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Description
This study sought to investigate the effectiveness of an on-line computerized eye movement training program in improving reading eye movement skills and reading comprehension in adult readers. Subjects were divided into two groups: the experimental group received 10 weeks of on-line computerized eye movement training, while the control group received no training. Subjects who completed the training program demonstrated improved reading eye movements, without appreciable change in reading comprehension. There were few or no changes in targeted variables with control group subjects. The use of the on-line computerized eye movement training program shows promise as a tool to enhance oculomotor efficiency with adult readers. Additional research incorporating a more diverse and larger sample size will be needed to confirm this finding.

Disciplines
Optometry

Effectiveness of an On-line COMPUTERIZED EYE MOVEMENT TRAINING Program to Improve Oculomotor Control in Adult Readers: A PILOT STUDY

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Abstract

This study sought to investigate the effectiveness of an on-line computerized eye movement training program in improving reading eye movement skills and reading comprehension in adult readers. Subjects were divided into two groups: the experimental group received 10 weeks of on-line computerized eye movement training, while the control group received no training. Subjects who completed the training program demonstrated improved reading eye movements, without appreciable change in reading comprehension. There were few or no changes in targeted variables with control group subjects. The use of the on-line computerized eye movement training program shows promise as a tool to enhance oculomotor efficiency with adult readers. Additional research incorporating a more diverse and larger sample size will be needed to confirm this finding.

Key Words

duration of fixation, eye movement recording, fixations, oculomotor control and skills, PA/VE, reading comprehension, regressions, Taylor Reading Plus Program™, span of recognition, words/minute, Visagraph II, web-based computerized eye movement training

Introduction

Previous literature has documented improvement in eye movements, oculomotor skills and reading comprehension with eye movement therapy.[1-6] Solan investigated computer-based eye movement and reading training program intervention with elementary school children who had reading difficulties. He reported improved eye movements, as evidenced by eye movement recordings, along with significant gains in reading comprehension.[5]

Okumura investigated whether vision therapy (VT) and home-based computerized eye movement training could improve oculomotor skills during reading.[6] Eighteen Japanese-speaking college students, who were normal readers, served as subjects and were divided into three groups: a VT group, a Computerized Eye Movement Training (CEMT) group, and a control group. Subjects in the VT group received full-scope, traditional, office-based VT that included computerized eye movement training. CEMT subjects received five weeks of entirely home-based computerized eye movement training without traditional VT. Subjects in the control group received no intervention. For his study, Okumura created a software program that was similar to the program Solan had used. This program required participants to count the appearances of a specific digit or letter while following a left-to-right sequential presentation of three equally spaced characters per line on the screen. The procedure started at 40 lines per minute and ultimately reached 120 lines per minute. Analysis of eye movement recordings indicated no improvement in the control group. Significant and nearly equal improvement were found for both the VT and CEMT groups for all Visagraph II (see Materials section below) measurement parameters, except for duration of fixation and reading comprehension. In these two findings, the VT group's results were better.

The purpose of the present study was to investigate the effectiveness of a web-based computerized eye movement training program in improving the eye movements, other oculomotor skills, and reading comprehension in a sample of normal reading adults.

Materials

The newly developed on-line web-based version of the Taylor Reading Plus software was used for this study (Taylor Associates, 200-2 East 2nd Street, Huntington Station, New York 11746). Reading Plus is composed of several elements. "Appraisals" is initially used to determine the subject's reading level for the "Core" (training) programs. The training programs are Perceptual Accuracy/Visual Efficiency (PA/VE) and Guided Reading.[7]

The Appraisal programs consist of the Visagraph II System (available from Taylor Associates) and the Reading Placement Appraisal (RPA).[8] The Visagraph II is an eye-movement recording system that measures several essential elements of reading eye movements, including efficiency. It has been described by Taylor Associates as measuring the "Fundamental Reading Process," which includes visual/functional proficiency, perceptual development and information processing competence.[9] The Visagraph II is also

claimed to assess reading efficiency, to evaluate and provide corrective instruction for difficulties in visual perception, reading fluency and visual/functional difficulties. The instrument samples eye-movement position 60 times per second, and automatically computes and analyzes various reading performance measures.[8]

The RPA is a three-part computerized appraisal that determines the most appropriate level of reading instructional content and automatically places subjects into the appropriate Taylor Reading Plus programs.[7] RPA can be completed by a subject in 20-30 minutes. Each subject's performance is available in either display or printout form, and indicates the independent reading level, usual reading rate, comprehension, vocabulary study level, perceptual memory readiness and decoding competence.

