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Curtailing the Reading Difficulties of International Students Through an Online Eye Training Interventions

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Abstract
Eye training interventions have been shown to improve reading skills of students. Investigators pondered about its effectiveness with developmental reading students in college who completed 122 online modules related to word reading speed and comprehension. Students not only increased their word reading speed to a statistically significant rate, but they also increased their comprehension rates of passages regardless of factors such as instructor of record, course time, or module completion time. Findings further depict the considerable relationship between eye movements and reading, prompting teachers to incorporate known eye training techniques to prepare struggling readers to be more efficient readers.

Reading proficiency remains stable nationwide despite a decade (and still counting) of the educational philosophies and standardized testing environment of No Child Left Behind. An influx of strategies and methods floods the academic literature in an attempt to remedy stagnant levels of reading comprehension (Duffy, 2003; Harvey & Goudvis, 2007; Pressley, Johnson, Symons, McGoldrick, & Kurita, 1989; Rosenshine & Meisier, 1992) and word reading ability (Perfetti, 2007; Rasinski & Padak, 2008; Walpole & McKenna, 2004) based on a variety of conceptual and theoretical constructs.

One university experiencing similar patterns of mediocrity explored whether collegiate students enrolled in a developmental reading course could increase reading speed while maintaining or increasing comprehension levels through the utilization of an eye training software program. Eye training programs are currently receiving renewed attention in the field of literacy education (Samuels, Rasinski, & Hiebert, 2011). Students struggling to read benefit from instruction in word reading and comprehension - both of which begin with eye recognition of words and cognitive processing of textual meaning.

Although comprehension is central to reading, information is processed only when the eye pauses with an eye fixation (Samuels, Hiebert, & Rasinski, 2010). By eliminating backward saccades or regressions, using rapid serial visual presentation of words, and utilizing tachistoscopic scroll presentation of words in eye training exercises (rapid flashing of words on computer screen), readers may increase the speed of visual processing and in turn, uptake of information (Rayner & Sereno, 1994; Taylor, 1971). Computer-based applications have been studied on a limited basis for training eye mechanisms in adults towards improving eye movement skills and reading comprehension (Laukkanen, 1995; Solan, 2001; Tran, Yu, Okumura, & Laukkanen, 2004). In an effort to continue the university’s mission in preparing students for career readiness, this study aimed to
evaluate the effect of the eye training program, AceReader Online, on developmental readers’ word reading and comprehension rates who were enrolled in a four-year regional university in South Texas.

Theoretical Framework

The current study relies on theories of oculomotor eye movements and their relationship to word reading and reading comprehension (Huey, 1968; McConkie, Kerr, Reddix, & Zola, 1988; Rayner, 1975/1983/1998; Samuels, Rasinski, & Hiebert, 2011; Woodworth, 1938). It is theorized that training the eye to recognize words in isolation faster can subsequently increase the rate of reading words in context. Tachistoscopic studies involving the brief exposure and isolated presentation of letters or words have long intrigued psychologists and reading researchers (Rayner, 1975). Just as teachers model fluent reading, tachistoscopic exercises provide a pacing tool for readers.

Direct Perception Theory assumes that readers fixate on identifying text rather than hypothesizing what will come next. Beginning readers use all of their cognitive capacity on word recognition and then switch their attention to comprehension (Samuels, Rasinski, & Hiebert, 2011). Recent discoveries indicate that information is processed only when the eye pauses within an eye fixation (Samuels, Hiebert, & Rasinski, 2010). Beginning readers first use cognitive capacities on word recognition, then on word decoding, and lastly on comprehension (Samuels, Rasinski, & Hiebert, 2011).

McConkie and Rayner (1974) established online computer techniques involving eye-tracking computer systems to investigate the relationship between eye movements and word reading. These applications were narrowly used for training eye mechanisms responsible for word recognition; the limited scope of these studies provides a rationale for investigating if collegiate readers in a developmental reading course can increase their reading speed and comprehension levels through an online eye training program.

Review of Literature

Ongoing Need for Developmental Reading Instruction

In 2007, the National Assessment of Adult Literacy in the United States reported that adult reading scores declined among all education levels. From 1992 to 2003, the proportion of U.S. college graduates who read at a proficient level declined from 40% to 31%. In 2004, almost 42% of all freshmen attending two-year public colleges enrolled in at least one developmental course (U.S. Department of Education, 2004). The Literacy of America’s College Students (2006) report confirmed that more than 50% of students at four-year colleges/universities did not score at the proficient level of literacy. Of the two million students who begin post-secondary education each year, 36% of undergraduate students were identified as needing a developmental education course in 2008-2009 (Baer, Cook, & Baldi, 2006).

