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Use of the Taylor Visagraph II system to evaluate eye movements made during reading

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Methods: Fifty first year optometry students served as subjects. Each read 5 standard Taylor Level 10 (College) paragraphs during each of two sessions while eye movements were assessed by the Visagraph II.

Results: The Visagraph II operated correctly for 498 of the 500 trials; operator error caused two malfunctions. Significant differences were found between scores from the first paragraph read and subsequent paragraphs. Nonlinear relationships were found between most of the variables especially those involving grade levels and spans of recognition. Session to session comparisons produced relatively high split-half correlations. Correlations between Optometry Admission Test Reading Comprehension scores and all but two Visagraph II scores were not significantly different from zero. Also of interest was the wide range of reading eye movement skills; several of the optometry students appeared to have skills that placed them at below fourth grade -level.

Conclusions: The Visagraph II is a potentially useful device for the assessment of eye movements made during reading. It performed properly over a large number of trials and produced data that seemed to be reliable indicators of reading skills. Paragraph to paragraph variations in mean scores suggest caution in interpreting small changes in performance across paragraphs and the need for at least one practice trial before usable data are obtained. Further, an understanding of the nonlinear relationships between some of the Visagraph II scores can help to prevent misinterpretations or inappropriate use of statistical comparisons that assume linearity.

Degree Type
Thesis

USE OF THE TAYLOR VISAGRAPH II SYSTEM TO EVALUATE EYE MOVEMENTS MADE DURING READING

PRESENTED BY:

Dirk Colby

In partial fulfillment for the Master of Education,
Visual Function in Learning
at Pacific University

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Dr. Anita McClain
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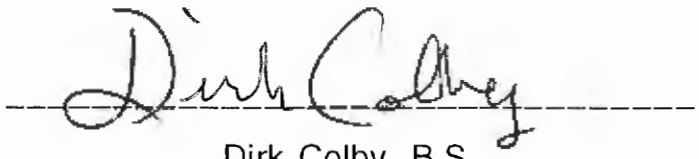
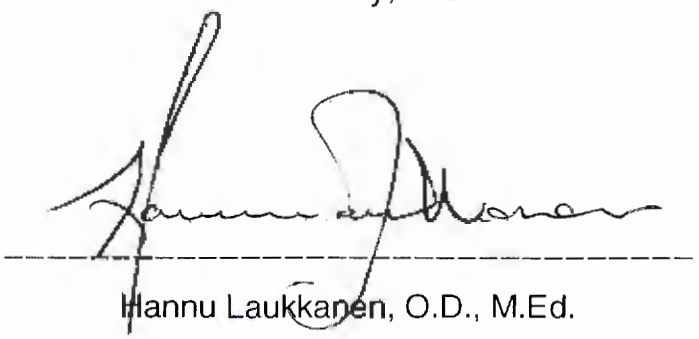


Dirk Colby, B.S.



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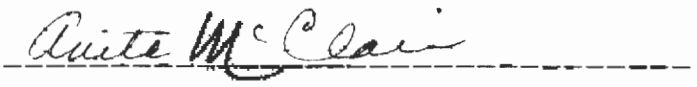

Anita McClain, M.Ed, Ed.D.

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Key Words: Visagraph II, reading, eye movements, reading disability

INTRODUCTION

The Visagraph II is the latest in a series of eye movement monitoring devices made by Taylor Associates.[b] It uses infrared emitters and detectors mounted in safety-type goggles to determine eye positions by sensing the differential infrared reflections from the cornea, sclera, and other anterior ocular surfaces.[1] (Figure 1) Analog information about eye positions is converted to digital values by the system and these digital values are transferred to an IBM PC compatible computer. Software in the computer then analyzes the data to determine when certain types of eye movements occur.

Insert Figure 1 About Here

Commonly, the Visagraph II is used to evaluate eye movements made while a subject reads one or more standard paragraphs distributed by Taylor Associates.[b] These paragraphs provide content appropriate for readers ranging from primary to adult/college. To evaluate a subject's eye movement skills, an age appropriate paragraph is read silently while eye movements are analyzed by the Visagraph II system. Analysis begins with the development of a "idealized' eye movement trace which is constructed by the computer software from the often somewhat noisy and variable raw data produced by the goggles. This idealized trace has stable fixations with abrupt saccadic movement representations which are easy for the software to count. The accuracy with which the idealized trace represents actual eye movements as opposed to

electrical noise, eye blinks, etc. sets limits on the accuracy of numeric data provided by the Visagraph II. These numeric data include the number of fixations made per 100 words, the number of right to left regression eye movements, and reading speed in words per minute. The system also calculates several derived values including the equivalent grade level of the subject's reading eye movements based on normative data collected by Taylor and colleagues.[2]

Reading difficulties can be caused by a number of problems including those associated with eye movement control.[3-13] For this reason, the ability to accurately and objectively monitor eye movements during reading can be of significant diagnostic value in the evaluation of selected patients with reading problems. If the Visagraph II provides reliable and valid data, it should have applications in clinical settings where children with reading difficulties are evaluated and treated.

Project Goals

This project was designed to evaluate the operation of the Visagraph II system and to determine the reliability and validity of the data it produced when 50 subjects each read 10 Taylor High School/Adult/College level paragraphs.

SUBJECTS AND PROCEDURES

Subjects

Fifty first year optometry students served as subjects; 25 were males (mean age 27.6 years, SD 4.8) and 25 were females (mean age 24.3 years, SD 2.6). None had ever been diagnosed as reading disabled or dyslexic, and all read at a level sufficient to

have completed college and obtained entry into optometry school. Each subject demonstrated at least 6/6 near Snellen equivalent acuity at 40 cm (with correction if required) and gave informed consent for participation in the project.