The Core programs (PA/VE and Guided Reading) purportedly develop "the most basic skills essential to fluent, silent reading and all learning and vocational needs." According to Taylor Associates, PA/VE develops (through scanning and flash activities): attention/concentration, improved visual skills, effective directional attack, rapid, accurate and orderly seeing, and a strong visual memory. Similarly, Taylor Associates describe Guided Reading as developing fluency (efficiency) in the most basic reading processes (visual/functional, perceptual and information processing), resulting in ease and comfort, adequate reading rates and improved comprehension. Timed and left-to-right scanned reading improves the subliminal reading capabilities that comprise the fundamental reading process and increases the potential for flexibility in reading.[7]

Subjects

Thirty optometric students between the ages of 23 and 38, and 10 non-optometric students initially volunteered as subjects for our study: 26 were males (mean age, 26.1 years; SD, 6.0) and 14 were females (mean age, 22.0 years; SD, 1.9). Each subject demonstrated at least 20/30 near Snellen equivalent at 40 centimeters (with correction if required). Permission to conduct this study was obtained from the Pacific University Institutional Review Board and all subjects signed Informed Consent Documents. All participants initially denied ever having been diagnosed as reading disabled or dyslexic, and all read at a level sufficient to have completed college in the U.S. However, only five subjects, age 24 to 35 (mean age, 26.0 years; SD 4.5) completed the PA/VE and Guided Reading training. Additionally, only three control subjects (mean age, 25.3 years; SD 0.58) completed the requisite Visagraph II evaluations within the prescribed 12-week time limit needed to match control subjects with experimental subjects.

Methods

This study was designed to compare two groups of subjects; a computerized eye movement training (CEMT) group and a matched control group. Group assignment was not random, although randomization had been a goal prior to the study. At the outset, all of the students who indicated interest in our study were asked whether they would be willing to commit the necessary time to complete the Reading Plus training. Because only 20 subjects initially agreed to this commitment, they were arbitrarily assigned to the experimental group. The remaining subjects who agreed only to have Visagraph II evaluations at the beginning and end of the 12-week study period were assigned to the control group.

Experimental subjects were assigned 10 weeks of on-line, web based computerized eye movement training designed to enhance reading and eye movement skills. Subjects in the control group received no intervention, other than diagnostic evaluations. Both control and experimental subjects had their reading eye movement skills evaluated at the beginning and end of the 12-week study period with the Visagraph II. Data from both groups were analyzed for: fixations, regressions, span of recognition, duration of fixation, reading rate with comprehension, and reading comprehension; the latter was determined by the number of the correct answers to the 10 comprehension questions following the eye movement recording.

Visagraph II Evaluation

After an orientation to the Taylor Visagraph II system, each subject was comfortably seated and asked to hold the Taylor text 40 centimeters from the eyes at an angle of approximately 30 degrees downwards from primary gaze. Goggles were placed over the subject's near correction (when indicated) and the interpupillary distance was adjusted by centering the pupils through the apertures while subjects viewed a near target.[8]

Three separate Visagraph II recordings were measured for each subject at each evaluation session.[11] To enhance reliability, we mimicked past Visagraph II studies[1,12-15] by not including the first measurement (trial) from each evaluation session in our data analysis. Instructions to each subject followed the specified protocol listed in the Visagraph II Manual.[8] Each subject read three different 100-word, Level 10 (college level) Taylor paragraphs from the Visagraph II reading selection book. Because optometry students are familiar with the topic of Braille, the Braille story was excluded. After reading each story, subjects answered 10 comprehension questions. Although the Visagraph II Instruction Manual specifies a 70 percent comprehension threshold, recordings were accepted if at least six questions were correctly answered for the reading passage. An additional recording with a different story was added when comprehension was below 60 percent. A trial reading selection was necessary to validate the reading level as well as to familiarize the subjects with the "feel" of the goggles. The trial story was read either silently or aloud. Subjects were directed to read the second selection silently. Eye movement recordings from the last two readings were collected and analyzed.