Aud et al. (2011) defined the need for developmental education as “Remedial courses, usually in mathematics, English,
or writing, provide instruction to improve basic knowledge and skills within a subject and to develop social habits related to academic success at the college level” (p. 70). Developmental courses and programs support underprepared students in post-secondary schooling by providing additional instruction in reading, writing, and math skills. One of the quintessential components of academic success is the ability to read (Boylan & Saxon, 1998; Maxwell, 1997). The National Survey of America’s College Students (2006) explained:

Rapid changes in technology make it necessary for adults of all ages to use written information in new and more complex ways. . . . Every adult needs a range of literacy skills to achieve his or her personal goals, pursue a successful career and play an active role as a citizen. High levels of literacy also enable individuals to keep pace with changing educational expectations and technologies and support the aspirations of their families. (p. 4)

The connection of reading and academic success in higher education is well studied and understood (Boylan, 2003; Maxwell, 1997; Snow, Porche, Tabors, Patton, & Harris, 2007). The importance of developmental reading to underprepared students is also well documented (Boylan, 2003; Stahl & King, 2009).

Developmental reading skills. Many postsecondary developmental reading courses focus on basic reading skills, study skills, vocabulary, fluency, and comprehension development (Calhoon, 2005; Caverly, Nicholson, & Radcliffe, 2004, Maxwell, 1991; Ruddell & Unrau, 2012). Developmental reading students often do not know or do not use basic reading strategies such as identifying the main points of a reading selection or self-monitoring skills related to their academic learning (Long & Long, 1987; Maxwell, 1997, Van Blerkom & Van Blerkom, 2004). Underdeveloped reading skills can lead to decreased engagement in academic courses and negative academic attitudes and motivation towards reading tasks (Alexander & Filler, 1976; Caverly, Nicholson, & Radcliffé, 2004; Maxwell, 1997). Successful students – those who learn and employ those reading skills – can, in turn, improve their comprehension of any text.

Some developmental reading programs have shifted towards assessing the literacy skills of developmental reading students using digital measures. In recent years, there has been an increase in reading software programs designed to augment students’ reading difficulties in reading, accuracy, and speed. The continuing presence of developmental reading students in postsecondary institutions and the continuing efforts to improve the instructional methods (including the use of computers or another technology) has deep historical foundations (Author, 2011; Belzer, 2011; Eckert, 2011). Still, few developmental reading courses incorporate digital eye testing or training within the course framework.

Eye Training

Research suggests that developmental students may be trained to read faster through the use of computers and eye training; yet, the results are not conclusive as to the value on students’ comprehension (Bond & Tinker, 1967; Calef, Piper, & Coffey, 1999; Rayner,
Two studies with collegiate developmental reading students show no significant changes in posttest reading rates between students who read on paper and those who use computer or speed reading packages (Kuehner, 1999; Wepner, Freely, & Wilde, 1989). However, eye movement research may provide explanations for these results. There is continuing debate whether slow eye movements cause reading problems or if reading problems cause slow eye movements.

Historical perspectives. Bond and Tinker’s (1967) *Reading Difficulties: Their Diagnosis and Correction*, may be one of the definitive references in a review of the study of eye movements and its connection to the reading process. They reported that the first study of eye movement and reading was conducted by Emile Javal (1879) in Paris, France. Eye movement research surged after Edmund Huey’s (1900) efforts to record eye movements in reading and Raymond Dodge’s (1901) work to photograph eye movements during reading. Bond and Tinker detailed numerous studies between 1900 and 1967 that describe the connection of speed reading, comprehension, and eye movements; the relationship of speed to comprehension in reading; and the role of eye movements in diagnostic and developmental reading. The results of their meta-analysis on eye movement research can be summarized as follows:

- In reading, the eyes make several stops, a fixation pause, while following a line of print. Fixations are the only clear periods of vision and they average 94% of the reading time.
- While reading, eyes are motionless or fixed for a considerable amount of time.
- The time between fixations and interfixation movements are so rapid that clear vision is impossible and no reading can take place. Interfixations average 6% of the reading time. Sometimes the eyes move backwards to previously read material. This is called regression - to reread the material or to get another review for understanding of what was read.