Procedures

The procedures used in this study follow those described in the Visagraph II users manual.[14] They are also essentially the same as those used in a previously published evaluation of the Ober2 Model B-1200 system which also uses goggles with infrared optical detectors to monitor eye movements.[15] Following an orientation to the Taylor Visagraph II system, the subject was comfortably seated 40 cm from a text holder inclined back at an angle of approximately 30 degrees from vertical. The text holder was positioned below the subject's horizontal line of sight so as to simulate a normal reading posture. Goggles were placed over the subject's near correction (if any) and adjusted for interpupillary distance by centering the pupils through the apertures as the subject viewed a near target.

Room illumination consisted of a 60 watt incandescent bulb in a desk lamp indirectly illuminating the text holder from a distance of 1.5 meter. A chin rest was used to stabilize the subject's head during reading. (Figure 2)

Insert Figure 2 About Here

Reading material consisted of Taylor Level 10 paragraphs designed for college students. The paragraphs were each 10 lines long, were typed double spaced on bond white paper using 12 point

Times bold font (approximately 20/70 near Snellen equivalent), and were displayed one at a time in the same order for each subject. Paragraph names and reference numbers used for identification are shown on Table 1.

Insert Table 1 (Taylor Paragraph Names) About Here

Instructions to the subject followed those in the Visagraph II manual and Taylor paragraph booklet.[14] Each paragraph was read silently with no time limit. After reading, the subject answered 10 standard comprehension questions about the content of the paragraph. These questions were presented orally by the examiner. The subject then had an approximately 1.0 min. long rest period. During this period, the subject did not remove or displace the goggles but could lift the chin from the rest and close the eyes if desired. To avoid introducing extraneous variables, the goggles were not re-positioned between trials.

Data were obtained in two sessions separated by 3 to 4 weeks; the first 5 paragraphs were presented during the initial session and the last 5 were presented during the second session.

RESULTS

Operation of the Visagraph II

The Visagraph II produced usable analyses for 498 of the 500 trials (50 subjects times 10 paragraphs per subject). The two analysis failures were caused by operator error and the trials were repeated without further problem. This record of successful analyses places the Visagraph II in marked contrast to an Ober2

Model B-1200 system that failed to complete almost a third of its analyses during a similar evaluation.[15]

Placement of the goggles on the subjects was straight-forward and the goggles were relatively comfortable to wear (although they did leave shallow "dents" in the forehead if their elastic straps were tightened too much). The Visagraph II goggles are large enough to allow most spectacle frames to be worn underneath them, but they lack external trial lens cells.

Operation of the MS-DOS based Visagraph II computer program was straight-forward, and the option windows provided relatively clear choices. However, some knowledge of the DOS operating systems is helpful for such tasks as copying files, compressing the hard drive, etc. PC users will not have a problem with this, but Macintosh users will miss their Mac operating system. The only computer-related problem encountered with the versions 2.6 Visagraph software used in this project was that the directory of stored subject records could display only the names of 400 records and this required the creation of multiple directories and moving records from one directory to another. This problem, which was not described in the Version 2.6 Visagraph II manuals, has been eliminated in newer versions of the software.[c]

Output displays were clear and easy to understand. Data are presented in numerical form and a graph shows the data converted to school grade equivalents by using Taylor norms. (Figure 3)

Insert Figure 3 (Printout Sample) About Here

The display gives fixation, regression, span, and duration data for the right and left eyes separately but uses only the data from the eye with the most fixations (or most regressions in case of a tie) to calculate the remaining values. A summary of the values presented by the Visagraph II, the abbreviations for these values that will be used in this paper, and how these values are determined is presented on Table 2.

Insert Table 2 (Values, Abbreviations, and Determinations) About Here

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Based on the assumption that the two eyes can have unequal numbers of fixations and regressions, correlations between right and left eye data are also reported by the Visagraph II. These correlations were not analyzed in this study.

Reliability of Paragraph by Paragraph Data

To assess the equivalency of the ten Taylor Level 10 paragraphs, repeated measures analyses of variance (ANOVAs) were used to compare the Visagraph II data across paragraphs for all 50 subjects. Means, standard deviations, and ANOVA probability values are shown on Table 3. Note that all of the ANOVA comparisons except number of Regressions and Direction of Attack show significant differences between some of the paragraphs. Post-hoc Scheffe testing used a 0.10 probability value[16] indicates which paragraphs produce significantly different values. (Table 4)

Data from paragraph 1 differs from data for several the paragraphs read later in the first session and during the second

session. Surprisingly, however, instead of indicating poorer reading performance for paragraph 1 (Amundsen), most of the data indicate better reading performance as compared to data from subsequent paragraphs. The exception to this is the mean percent accuracy on the comprehension quiz for paragraph 1 which is the lowest for any of the paragraphs. By way of explanation, perhaps the subjects changed their reading strategies and slowed their reading rates for subsequent paragraphs based on their problems with the paragraph 1 quiz questions. This finding suggests that at least one practice trial must be given to help subjects learn what is expected of them before any diagnostic data are recorded.

Insert Tables 3 (Paragraph by Paragraph Means and ANOVA Results) and 4 (Scheffe Post Hoc Test results) About Here

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Data from paragraph 8 (Frank Lloyd Wright) also differ from other paragraphs in many of the comparisons. Because of high fixation and regression values, the equivalent grade level was the lowest for this paragraph, but quiz accuracy was highest. Perhaps the subjects found the content of this paragraph especially interesting, or perhaps the paragraph has a somewhat higher conceptual difficulty level. The high quiz scores for paragraph 8 argue for the former possibility.

