Achievement Test.

A tape recorder was used during all testing. This allowed the examiner more freedom to interact naturally with the subjects without having to be too concerned with exact timing and scoring at the time the tests were given. These tests could therefore be analyzed more accurately at a later time.

The listening comprehension subtest of the Durrell was administered to each subject. The purpose of this was to ensure that reading difficulty was not the result of the lack of language development. The subjects were read at least two paragraphs beginning

with the subjects present grade placement in school. Depending upon the comprehension level the next easiest or hardest paragraph was then read. The level was used at which the child comprehended at least 70% of the material. From this a listening comprehension grade level was determined.

The oral reading comprehension subtest of the Durrell was administered to each subject. In accordance with the protocol for administering this portion, the subjects read three selections starting with the subjects grade placement. Comprehension was measured by the child correctly answering specific questions. Again only comprehension levels above 70% were considered. Timing, comprehension and reading errors were all rechecked with the aid of the tape recorder. The number of words in each paragraph were counted in order to calculate reading rate. From this test a silent reading comprehension grade level was determined as well as a reading rate in words per minute (wmp).

The silent reading subtest of the Durrell was administered to each subject. Each subject read parapraphs of the same level of difficulty as those read for the oral reading portion. Timing the silent reading was done by noting when the subjects opened their eyes to begin reading and when they closed their eyes when the reading was completed. Instead of asking specific questions about the paragraph, this portion of the Durrell requires the subject to recall as much as possible. Only the number of unaided recalls was used as a measure of comprehension. Again only those above the 70% were considered. The number of words in each paragraph were counted in order to obtain a reading rate, and from this test a reading grade level was determined as well as a reading rate in words per minute.

Reading comprehension levels were then determined on each subject with the use of the Biometric Reading Eye II. Each subject was given a pre-test to determine the paragraph level to be read. The beginning card was determined by the subject present grade placement. The subject read this paragraph orally. If four or more words were missed, the subject was given the next easiest paragraph until no errors were made. The level at which there were no oral errors was the level used during the actual testing. Eye movements were recorded for the grade level and comprehension was measured by answering the ten true or false questions on the back of the card. A 70% level was required for adequate comprehension. The total reading time was recorded from the eye movement charts. The number of fixations and regressions were counted. Using the reading rate (wmp) and the number of fixations and regressions, a reading grade level in terms of relative efficiency was determined as described in the Eye Trac II manual. This Relative Efficiency (R.E.) is calculated by the following formula:

$$R.E. = \frac{\text{rate in wpm}}{\text{fixations /100 words + \# regressions/100 words}}$$

The R.E. value was then converted to a grade level by a conversion charg supplied with the Reading Eye II manual.[7]

Statistical Treatment of the Data

Ten pieces of information were evaluated for statistical analysis purposes. The variables under consideration were 1) actual grade placement, 2) Durell listening comprehension grade level, 3) Durrell oral reading comprehension rate in wpm, 4) Durrell oral comprehension reading grade level, 5) Durrell silent reading comprehension rate in wpm, 6) Durrell silent reading comprehension grade

level, 7) Metropolitan Achievement Test reading grade level, 8) Grade level for comprehension of the paragraph read on the Reading Eye II, 9) Comprehension on Parapraph in Reading Eye II; reading rate in wpm, on 100 grade level for reading calculated by relative efficiency (R.E.)

RESULTS

A 10 x 10 multiple Pearson product movement correlation analysis was carried out on the ten variables measured.

(Table 1)

The means and standard deviations are listed in Table 2

(Table 2)

The results of the multiple correlations and their significance is shown in Table 3.

(Table 3)

As can be seen, there were numerous significant correlation (p .01).

Durrell Listening comprehension was significantly related to the Eye Trac Grade level, Durrell Oral comprehension Grade Level, and the Durrell Silent comprehension grade level.

Oral reading comprehension on the Durrell was significantly related to five factors; Durrell listening comprehension, child's present grade, Durrell silent comprehension grade level, Metropolitian reading level, and Eye Trac II and grade level.

Silent reading comprehension grade level on the Durrell was significantly related to Eye Trac II grade level, oral reading comprehension grade level, and Durrell listening comprehension level.

Finally, the Eye Trac II grade level in silent reading comprehension was significantly related to the child's grade level, Durrell listening comprehension grade level, silent reading comprehension grade level, and Metropolitan reading test grade level.

We further analized the relationship between word per minute (wmp) rate in the reading comprehension tests. The oral reading comprehension wpm rate did not significantly relate to any other test.