Reading Placement Appraisal

Protocol for computerized training procedures closely followed those specified in the Reading Plus user's manual. Subjects in the experimental group received written instructions on how to log on to the PA/VE and Guided Reading programs.[7] Following orientation to the Taylor Reading Plus system, subjects were then required to log on to the Reading Plus website. They then completed a Reading Placement Appraisal (RPA). RPA results served as a benchmark to place subjects in an appropriate reading improvement course of study. The RPA consists of Content Level/Rate Determination, Comprehension Level, and Vocabulary Level. See Appendix A for Visagraph II and RPA further information.

PA/VE and Guided Reading Training

Following RPA, subjects were individually assigned to their appropriate

level of PA/VE and Guided Reading training. See Appendix A and B for descriptions. The five experimental group subjects finished their training within the prescribed 10-12-week study period.

Subjective Questionnaire

Following the 10-week training program, performance questionnaires (via telephone) were administered to determine whether there were subjective benefits from the training. Training participants were asked if they had noticed any changes related to: reading rate improvement, reading comprehension, ease of reading, or reading efficiency after 10 weeks of training. Subjects were asked to rank any subjective changes noted in these behaviors on a five-point scale. The five-point scale ranged from 1=Strongly Agree, 2=Agree, 3=Neutral, 4=Disagree, to 5=Strongly Disagree. (See Appendix C.)

Results

Visagraph II

Table 1-1 summarizes the raw scores for the experimental subjects pre and post training; Table 1-2 does so for the control subjects. The tables depict fixations, regressions, span of recognition, and duration of fixation for each eye. The similarity of values comparing right to left eyes indicates good general consistency for the measurements. The bottom two rows of each table summarize reading rate, and relative reading efficiency data for each subject. Note that in table 1-1, pre-intervention eye movement performance of experimental subjects 1, 2, and 4, were well below college level, and that the magnitude of the post-intervention improvement for subjects 3 and 5 is more modest.

Table 2 summarizes group mean scores before and after testing for both the experimental and control subjects. Pre-intervention means for the experimental group are poorer than the Taylor norms, but nearly on par following the training. Greater mean improvement is seen in all Visagraph II measurement categories for the experimental group than with the control group.

Table 3 presents the pre-post percentage changes for individual subjects in both groups (post-Visagraph minus pre-Visagraph, divided by pre-Visagraph, times 100). Also included in these tables are results from the Visagraph II reading comprehension test that was administered after each eye movement recording. Comparison of experimental to control subjects highlights the impressive double-digit percentage improvement with experimental subjects compared to smaller changes seen with the controls. With experimental subjects 1, 2, and 4, notice that the grade level efficiency gain is much greater than for experimental subjects 3 and 5.

For statistical analysis, our hypothesis was that all experimental subjects would demonstrate improvement in Visagraph II scores after the Reading Plus intervention, and that mean improvement would be sig-

Table 1-1. Visagraph II raw scores for the experimental subjects before and after ten weeks of on-line Reading Plus training. Left and right refer to each eye.

	Subject 1		Subject 2		Subject 3		Subject 4		Subject 5	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
FIX Left	140	116	98	94	65	63	134	109	78	69
FIX Right	142	115	97	94	65	64	130	114	77	70
REG Left	12	12	17	6	5	3	16	7	5	1
REG Right	17	12	16	6	4	3	17	9	5	1
SPAN Left	0.71	0.86	1.02	1.06	1.54	1.59	0.75	0.92	1.28	1.45
SPAN Right	0.70	0.87	1.03	1.06	1.54	1.56	0.77	0.88	1.30	1.43
DUR Left	0.28	0.27	0.25	0.22	0.40	0.22	0.31	0.30	0.21	0.20
DUR Right	0.27	0.26	0.25	0.22	0.40	0.27	0.31	0.30	0.21	0.20
RATE	151	180	246	283	228	341	144	169	320	401
GRADE	4.1	6.9	8.3	13.1	13.5	14.1	4.2	6.6	13.7	15.1

Table 1-2. Visagraph II raw scores at the beginning and end of the 10-week study period for the three control subjects