Correlations Between Visagraph II Data Values

The data values determined by the Visagraph II assess different reading parameters but should covary as a function of overall reading ability. For example, better readers should make

fewer fixations and have longer spans of recognition, shorter fixation durations, and fewer regressions. To assess these relationships, Spearman rho correlation coefficients were calculated using data from all 500 trials. (Table 5) Rho values (corrected for ties) were used because scatterplots showed that the relationships between many of the variables were nonlinear. The nonlinearity is most apparent in comparisons between grade levels versus all other variables, fixations versus spans of recognition, and fixations versus relative efficiencies. Scatterplots illustrating the nonlinear relationships are shown on Figures 4 and 5.

Insert Table 5 (Correlation Matrix) and
Figures 4 and 5 (Scatterplots) About Here

Several trends are evident in the scatterplots. One of the most striking is the wide range of data produced by the subjects. What was considered to be a group of relatively homogeneous readers (first year optometry students) seems in reality to be group of quite heterogeneous readers. If the Visagraph II data are valid, some of the subjects apparently made more fixations than there were words in the paragraphs (i.e., they were monosyllabic perceivers). Beyond this, many of them demonstrated a fourth grade or lower reading eye movement skills, yet each was capable of graduating from college with high grades and surviving most of their first year of optometry school. Either the Visagraph II data are not valid for these subjects, or the subjects have developed some very effective compensation strategies for overcoming their poor reading eye movement skills.

Some of the correlations shown on Table 5 are artifactually high because certain of the Visagraph II scores are calculated from other scores. For example, relative efficiency is calculated by using fixations and regressions, so the high correlations between these values are artifactual.

Span of recognition is also artifactually related to the number of fixations in a negative and non-linear manner. This is because span is calculated by dividing the number of words read (a constant of 100 words in each of the paragraphs) by the number of fixations made. Mathematically, any range of numbers divided into a constant produces a curve like that shown for the relationship between fixations and spans.

The relationship between equivalent grade level and relative efficiency is also artifactually high and nonlinear. The Visagraph II uses a "table look up" routine involving an application of Taylor norms to convert from relative efficiency to grade level. Beyond about grade level 12, this table produces decreased magnitudes of the increments in grade level scores for equal increments in relative efficiency.

Other relationships are also apparent on the scatterplots. For example, there is a relatively high positive correlation between fixations and regressions. This is consistent with the theory that as reading skill increases, the reader makes fewer fixations and fewer regressions. With respect to other variables, durations of fixation seem almost totally unrelated to any of the Visagraph II parameters. Durations, calculated by dividing the total reading time by the number of fixations, has a correlation of only 0.06 with fixations.

This suggests that the total reading time must have been quite variable for the subjects.

Finally, percent correct data from the quizzes were essentially unrelated to any of the other variables. This is possibly due to the restricted range of quiz scores.

Comparison of Data from the First and Second Sessions

If the Visagraph II data assesses stable and reliable components of reading ability, a comparison of values produced during the two measurement sessions should yield high correlation and split-half reliability coefficients. (The split-half reliability is essentially a correlation coefficient adjusted for the fact that only half of the data, i.e., 5 paragraphs, are used for each part of the calculation.)[16]

Coefficients comparing all 5 paragraphs read during each of the sessions and comparing only the last 4 paragraphs read during each session are shown on Table 6. The rationale for comparing only the last 4 paragraphs is that any "first trial" effects are removed from the data. Omitting paragraphs 1 and 6 increases the reliability coefficients slightly, again suggesting that at least one practice trial should be given before meaningful data are collected with the Visagraph II.

Insert Table 6 (Split-Half Reliability Coefficients) About Here

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With the exception of the quiz data (which the Visagraph II manual indicates should be used to determine whether the reading data from the paragraph are of acceptable quality), the relatively

high split-half coefficients suggest that the Visagraph II reliably assesses several parameters associated with the reading abilities of the subjects in this project.

DISCUSSION

This project was designed to evaluate the operation of the Visagraph II system and to determine the reliability and validity of the data it produces.

System Operation

With respect to operation, the Visagraph II performed essentially all of the 500 analyses in this project correctly and provided useful data in each case. This is a significant improvement over the 30% analysis failure rate for the Ober2 Model B-1200 eye movement analysis software that was evaluated previously.[15] The only operational problem encountered with the Visagraph II Version 2.6 software used in this project was an inability to see the names of more than 400 data records at a time in the computer storage directory listing; this problem has been corrected in subsequent software versions.[b]

Reliability

Reliability is defined as the ability of a system to produce similar outputs when similar inputs are presented. In this project, the reliability of both inter-paragraph and inter-session data were determined. In a previous study using the Ober2 Model B-1200 eye movement analysis system, reliability comparisons of the Taylor Level 10 paragraphs showed a mean 2.9 year equivalent grade level difference between paragraphs 4 (John Roebling) and 6 (Clarence Darrow) for data from 50 optometry students.[15] For unknown

reasons, this pattern was not seen in the present study. Grade level equivalent data from the Roebling and Darrow paragraphs were not significantly different, but various scores from other paragraphs were. No particular pattern in the significant differences was observable except that reading scores from paragraph 1 were significantly better than comparable scores from paragraphs read later. This indicates the need for at least one warm-up paragraph to be presented along with feedback from the quiz questions before reliable data can be collected. The scattered differences between scores from the 10 paragraphs also indicates the need to use significant caution when interpreting small differences in reading scores for individual subjects.

Inter-session reliability was assessed by using split-half coefficients. The fact that these coefficients were quite high demonstrates that the values provided by the Visagraph II are indicators of relatively stable reading eye movement skills, as opposed to skills that might fluctuate day by day.

Validity

The validity of a score is determined by the degree to which it actually measures what it purports to measure. It is possible for a test to produce very reliable, but invalid, data. For example, if the height of a person is measured repeatedly with a ruler that had been mis-marked so that each inch division is only 0.75 inch in length, the measurements could be very reliable (i.e., repeatable) but not valid. The numbers would not represent the true height of the person as would have been determined by use of a "gold standard" perfect ruler.