However, the Durrell silent reading comprehension level word per minute rate did relate significantly ($r=0.69$, $p < .01$) with the Eye Trac II reading comprehension word per minute rate and the Eye Trac relative efficiency grade level. ($r=0.75$, $p < .01$).

Since a significant correlation between word per minute rates were found on the Surrell silent comprehension level and the Eye Trac II Silent Comprehension level. A t-test was performed resulting in no significant difference between the wmp in both silent reading comprehension tests. $t= 0.33$, $p < .05$)

Discussion

The study of eye movements during the task of reading is not a new one. There has been studies investigating this activity for at least one hundred years.

Numberous investigators have looked at the role of eye movements during reading with various instruments. The most current one, available in 1969, Reading Eye II, by Biometrics yields a record of the number of fixations and regressions and overall reading time. Over the years, various reading diagnosticians have questioned the value of measuring eye movements in reading. They questioned whether eye movements was a valid measure of reading test results. However, from numerous studies today, there is strong support that the Eye Trac does accurately reflect an individual's reading habits and performance.

Unfortunately, the evaluation of reading performance in schools today with the use of eye movement analysis has decreased significantly over the past decade.

Informal tests of silent and oral reading and, of listening comprehension are being used more and more frequently to assess reading levels, progress in remedial reading programs, and remedial approaches for reading disabled children. Measures of listening or auditory comprehension are often used to estimate potential reading levels since they probe the level of language complexity or reading materials that a child can comprehend when listening.

Oral reading ability is not considered strong support of associated reading comprehension. Therefore it is not uncommon to use standardized questions and demand performance in comprehension when analyzing the child's oral reading level.

Silent reading comprehension has many variables obviously beyond the scope of this discussion. The silent reading rate (words/minute) with comprehension of at least 70% or greater is a meaningful measure of reading.

Reading diagnosticians attribute very low reading rates to such factors as word reading, narrow recognition spans, many regressions, and other faulty eye movement behaviors. The fact that these factors cannot be detected or measured without eye movement analysis seems to elude these diagnosticians and apparently does not hamper their diagnosis and treatment plans for such problems in reading performance.

To help resolve some of this inconsistency, we conducted this study to compare silent and oral reading comprehension in two tests, one with Eye Trac II and one with Durrell Analysis of Reading Difficulty eye movement data.

When we compared the Durrell's silent reading comprehension grade level with the Eye Trac II grade level, both with at least 70% comprehension, we found a significant relationship ($r = 0.78$, $p < .01$) and there was no significant difference in the mean scores ($t = 1.23$, $p > .01$). This is interpreted as meaning that these two tests are capable of measuring essentially the same grade level. However, this did not consider the impact of eye movement. Therefore, we compared the Durrell Silent eading Comprehension level converted to a word per minute rate with the Eye Trac II word per minute rate with comprehension. We found a significant relationship ($r = 0.69$, $p < .01$) with no significant difference in their mean scores ($t = 0.60$, $p > .01$). Therefore, what was measured essentially were very similar spans of recognition in two separate silent reading tasks. This is consistent with earlier studies where correlations of 0.83 at the fourth and seventh grade levels and 0.91 at the tenth grade level were found between reading rate with an eye movement camera and a rate of reading test.

The Eye Trac II uses the eye movement data of words per minute, fixations, and regression to determine "relative efficiency" (R.E.) in the specific grade level of reading comprehension. In other words, the R.E. measures the relationship of fixations/regressions with silent reading comprehension word per minute rate. It measures his level of visual activity in the reading performance relative to his reading rate with at least 70% comprehension.

Practically, a child could be reading at his grade level, but is performing inefficiently even though his rate (wpm) is appropriate for his grade. The Eye Trac II R.E. was compared with the Durrell Silent reading rate (wpm) in order to see if there is any relationship. There was a significant relationship found ($r = 0.75$, $p < .01$)

This, therefore, lends support to the use of the reading rate (wpm) at minimum 70% comprehension levels in a non eye-movement test (Durrell) of silent reading comprehension relative to the impact of visual activity during such a test.

Further analysis shows that if we compare the Durrell silent reading comprehension grade level which does not reflect visual activity through wpm rate, with the Eye Trac II relative efficiency score, we find no relationship ($r = 0.20$, $p < .01$) of any significance. In fact, the only significant relationship we found of eye movement activity and reading performance occurred when silent reading was considered as word rate with comprehension.

Another observation based on our data is that oral reading comprehension, when converted to rate with comprehension, did not have a significant relationship with any of the other measures of reading performance. From the data, it was demonstrated that a number of the reading tests, in terms of grade level, are related

and predictive of one another. This is not a surprising relationship.