Patterns of eye movements provide clues to one’s level of reading proficiency (Bond & Tinker, 1967; Calef, Pieper, & Coffey, 1999; Fernald, 1943; Harris & Sipa, 1990; Samuels, Rasinski, & Hiebert, 2011). Typically, in order to read text, different eye movements are required. These movements include fixating word after word, horizontal saccades that move the eyes left to right, and oblique saccades that transition eyes to the subsequent line of text (Jainta & Kapoula, 2011). These elements drive the research and subsequent methods of recording eye movements, often found in developmental programs/clinics, as a way to diagnose reading difficulties. The identification and diagnosis of reading struggles preempts the training of eye movements to improve reading performance. The underlying assumption is that eye movements are important determinants of reading proficiency. If a developing reader learns ideal eye movement patterns, increases in
both word reading and comprehension may result.

Instructional Implications

How the eye processes information on a printed page indicates that the eye is always moving; however, information is only passed to brain for processing and meaning construction when the eye pauses (fixation). To process all the information on a page, the eye must move rapidly from point to point to cover the page, and it is only during the fixations (pauses) that the information is sent to the brain and translated for meaning (Samuels, Rasinski, & Hiebert, 2011).

Teachers need to understand the role eye movements have in reading. Eye movement is an important indicator or symptom of reading skill. “If there is a problem that relates to the eyes or faulty movements, teachers should be aware of the symptoms so that the problem can be identified and corrected” (Samuels, Hiebert, & Rasinski, 2011, p. 26). The reading process does not proceed smoothly because the eye is always moving and recognizing information. When a reader does not recognize a word, there is a backward eye motion called re-reading. These rereads usually go back several words. Regression is used to correct faulty eye motions that place the point of focus in the wrong location, impairing word recognition for students of any age.

Non-fluent readers often struggle with both decoding and comprehension. Studies show developing readers cannot see the whole word as well as fluent readers. The dynamic activity of reading can be explained as follows:

1. Stabilize the eye
2. Focus
3. Decode – recognize the word, know how to say it, which may or may not be accurate and may use up the cognitive resources. Once the word is recognized,
4. Comprehension becomes a combination of moving the attention back and forth between decode and meaning (Samuels, Heibert, & Rasinski, 2011).

Underprepared students who complete a developmental reading course attain more success in college when compared to those who do not take such a course (Boylan, 2001, Cox, Freisner, & Khayum, 2003). Developmental students who are “explicitly taught strategic reading” outperform peers who do not receive explicit instruction (Caverly, Nicholson, & Radcliffe, 2004). The reading difficulties of underprepared college readers are complex and often extend beyond vocabulary, fluency, and comprehension. Underlying factors for struggling readers should be explicitly addressed via intervention programs. As Farstrup and Samuels (2011) conclude, it is important for professional instructors of reading to be aware of the role of eye movements in the reading process.

Methods

Setting/Participants

In a recent semester, students enrolled in a developmental reading course at a Hispanic-serving regional four-year university in South Texas completed new requirements involving the use of AceReader Online - a newly embedded
course component. The developmental reading course was instituted in 1999 in response to University requirements and a student population that did not pass a standardized college entrance test. The course concentrates on improving reading comprehension, recognition of the organization of ideas in written material, study skills, vocabulary development, and critical reasoning skills. Permission to participate in this research study designed to increase word reading speed and comprehension was obtained from 94 (55 female/39 male) students in the four sections of the course. Participants represented a range of ethnicities: 48% Hispanic, 23% White, 15% International, and 8% Black.

Supplemental Program

AceReader Online. Good readers learn forward saccades, and computers can aid this process. Readers look at a point on a computer screen, where all the words from a text are presented one at a time in a flashing sequence. This type of text presentation system prevents the reader from making regressions and in turn, promotes comprehension. AceReader Online is a program used by schools, learning centers, public learning environments, businesses, and individuals for the purpose of improving their reading skills. Through tachistoscopic scroll presentation and rapid serial visual presentation, AceReader Online is intended to assist the reader in learning how to absorb multiple words at one time. By reducing the time required for eye fixation and expanding the eye fixation zone, the online software program seeks to break the habit of eye regression and re-reading. The purpose of AceReader Online is to incorporate a series of eye training exercises to enhance reading speed and comprehension of developmental college students.