In the case of data from the Visagraph II, two types of validity can be considered. The first involves determining whether the numbers representing eye movements (e.g., fixations, regressions, etc.) accurately represent the actual eye movements made. In other words, did the computer system make an accurate conversion of the raw eye movement data to the idealized trace, and then did it analyze the idealized trace accurately? Unfortunately, there is no absolute way to determine this because no gold standard eye movement data were determined along with the Visagraph II data.

The second type of validity involves the degree to which the derived scores, e.g., grade equivalents, actually represent the inherent reading abilities of the subjects. This issue can be approached by considering the implications of the data produced by the Visagraph II and by comparing the data to reading abilities as measured by a standardized test.

If the Visagraph data are both reliable and valid, it is necessary to accept the fact that the average first year optometry student made separate fixations on 94 of the 100 words in each paragraph and made more fixations than there were words in paragraph 8. (Table 3) (In part this could be caused by the fact that the typical student needed to make about one regression on each line of the 10 line paragraph.) It is also necessary to accept the fact that although the average student had reading eye movement skills at about an 11th grade level, on random paragraphs some of the students had eye movements that corresponded to skill levels below 4th grade. (Figure 5) Since all subjects had reading abilities that were sufficient to graduate from college with high grades and

survive at least one reading-intensive semester in optometry school, questions can be raised about the validity of the scores from some of the paragraphs.

As a second indicator of whether the Visagraph II scores are valid indicators of reading ability, the scores can be compared to scores from the standardized Reading Comprehension Sub Test of the Optometry Admissions Test (OAT). This test was taken by all of the subjects approximately one year before Visagraph II testing. It consists of comprehension questions based on a selection of scientific writing that must be read in a fixed time period.

As indicated on Table 7, the Spearman rho correlations between OAT and Visagraph II scores were low and non-significant except for fixation durations and performance on the comprehension quiz. The significant correlation between Visagraph II and OAT comprehension scores suggests that both index a single trait that the subjects possess (i.e., the ability to answer comprehension questions). The lack of correlation with other Visagraph II scores (except duration of fixations) suggests that comprehension ability is relatively unrelated to the eye movement skills used during reading paragraphs. This is also demonstrated by the fact that none of the eye movement-related Visagraph II scores correlate significantly with the Visagraph II paragraph comprehension test scores. Further studies are underway to address this issue.

Insert Table 7 (OAT versus Visagraph II Score Correlations) About Here

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In summary, the objective, computerized nature of Visagraph II testing will have appeal for both users and patients as a means of diagnosing reading problems and monitoring therapy results so long as more precision and reliability than the instrument (or the eye movements themselves) can provide is not expected.

Acknowledgments

We thank Taylor Associates[b] for supplying the Visagraph II used in this study and for responding to several technical questions about its use. Taylor Associates did not influence the design of the study nor the reporting of the outcome. None of the authors have any financial interest in Taylor Associates or any organization associated with production or marketing of the Visagraph II. Dr. Yolton serves as an scientific advisory board member for a norming study being conducted by Taylor Associates; he is not compensated for this service.

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Footnotes

a. Pacific University College of Optometry, Forest Grove OR 97116.

b. The Visagraph II is available from Taylor Associates, 200-2 East 2nd St., Huntington Station, NY 11746; Phone 1-800-732-3758. As of February 1997, the price of the Visagraph II System with Version 2.10 software was $3,125. This price does not include the PC-compatible computer required to operate the system.

c. Personal communication in March 1997 with Kurt Nyström, Compevo AB, developer of the Visagraph software, indicates that this problem has been fixed and that current program versions (e.g., Version 2.10) allow directory display of up to 65,000 record names.

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Table 1. Name identifications for standard Taylor College Level 10 paragraphs.

Paragraph Reference Number	Names for Taylor Level 10 (College) Paragraphs
1	Amundsen
2	Houdini
3	Braille
4	John Roebling
5	Dorothea Dix
6	Clarence Darrow
7	Paganini
8	Frank Lloyd Wright
9	Sir Ernest Shackleton
10	Clara Barton

Table 2. Names, abbreviations, and definitions of data produced by the Visagraph.

Name and Abbreviation	Measurement or Calculation
Fixations (FIX)	Number of eye pauses per 100 words read.
Regressions (REG)	Number of significant right to left eye movements (excluding return sweeps) per 100 words read.
Span of Recognition (SPAN)	Number of words read divided by the number of fixations made.
Duration of Fixation (DUR)	Total reading time in seconds divided by number of fixations made.
Reading Rate with Comprehension (RATE WITH COMP)	Reading rate in words per minute determined for all lines in the paragraph excluding the first and last.
Direction of Attack (DIR ATTACK)	Number of Regressions divided by number of Fixations.
Relative Efficiency (REL EFFIC)	Reading rate in words per minute divided by the sum of Fixations plus Regressions.
Reading Rate Adjusted for Rereading (ADJ READ RATE)	Reading rate in words per minute excluding any lines or parts of lines that are reread.
Percentage Correct on Quiz (% COR)	Percentage of correct answers given to 10 question comprehension quiz given after paragraph has been read.
Grade Level Equivalent (GRADE)	An equivalent academic grade ranging from 1 to 18 determined by converting the Relative Efficiency to a Grade Level Equivalent using norms provided by Taylor. This is a nonlinear conversion.

Table 3. Mean values and standard deviations (in parentheses) for data from Visagraph for each paragraph. Overall means for all paragraphs and p values based ANOVAs are also shown.