	Control Subject 1		Control Subject 2		Control Subject 3	
	Pre	Post	Pre	Post	Pre	Post
FIX Left	107	104	88	87	115	111
FIX Right	107	105	88	87	114	110
REG Left	17	15	2	2	25	26
REG Right	21	16	2	2	28	26
SPAN Left	0.93	0.96	1.14	1.15	0.87	0.90
SPAN Right	0.93	0.95	1.14	1.15	0.88	0.91
DUR Left	0.31	0.31	0.22	0.22	0.34	0.31
DUR Right	0.31	0.31	0.22	0.22	0.34	0.31
RATE	177	180	302	305	154	155
GRADE	6.7	6.8	13.6	13.6	4.9	5.0

Table 2. Taylor National Norms[6] and the Mean scores in this study of the five experimental and three control subjects (right and left data combined to calculate means)

	Taylor National Norms	Mean Scores Pre-Training (experimental)	Mean Scores Post-Training (experimental)	Mean Scores Pre-10wks (control)	Mean Scores Post-10wks (control)
Reading Level Demand	College level	College level	College level	College level	College level
Fix/100 words	90	102.6	90.8	103.2	100.7
Regress/100 words	15	11.4	6.0	15.8	14.5
Span of recognition	1.11	1.06	1.17	0.98	1.00
Duration of fix	0.24	0.29	0.25	0.29	0.28
Rate with comprehension (words/min)	280	217.8	274.8	211	213.3
Grade level efficiency		8.8	11.2	8.4	8.5

nificantly different from zero. Table 4 summarizes pre-post t-test results (one-tailed). Improvement was significant for fixations, regressions, reading rate, and reading grade level efficiency. Significance with such a small sample was indeed surprising; the smaller the sample size, the larger the effect needed to reach significance.

A non-standardized post-hoc performance questionnaire (via telephone) was administered to all five experimental group subjects to gain a sense whether subjective change was perceived, and whether benefits seemed to transfer to reading skills from the 10 weeks of on-line training. The responses from that survey are presented in Table 5.

As seen in Table 5, all experimental subjects acknowledged improvements in one or more oculomotor skills parameters following the training. The category judged as least improved was duration of fixations. Most subjects were also unable to perceive any improvement with span of recognition. These questionnaire results should be interpreted with some caution, because it is believed that the average reader cannot subjectively sense most of the skills listed in Table 5. It is also conceivable that 10 weeks of training devoted mostly to eye movements increased sensitivity to those specific skills.

Table 3. Percentage change in Visagraph II scores following ten weeks for the experimental and control subjects (right and left eye data combined)

	Exp. Subj. 1	Exp. Subj. 2	Exp. Subj. 3	Exp. Subj. 4	Exp. Subj. 5	Control Subj. 1	Control Subj. 2	Control Subj. 3
FIX	-18.1%	-3.6%	-2.3%	-15.5%	-10.3%	-2.3%	-1.1%	-3.5%
REGRESS	-17.2%	-63.6%	-33.3%	-51.5%	-80%	-18.4%	0%	-1.9%
SPAN OF RECOG	18.6%	3.4%	2.3%	18.4%	11.6%	2.7%	0.9%	3.4%
DURATION OF FIX	-3.6%	-12%	-38.8%	-3.2%	-4.8%	0%	0%	-8.8%
RATE W/ COMPREHEN	19.2%	15.0%	49.6%	17.4%	25.3%	1.7%	1.0%	0.6%
CORRECT ANSWERS	39.3%	0%	0%	0%	11.1%	-3%	0%	-5%
GRADE LEVEL EFF.	68.3%	57.8%	4.4%	57.1%	10.2%	1.5%	0%	2.0%

Table 4. One-group t-test results for pre-post mean Visagraph II differences (experimental subjects only).

	mean	DF	t-Value	P-Value
Fixations pre-post	6.4	4	2.61	0.030*
Regressions pre-post	2.6	4	2.50	0.034*
Duration of fixation	0.02	4	1.45	0.111
Reading Rate pre-post	57.0	4	3.31	0.015*
Grade level efficiency pre-post	2.4	4	3.37	0.014*

Table 5. Self-assessment of subjective improvement after ten weeks of on-line training by the five experimental subjects

	Subject 1	Subject 2	Subject 3	Subject 4	Subject 5
FIXATION	1	2	2	1	1
REGRESSION	1	1	2	2	1
SPAN OF RECOGNITION	3	2	3	3	3
DURATION OF FIXATION	4	3	4	4	3
RATE WITH COMPREHENSION	2	2	1	2	1
CORRECT ANSWERS	2	3	3	3	2
1=Strongly Agree; 2=Agree; 3=Neutral; 4=Disagree; 5=Strongly Disagree					