Procedures

Students were briefed on the course requirements for completion of AceReader Online. Teachers of record provided a tutorial on how to create an account, login, complete the exercises, and take periodic word reading and comprehension assessments. The instructors observed the progress of students and reported to the individuals as well as the course supervisor if and when students were behind, on, or above expected levels of module completion. Students were required to complete two levels representing 6-8th grade reading levels according to the Dale-Chall Readability Formula; each level contained 61 modules. These two levels were selected due to the estimated reading levels of the students enrolled in the courses over the past decade.

Students were advised to read on-screen instructions and reading tips throughout their online eye training activities. The modules were designed to be completed in groups of five (per week according to the syllabus to ensure completion); the reading activity began with a warm-up drill followed by various skill and eye activities, and culminated with a self-paced reading comprehension test. Each lesson of the online eye training program included:

1. Various warm-up drills were designed to prepare the participant’s eyes and brain for upcoming exercises through a variety of methods and activities, including the use of flashing graphics and highlighted text.
2. Four sessions of practice that concentrated on training the eyes through the use of intermittent word exposure

3. Two eye training games, which fluctuated from eye span to tachistoscopic flash and recall, involved a student having to correctly respond 10 consecutive times for completion

4. Timed, self-paced reading comprehension test upon completion of the reading comprehension test

As the modules are successfully completed, the activities increase in difficulty to train the eyes to take in more information during a set period of time.

Data Collection

Students established a Base Reading Speed (BRS) by taking a pretest for reading speed before beginning the eye training exercises in the online portal. The students’ BRS were determined via a timed reading selection of a leveled passage. Readers were required to earn a 75% on comprehension questions for the BRS to be recorded. The results set the speed of reading for students during the subsequent drills. Instructors collected data on literacy elements including: pretest - words per minute (pre WPM), posttest - words per minute (post WPM), pretest - comprehension score, and posttest - comprehension score.

Data Analysis

This investigation sought to determine the effectiveness of AceReader Online for use in a college developmental reading course to increase students’ reading rate while maintaining or increasing comprehension abilities. The single-group research design consisted of pre/post measures of word reading speed and comprehension. Mean gain scores and standard deviations from the \((N = 94)\) participants were calculated from the two indicators: word reading speed (WPM) and passage comprehension (Lexile Framework for Reading) embedded within AceReader Online. A \(t\)-test was performed to compare differences between means for pretest and posttest scores for silent reading comprehension within the group. Bootstrapping was also utilized to examine the robustness of statistics. Effect sizes were calculated when statistically significant results were found.

Results

Data were collected from participants throughout the Fall 2011 semester. Baseline measures of both word reading speed and comprehension were obtained prior to the commencement of practice exercises involving rapid serial visual presentation of words and tachistoscopic scroll presentation of words. AceReader Online contained integrated assessment components, allowing students to be assessed in similar ways to their practice exercises, following the Author’s (2014) guidelines that students should be tested in the same media format in which they receive instruction (i.e., digital instruction and digital testing, or paper instruction and paper testing). A paired \(t\)-test was selected to compare individual words per minute scores: pretest scores \((M = 176.6; SD = 8.3)\) and posttest scores \((M = 289.8; SD = 24.2)\) following the 12-week intervention, resulted in \(t(93) = -4.283, p < .001, CI_{95} -165.7, -60.7\). Because the distributions of the data for both word reading speed were
highly negatively skewed, implying a non-symmetrical distribution, a bootstrap paired t-test was conducted, which indicated similar results, \( p < .01 \) (\( p = .003 \)). Further, Cohen’s effect size (\( d = 6.26 \)) suggested an extremely high practical significance.

Paired t-test results on comprehension scores from pretest to posttest indicated statistically significant findings as well. Pretest scores (\( M = 83.2; SD = 5.5 \)) and posttest scores (\( M = 85.2; SD = 8.0 \)) were collected before and after the 12-week intervention, resulting in \( t(93) = 2.00, p < .05, CI_{95} \) -3.98, -0.03. Because the distribution of the data for both pretest and posttest in reading comprehension were highly positively skewed, a bootstrap paired t-test in SPSS was utilized, netting similar results (\( p < .05 \)). Cohen’s effect size (\( d = .029 \)) denoted a small practical significance.

Cross-correlations between word reading speed and comprehension scores were tabulated to determine if students who improved in reading rate also improved in comprehension. Results revealed a weak correlation (\( r = .14 \)) between the two variables.