PARAGRAPH	FIX	REG	SPAN	DUR	RATE WITH COMP	DIR ATTACK	REL EFFIC	ADJ READ RATE	%COR	GRADE
1	85.6 (24.1)	8.3 (9.1)	1.25 (0.32)	0.28 (0.05)	268.9 (77.0)	8.94 (6.91)	3.36 (1.86)	280.2 (71.9)	71.8 (18.3)	12.20 (3.27)
2	94.6 (37.3)	11.4 (11.9)	1.17 (0.34)	0.29 (0.05)	246.3 (84.4)	10.58 (6.36)	2.89 (1.86)	259.8 (87.3)	74.2 (18.8)	10.99 (3.89)
3	91.2 (24.3)	9.9 (8.4)	1.18 (0.32)	0.29 (0.05)	249.8 (77.1)	10.08 (6.34)	2.90 (1.65)	269.0 (72.1)	76.4 (16.3)	11.03 (3.87)
4	90.0 (25.4)	9.7 (7.6)	1.18 (0.28)	0.28 (0.05)	255.4 (78.7)	10.16 (6.13)	2.91 (1.65)	273.4 (75.9)	82.8 (14.4)	11.39 (3.71)
5	91.3 (31.4)	10.4 (11.0)	1.23 (0.34)	0.28 (0.05)	259.3 (92.2)	10.16 (6.79)	3.10 (1.94)	280.9 (84.8)	75.6 (14.9)	11.33 (4.11)
6	94.9 (22.7)	10.0 (9.3)	1.12 (0.26)	0.26 (0.05)	259.8 (73.3)	9.84 (6.59)	2.81 (1.43)	278.9 (65.8)	75.8 (13.6)	11.38 (3.36)
7	96.2 (25.3)	10.8 (8.7)	1.16 (0.53	0.26 (0.04)	255.1 (72.9)	10.66 (6.69)	2.74 (1.40)	277.6 (74.1)	83.4 (12.9)	11.12 (3.76)
8	102.4 (24.2)	11.9 (8.8)	1.03 (0.24)	0.26 (0.04)	254.4 (77.1)	10.96 (7.00)	2.48 (1.48)	280.2 (77.1)	88.6 (10.5)	10.32 (3.81)
9	98.5 (24.1)	11.0 (8.8)	1.07 (0.25)	0.26 (0.04)	250.3 (75.3)	10.28 (6.60)	2.63 (1.49)	263.5 (72.8)	79.4 (13.0)	10.84 (3.62)
10	97.0 (28.0)	10.1 (7.4)	1.11 (0.28)	0.26 (0.04)	258.6 (83.7)	10.14 (6.04)	2.83 (1.68)	282.0 (76.0)	86.0 (7.6)	11.06 (3.78)
Overall mean	94.18 (27.2)	10.34 (9.2)	1.15 (0.33)	0.27 (0.05)	254.9 (79.0)	10.18 (6.52)	2.82 (1.65)	274.5 (75.7)	79.4 (15.2)	11.17 (3.72)
ANOVA p value	< 0.001	0.19	< 0.001	< 0.001	0.026	0.49	< 0.001	0.004	< 0.001	< 0.001

Table 4. Scheffe post-hoc test results. Comparisons shown indicate significant differences at the $p < 0.10$ level.

FIX	REG	SPAN	DUR	RATE WITH COMP	DIR ATTACK	REL EFFIC	ADJ READ RATE	%COR	GRADE
1 vs 8-10	None	1 vs 8, 9 5 vs 8	1 vs 6-10 2 vs 6-10 3 vs 6-10 4 vs 6-10 5 vs 6-10	None	None	1 vs 8 1 vs 9	None	1 vs 4, 7, 8, 10 2 vs 8, 10 3 vs 8 5 vs 8, 10 6 vs 8, 10	1 vs 8

Table 5. Correlation matrix for data from the 500 trials for all subjects and paragraphs. All correlation values are Spearman rho coefficients that have been corrected for ties.

	FIX	REG	SPAN	DUR	RATE WITH COMP	DIR ATTACK	REL EFFIC	ADJ READ RATE	%COR	GRADE
FIX	1.00									
REG	0.73	1.00								
SPAN	-0.94	-0.72	1.00							
DUR	0.13	0.37	-0.13	1.00						
RATE WITH COMP	-0.85	-0.77	0.85	-0.59	1.00					
DIR ATTACK	0.55	0.96	-0.55	0.42	-0.66	1.00				
REL EFFIC	-0.94	-0.82	0.93	-0.40	0.96	-0.68	1.00			
ADJ READ RATE	-0.78	-0.65	0.77	-0.56	0.92	-0.54	0.88	1.00		
%COR	0.16	0.03	-0.16	-0.10	-0.07	-0.02	-0.10	-0.05	1.00	
GRADE	-0.95	-.082	-0.94	-.039	0.97	-0.68	1.00	0.89	-.010	1.00

Table 6. First to second session correlation and split-half reliability coefficients for all paragraphs and coefficients calculated by omitting data from paragraphs 1 and 6. This omission was done to eliminate any "first trial" effects in each session.

	ALL PARAGRAPHS		OMIT PARAGRAPHS 1 AND 6	
	CORRELATION COEFFICIENT	SPLIT-HALF RELIABILITY	CORRELATION COEFFICIENT	SPLIT-HALF RELIABILITY
FIX	0.59	0.74	0.61	0.76
REG	0.55	0.71	0.56	0.72
SPAN	0.52	0.69	0.52	0.69
DUR	0.69	0.82	0.72	0.84
RATE WITH COMP	0.78	0.88	0.81	0.90
DIR ATTACK	0.61	0.76	0.63	0.77
REL EFFIC	0.71	0.83	0.75	0.86
ADJ READ RATE	0.77	0.87	0.79	0.88
%COR	0.15	0.26	0.15	0.26
GRADE	0.71	0.83	0.72	0.85

Table 7. Spearman rho correlation coefficients for OAT Reading Comprehension Sub Test scores versus Visagraph II scores. Probability values indicate whether the correlation coefficient is significantly different from zero.