Discussion

Reading is an intricate ensemble of neurological processes that requires, but is not limited to: recognition, decoding, phonological and syntactic awareness. Skillful reading requires a very high level of visual functioning and eye movement efficiency.[1] The eyes must very precisely navigate a sea of symbols for meaning to be derived from the words. The ability to do so skillfully improves with both maturation and practice, but it appears to plateau during the college years.[9] Intuitively, with adult readers and, presumably, skilled eye movers such as optometry students, one would not expect a great deal of improvement because these subjects would be near their normative developmental plateau for eye movement efficiency in accordance with the Taylor norms.

A goal of this study was to investigate whether adult students would demonstrate eye movement efficiency improvement as a result of on-line Reading Plus participation. Interestingly, even given the limited number of participants, our results are suggestive of eye movement improvements. The objective data strongly suggested improvements in nearly all reading eye movement characteristic categories (fixations, regressions, reading rate, and reading grade level efficiency). In addition, this improvement effect was also suggested by the responses to a subjective questionnaire related to "noticeable effects" following the on-line training. All five subjects felt there were improvements in one or more parameters of their eye movements or oculo- motor skills following the training.

An intriguing follow-up question is whether high functioning adult readers can indeed benefit from the Reading Plus training as much as adults who read well below their age and educational achievement level. A second interesting question is why two of the experimental subjects and two of the control subjects in this study possessed such underdeveloped reading eye movement patterns, even after having graduated from college. Recall that the pre-intervention scores for experimental subjects 1 and 4 resembled those of elementary schoolchildren; subject 2's pattern was similar to that of a middle school child, while subject 3 and 5 were at college level. Retrospective background information for the five experimental subjects yielded some clues.

To help shed light upon the second question, Optometry Admission Test (OAT) Reading Comprehension Test scores were obtained retrospectively for the five experimental subjects, and for two of the control subjects. These scores are derived from the percentage of correct an-

swers to a 50-question test based upon three separate 1200-1500 word passages read before the questions. Respective standard scores for the five experimental subjects were: 320, 350, 330, 210, and 250 (200-400 point scale). These ability scores correspond to the following national percentiles: 70, 90, 78, 1.4, and 11, respectively. Matching percentile scores were available for only two of the control subjects: 80th percentile, and 97.8th percentile (340, and 380). Although these OAT Reading Comprehension Test scores were gathered more than three years prior to the present study, on the surface they do not appear to predict Visagraph II reading efficiency performance—with the possible exception of experimental subject 4. A plausible explanation for this lack of correspondence may relate to differing strategies employed for each task. Put another way, a mature reader may possess the capacity for both excellent comprehension and efficiency, but not be able to successfully deploy both on a given task.

Follow-up questioning with the experimental subjects revealed that English was the second language for both experimental subjects 1 and 5. Although English as a second language may have contributed to reduced reading efficiency with subject 1, subject 5 demonstrated admirable efficiency in spite of having learned English during the teenage years and scoring relatively poorly on the OAT reading test. Following the training, subject 4 admitted to a long educational history of reading difficulty (after initially denying it). Given subject 4's history, slow reading rate, and the long average durations of fixations both pre and post, it would not be surprising if multidimensional decoding and binocular problems turned up with further testing.

Do adults with poor eye movement efficiency skills gain more from Reading Plus training than adults whose scores are near normal to begin with? Reasonably, one could make an argument that poorer adult readers (well below the normative plateau) would have "more room" to grow as a result of training. A cursory glance at Table 3 would seem to imply that subjects 1, 4, and 5, showed double digit percentage improvements in the most categories, however, subject 5 had the best overall efficiency prior to the training. The best overall indicator of improvement should be "grade level relative efficiency" score because it is derived from the performance categories documented with the strongest developmental trends (reading rate divided by the sum of fixations and regressions).[8] Based upon the relative efficiency scores alone, subjects 1, 2 and 4 improved most, supporting the notion that poorer readers to begin with will benefit more than better readers. Even so, subjects with good reading eye movement skills beforehand can significantly benefit from Reading Plus training. Subject 3, who had the second best pre-intervention skills, showed a reading rate increase from 228 to 341 words per minute; a speed improvement of nearly 50 percent without a loss of comprehension. Further research will be needed to develop profiles of those likely be most helped by the training. Important future questions for optometry are: can the benefits of Reading Plus be amplified with the addition of traditional optometric VT for individuals with binocular and perceptual inefficiencies? Which therapy should be administered first, or should they be combined?