An important question must be raised in the analysis of this data. Why even measure eye movements in the task of reading? There are numerous reasons. First, to assess the peripheral "mechanical" functioning of the oculomotor system in the reading act. It provides an objective record of oculomotor behavior in reading and non reading tasks. Second, to obtain indications and direction for remedial approaches in reading dysfunctions. Such aspects of oculomotor behavior as directional attack and narrow recognition spans with high fixations rates could be made without eye-movement evaluation. As Spache points out, "The only symptoms observable by the teacher in cases of (poor) directional attack maybe a slow rate, a good deal of fumbling across the line, and perhaps a tendency to reversals in word order or frequent repetitions of words or phases. There are, of course, common behavior of poor readers and are often interpreted as indicating poor phonic skill or sight vocabulary deficiency, which may not be correct".[8]

Thirdly, to give indications in oculomotor and binocular coordination dysfunctions either independent or during the reading act. Such conditions as small amplitude nystagmus, accommodative convergence dysfunction, oculomotor palsies, are but a few of the conditions that can have a direct impact on the reading act.[9]

Disturbances of binocular coordination often give similar symptoms as those mentioned earlier in terms of directional attack and narrow recognition spans. Many of these, once identified, are often remediable through professional vision care.[10]

It should not be implied by the above discussion that oculomotor and binocular dysfunctions have a significant role in interfering in most or all cases of reading performance. However, these components must be considered in the differential diagnosis of reading dysfunction.

In conclusion, the data and results of this study lends support for the need of incorporating the assessment of the eye movement information during reading tests. If diagnosticians and practitioners of reading are to derive meaningful diagnosis, treatment plans and follow up data in reading performance, they need to consider not only the reading performance grade level, but the visual efficiency at which that level is achieved.

Obviously, one of the obstacles in the collection of eye movement data other than the diagnosticians attitude, is the cost of the instrumentation. However, we found in the modification of the Durrell silent reading comprehension test to a rate (wpm) with comprehension, this could possibly act as a viable predictive measure of visual efficiency without the use of eye movement monitoring instruments. These preliminary findings need to be replicated with larger groups as well as other measures of reading comprehension. If a significant relationship is found, then this would be of aid to the diagnostician involved in the evaluation and treatment of reading problems in children.

TABLE 3
Correlation Matrix for Measures
of Reading Performance

	PGL	DLC	DOR	DOGL	DSR	DSGL	MAT	ETGL	ETR	ETRE
PGL	----	0.54*	0.15	0.53*	0.19	0.43	0.38	0.61*	0.33	0.34
DLC		----	0.22	0.61*	0.04	0.73*	0.50	0.84*	0.01	0.01
DOR			----	0.42	0.46	0.27	0.14	0.25	0.36	0.22
DOGL				----	0.53*	0.68*	0.72*	0.77*	0.45	0.43
DSR					----	0.38	0.48	0.09	0.69*	0.75*
DSGL						----	0.65*	0.78*	0.17	0.20
MAT							----	0.59	0.16	0.23
ETGL								-----	0.01	0.03
ETR									----	0.94*
ETRE										-----

* $P < .01$

TABLE 2
Means and Standard Deviations
for the Ten Variables

Variable	Mean	Standard Deviation
PGL	4.714	0.561
DLC	4.333	1.255
DOR	107.381	17.226
DOLC	3.524	0.873
DSR	129.667	45.410
DSGL	3.857	1.062
MAT	4.262	1.616
ETGL	3.619	1.431
ETR	131.190	36.947
ETRE	3.976	2.298

TABLE 1
Abbreviations used in Tables

1. PGL = Present Grade Level of Subject
2. DLC = Durrell Listening Comprehension Grade Level (70%)
3. DOGL = Durrell Oral Comprehension Grade Level (70%)
4. DOR = Durrell Oral Comprehension: Words Per Mi nute Rate (WPM) from DOGL selection
5. DSGL = Durrell Silent Reading Comprehension Grade Level (70%)
6. DSR = Durrell Silent Reading Comprehension Words per Minute (WPM) rate on DSGL selection
7. MAT = Metropolitan Achievement Test; Reading Grade Level
8. ETGL = Eye Trac II Reading Comprehension (70%) Grade Level
9. ETR = Eye Trac II Word per Minute rate (WPM) on ETGL selection
10. ETRE = Eye Trac II relative efficiency from ETGL selection (re = $\frac{\text{rate (wpm)}}{\text{fixations/100 words = Regressions/100 words}}$

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