OAT Score versus:	Spearman rho	Probability value
FIX	-0.14	$p > 0.05$
REG	-0.20	$p > 0.05$
SPAN	0.13	$p > 0.05$
DUR	-0.36	$p < 0.05$ (Significant)
RATE WITH COMP	0.25	$p > 0.05$
DIR ATTACK	-0.20	$p > 0.05$
REL EFFIC	0.22	$p > 0.05$
ADJ READ RATE	0.26	$p > 0.05$
GRADE	0.20	$p > 0.05$
%COR	0.40	$p < 0.05$ (Significant)

Figure Legends

Figure 1. Visagraph II system showing goggles and computer connection box.

Figure 2. Subject wearing Visagraph II goggles reading Taylor paragraph.

Figure 3. Example output page printed by Visagraph II system.

Figure 4. Scatterplots for Visagraph II data showing relationships of other variables to fixations.

Figure 5. Scatterplots for Visagraph II data showing relationships of other variables to grades.

Figure 1

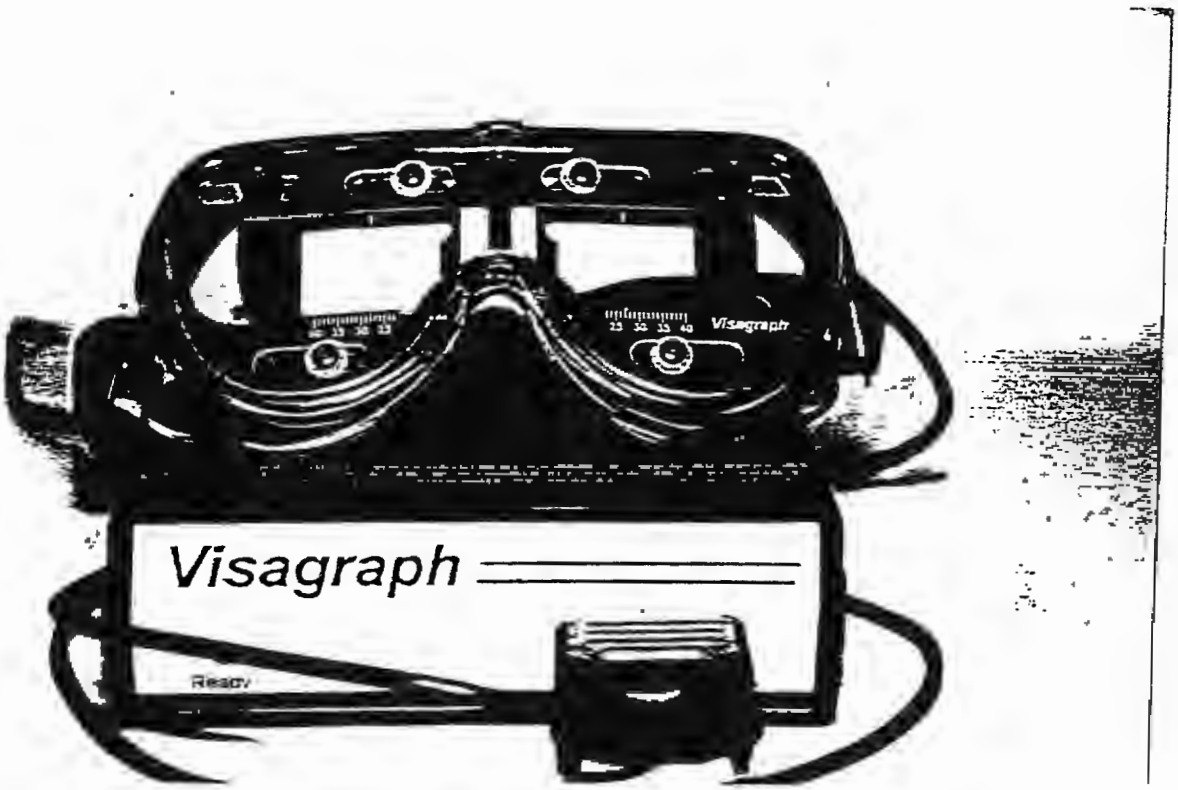
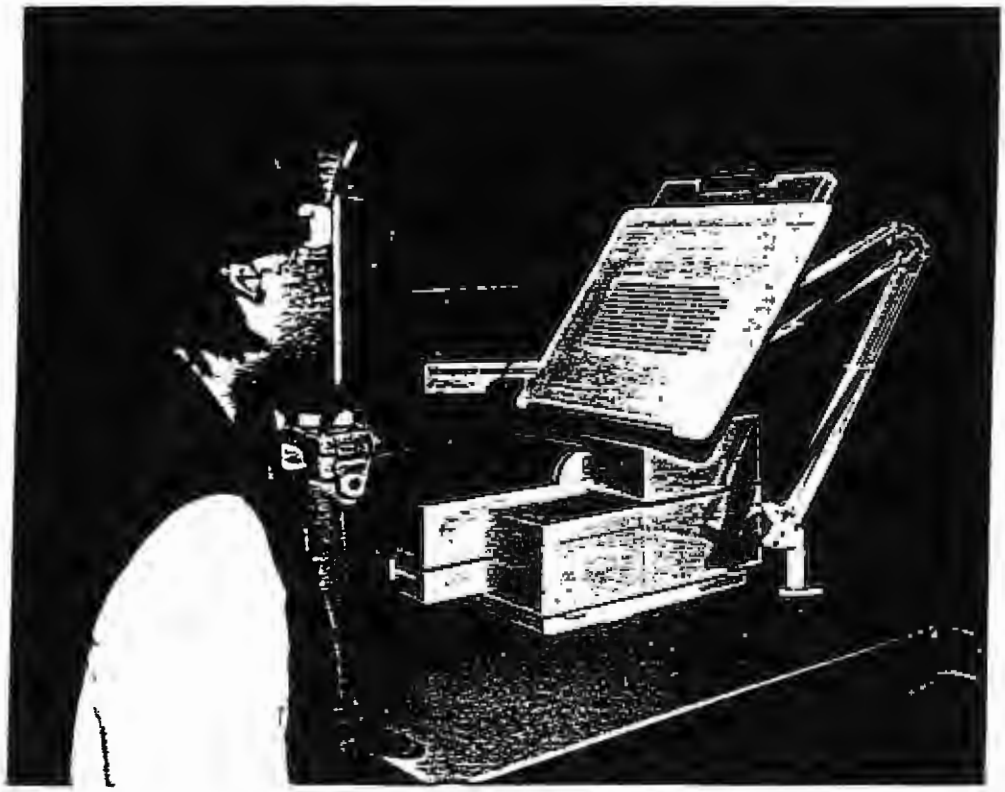