Previous research from both clinical and laboratory settings has indicated that eye movement therapy results in improved eye movements and oculomotor skills.[3-6] As mentioned before, Solan reported significant improvements with elementary school children using a non-web-based version of these computer programs.[5] Likewise, Okumura reported similar improvements with a group of Japanese college students using a program very similar to the one used by Solan.[6] The current pilot study was designed to investigate whether those potential effects could be replicated with web-based on-line PA/VE and Guided Reading training with non-reading disabled adult readers, specifically, a group of optometry students. A notable distinction between this study and those previously mentioned is that for each training computer session, our experimental subjects were required to log on the web and/or to download the appropriate PA/VE and Guided Reading programs to their personal computers from the Taylor Associates website. Subjects in this study were given scheduling recommendation guidelines, and general information on how to complete their individual training; however, they were free to log on whenever it was convenient for them to do so and complete their training sessions.

Was the on-line web-based Reading Plus Program user friendly? It was certainly convenient. Several subjects volunteered positive feedback about being able to do therapy when it best fit into their schedule. None of our five subjects reported any difficulty logging on the website or doing the therapy, with either a broadband or dial-up modem connection. From the researcher's perspective, we had no difficulties in accessing the website to use our administrator privileges to monitor training compliance and subject performance. This feature that allows the administrator to monitor the progress of subjects who are in training could prove to be an attractive benefit to the private practice doctor using this system in the future.

The most serious and frustrating limitation of this pilot study was the small sample size. Originally, 30 subjects agreed to participate in this study. Experimental subjects were asked to systematically log on-line (a minimum of 40 times over 10 weeks) and complete the PA/VE and Guided Reading programs, plus complete pre and post training Visagraph II assessments within the designated 12-week time limit. Although 30 subjects completed the pre-training Visagraph II measurements and agreed to do the PA/VE and Guided Reading training, only five followed through and completed the training. In addition, only three control subjects were available for Visagraph II assessment after the 12-week time window of the study.

Why did so few subjects who agreed at the beginning of this study to do the training, not follow through? In all likelihood, the meager incentive we offered for participation was insufficient to generate the enthusiasm necessary to follow through. Our primary incentive was the possibility of better intrinsic eye movements and reading skills. This may not have been perceived as a fair exchange for 40 sessions (10 weeks) of training time in the minds of busy optometry students.

Our second mistake was to limit our sample to third-year optometry students during the spring semester. During spring semester, most third-year Pacific University College of Optometry students are very busy finishing the classroom requirements of their last didactic year in professional school, plus senior thesis projects. In addition, third-year students are also preparing to move to different preceptor-

ship sites around the country. At a large number of these sites, there was no Internet access, so students there on preceptorship were unable to log onto the Taylor Associates web site and complete the on-line training. In retrospect, if we were to repeat this study, we would offer better incentives for participation, alter our recruiting strategy, and chose subjects whose on-line training could be more easily, carefully, and effectively be monitored.

However, while the number of participants in this study was limited, the objective and subjective results beg further investigation. This study should first be expanded to include a larger and more diverse sample of non-reading disabled adults to see whether the "improvement effect" demonstrated in this preliminary investigation of only optometry students, is in fact repeatable. Ideally, future studies should include a sample population that more closely mirrors the actual demographics of adult readers in the U.S. If reading eye movement improvement is possible with developmentally mature eye movers via PA/VE and Guided Reading programs with non-reading disabled adults, then logically its use with poor adult readers and reading disabled adults should investigated as well.

Based upon this pilot study, we believe that web based, on-line, PA/VE and Guided Reading therapy programs show great promise as a tool for improving eye movement efficiency and reading skills with adults motivated to complete the requisite training. Additional and more comprehensive studies are strongly recommended to confirm or disprove this premise.

The authors have no fiscal or proprietary interests in any of the instruments, computer programs or materials used in this study.