**Discussion**

Word reading posttest results indicated that these 94 participants in the developmental reading collegiate course improved 123 words read per minute on average (as measured by AceReader Online). Students experienced significant gains in all four sections of the course regardless of factors such as instructor of record, course time, or module completion time. The transition from reading 176 words (sixth grade level) to 289 words per minute (twelfth grade level) varied between participants, according to Carver’s (1990) reading rate equivalency scale (see Table 1). Some improved quickly through eye training exercises while others continued to grow throughout the duration of the 122 modules.

Word reading speed is only one aspect of effective reading; comprehension of content is also necessary for one to be considered a fluent reader (Author, 2012). Comprehension development was also targeted and thus measured before, during, and after the skill exercises involving rapid serial visual presentation of words and using tachistoscopic scroll presentation of words. Students not only increased their word reading speed to a statistically significant rate, but they also increased their comprehension rates of passages included in AceReader Online. Comprehension gains were particularly salient when accounting for the increase in passage difficulty throughout duration of the exercises.

Further analysis resulted in a low correlation between those who made gains in word reading speed and those who achieved comprehension increases. Online sessions emphasized eye training to bolster reading word speed and comprehension. These exercises had variable positive gains depending on the learner. However, it was apparent that students enrolled in a developmental reading course have diverse needs for improvement.

**Limitations/Delimitations**

This investigation utilized a convenience sampling during the Fall 2011 semester of all sections of the developmental reading course at one regional university in South Texas. Data
were collected from participants as they used AceReader Online and progressed through 122 online modules. In addition, three instructors were teachers of record for these 94 participants across four sections of the developmental reading course. This was also their first experience using AceReader Online and in providing guidance to students for duration of the study.

Further Study

Developmental reading course redesign has been needed for some time but the problem is confounded with the emerging technological literacy needs from students of all ages. Students struggle reading printed words, while others can read words proficiently but not retain the meaning of the text. Therefore, students must also be trained to improve their multifarious literacy skills in individually tailored settings where successes are cherished and consistent scaffolding prevails (Author, 2010; Samuels, Hiebert, & Rasinski, 2011). Supplemental eye training exercises provide an online environment of learning outside of students’ weekly scheduled classes. One particular avenue of suggested research is determining ideal durations of study needed for specific types of reading difficulties. For instance, students identified as word callers may be placed into several programs of remediation, where online intervention programs can yield data regarding which exercises are most effective and how much practice is needed before a student can move on to another focused area of study. With a renewed interest and revitalization in the study of eye movements (Samuels, Rasinski, & Hiebert, 2011), it is an ideal time to determine and disseminate successful supplementary practices in developmental reading.

Conclusion

Though basic tenets of reading are generally understood as word recognition and comprehension, knowing how to improve developmental reader proficiencies in these areas is challenging. Developmental reading courses often have a two-fold mission: (1) Provide explicit instruction to develop student literacy skills, and (2) Prepare students to understand the basics of academic language, reading, and writing development through an array of literary experiences. Supplemental programs like AceReader Online can increase reading speed and comprehension rates that can then transfer to everyday reading experiences.

Like an omni-directional flashlight, without well-trained eyes, content information may be blurred to the reader. In this study, participants’ eyes were trained to recognize words more proficiently, and with greater accuracy in word reading comes fewer saccades and regressions in eye movement, allowing the brain to more readily process and retain information. These outcomes have significance in school systems, tutoring programs, and other developmental courses when planning instruction to improve developmental literacy skills of collegiate students.

Through refined research and practice, educators enhance their abilities to foster reading development through eye training exercises. Though there is no panacea when remediating reading difficulties, programs like AceReader Online provide supplementary student
learning opportunities based on a rapid serial visual presentation of words and using tachistoscopic scroll presentation of words aimed at reading development. Educators should heed the call of Farstrup and Samuels (2011) to be cognizant of eye movements in reading and incorporate known eye training techniques to prepare struggling readers to be more efficient readers. Course designers, professors, and academic administrators alike should consider these findings when considering supplementary reading programs to better reach the commensurate needs of their student bodies.

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Evan Ortlieb is a senior lecturer at Monash University in Melbourne, Australia, where he teaches undergraduate and graduate courses in literacy and primary education. His scholarship focuses on struggling readers and remediating reading difficulties in elementary learners. He is also very interested in literacy clinics and preservice teacher education. Most recently, he has begun publication of an international book series entitled Literacy Research, Practice, and Evaluation. Dr. Ortlieb can be contacted at evan.ortlieb@monash.edu