Figure 2

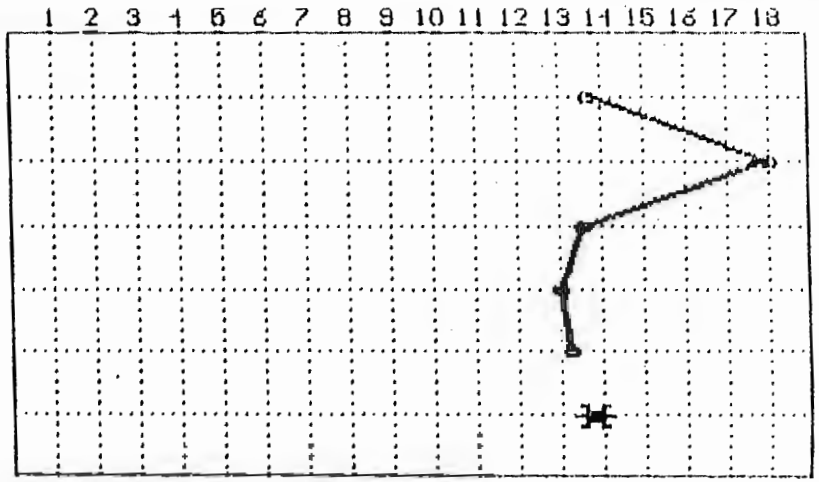


Reading Profile Visagraph

Grade/Goal

	Left	Right
Fixations/100 words	81	80
Regressions/100 words	1	1
Av. Span of Recognition (words)	1.23	1.26
Av. Duration of Fixation (sec)	0.24	0.25

Rate with Comprehension (words/min)	298
Relative Efficiency	3.63
Grade Level Equivalent	13.8
Directional Attack	1%
Rate adj. for Rereading (words/min)	298
Comprehension Questions Correct	80%
Cross Correlation	0.986



Countable lines in text	10
Lines found	9
Saccades in Return Sweeps	11

Comments

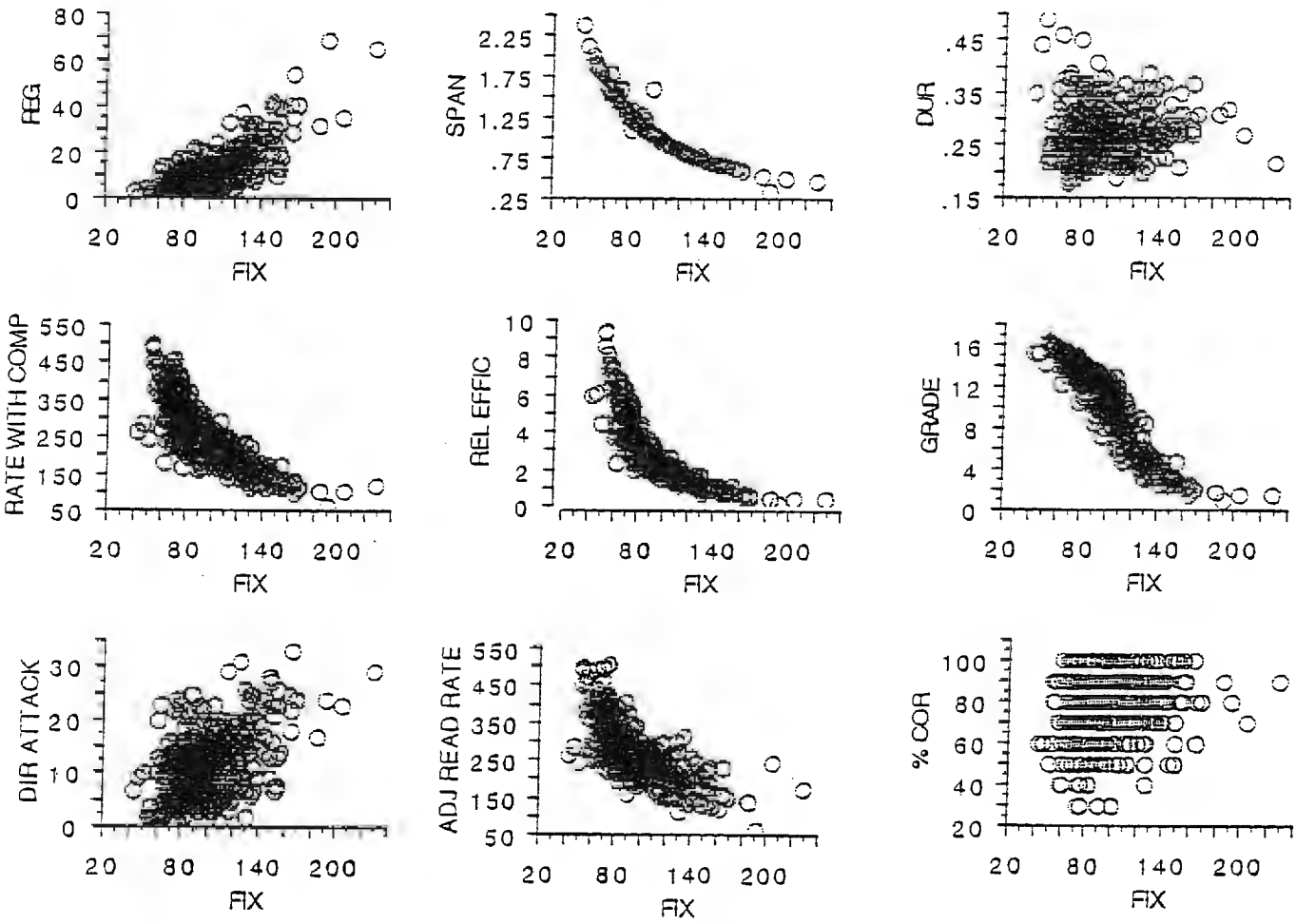
ESC - back to Main Menu
F1 - help
PrtScr - Print page