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Appendix A

Accessed from website:
www.readingplus.com

RPA and Visagraph II

Reading Plus® provides two unique assessment tools that can be used for placement within the Reading Plus® instructional programs in addition to providing ongoing assessment of student progress during their instructional course work.

RPA™ (All levels)

Reading Placement Appraisal is the first step for students as they enter the Reading Plus® System. RPA™ can be administered to a class of students in 20-30 minutes. This assessment determines each student's independent reading level, silent reading rate and vocabulary level, and prescribes the instructional programs and content levels that will be most beneficial for each student's individual needs.

VISAGRAPH IIIâ(All levels)

The Visagraph® Eye-Movement Recording System provides a detailed measurement of the efficiency of students foundational silent reading fluency skills which determine the effectiveness of all reading activities. It consists of a pair of goggles fitted with infra-red sensors that record the eye-movements of the reader as they read a short selection of text. The reports generated by the Visagraph® provide an objective measure of a student's existing reading ability, as well as the gains made during and after the completion of the Reading Plus® instructional programs.

Appendix B

Accessed from website: www.readingplus.com and www.ta-comm.com

PA/VE - Perceptual Accuracy/ Visual Efficiency

PAVE™ (All levels) – Develops perceptual accuracy/visual efficiency, the basic requisites for fluent silent reading.

Perceptual Accuracy (Flash) Training

Numbers or letters are flashed in tachistoscopic exposures of 1/10 second or more rapidly; subjects type in what they see. This training focuses attention and develops sustained attention; builds rapid, accurate and orderly seeing; as well as develops strong retentive visual memory.

Visual Efficiency (Scan) Training

Number or letters, widely spaced across a line, are scanned from left to right at progressively more rapid rates. Subjects respond or count each time a target element appears. This training develops effective left-to-right directional attack and ocular motility as well as improves binocular coordination and accuracy of fixation.

Guided Reading

Guided Reading™ (Levels1-adult) – Ensures development of basic visual and perceptual processes resulting in ease and comfort, increased reading rates and improved comprehension.

Guided Reading™ Paperback (Levels 1-3, children & adult)- Additional fluency development using Guided Reading™ with text from trade books providing high interest content.

In **Taylor's Guided Reading and Comprehension Power** approaches, there is strong emphasis on developing a wide diversity of comprehension skills. These skills are treated again and again in global inductive reading exercises and their accompanying question activities.

1. Literal Understanding
   - 1-1 Recalling Information and Details
   - 1-2 Following Sequence of Ideas or Events
   - 1-3 Identifying Speaker
2. Interpretation
   - 2-1 Main Idea
   - 2-2 Making Inferences
   - 2-3 Predicting Outcomes
   - 2-4 Drawing Conclusions
   - 2-5 Interpreting Figurative Language
   - 2-6 Visualizing
   - 2-7 Paraphrasing
3. Analysis
   - 3-1 Comparing and Contrasting
   - 3-2 Recognizing Cause and Effect
   - 3-3 Classifying
   - 3-4 Reasoning
   - 3-5 Identifying Analogies
4. Evaluation
   - 4-1 Detecting Author's Purpose
   - 4-2 Understanding Persuasion
   - 4-3 Recognizing Slant and Bias
   - 4-4 Distinguishing Between Fact and Opinion
   - 4-5 Judging Validity
   - 4-6 Determining Relative Importance
5. Appreciation
   - 5-1 Interpreting Character
   - 5-2 Recognizing Emotional Reactions
   - 5-3 Identifying Mood and Tone
   - 5-4 Identifying Setting

Appendix C

Self-assessment of subjective improvement after ten weeks of on-line training questionnaire

1. In your opinion, did the on-line computerized training program help to improve (reduce) your Fixations/100 words?
2. In your opinion, did the on-line computerized training program help to improve (decrease) your Regressions/100 words?
3. In your opinion, did the on-line computerized training program help to improve your Span of Recognition?
4. In your opinion, did the on-line computerized training program help to improve (reduce) your Duration of Fixation?
5. In your opinion, did the on-line computerized training program help to improve your Rate with Comprehension (words/min)?
6. In your opinion, did the on-line computerized training program help to improve (increase) the number of correct answers?

1. Strongly Agree
2. Agree
3. Neutral
4. Disagree
5. Strongly Disagree