Name :
Class : 10
School : PUCO

File : SMR-81-1 Text : T--7--81
Title : Cyrus McCormick 7-81

Figure 3

Figure 4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40
20
0
20 80 140 200
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SPAN
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1.75
1.25
.75
.25
20 80 140 200
FIX
DUR
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FIX
RATE WITH COMP
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FIX
REL EFFIC
10
8
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4
2
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FIX
GRADE
16
12
8
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0
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DIR ATTACK
30
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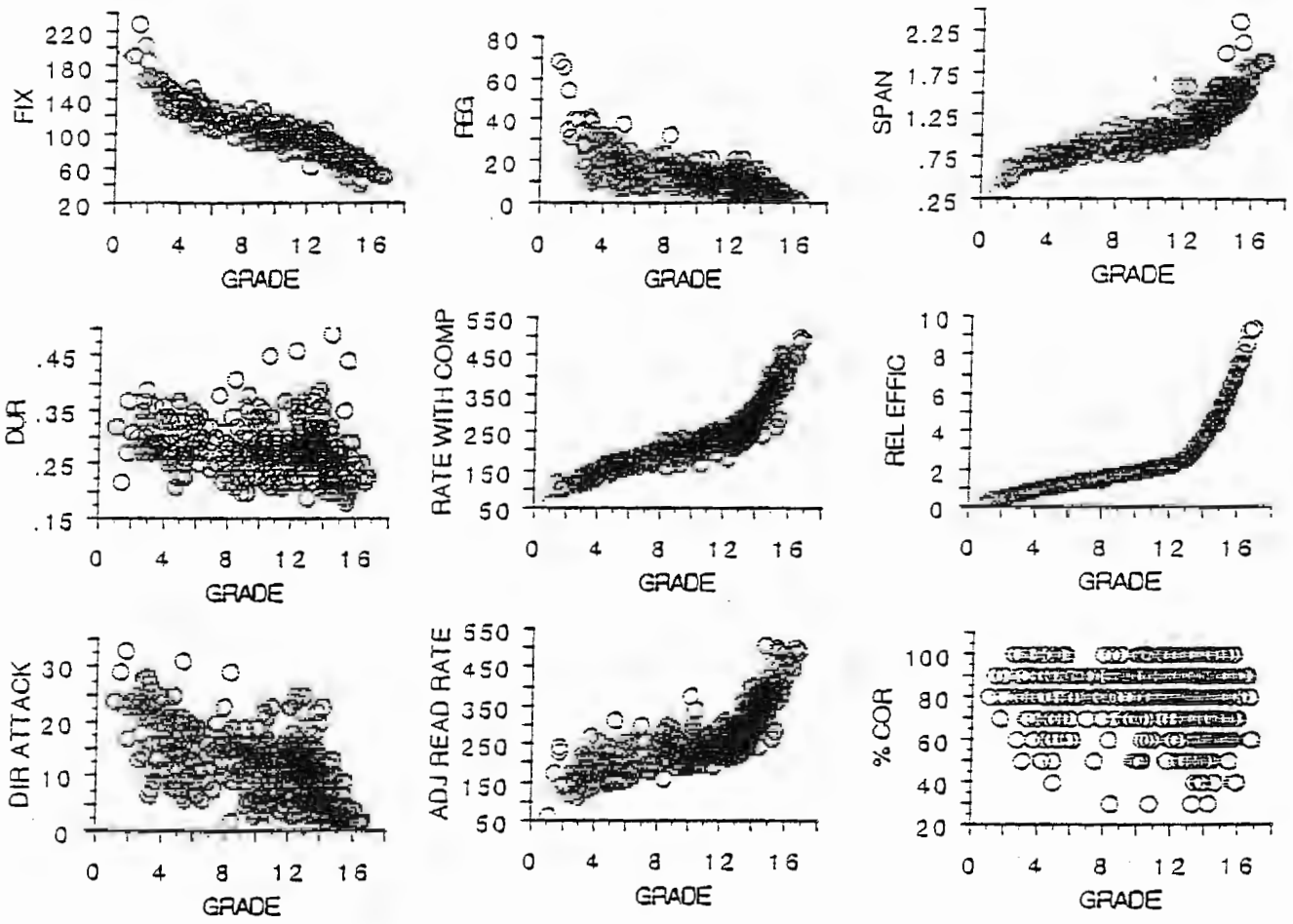
20 80 140 200
FIX
ADJ READ RATE
550
450
350
250
150
50
20 80 140 200
FIX
% COR
100
80
60
40
20
20 80 140 200
FIX

Figure 5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140
100
60
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0 4 8 12 16
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0 4 8 12 16
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GRADE