DIFFERENCES IN EYE MOVEMENTS BETWEEN ORAL AND SILENT READING

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ABSTRACT

Background: This research study explores the relationship of eye movements in oral versus silent reading tasks. Research on eye movements is plentiful using different systems to analyze the precise movements involved during reading, however, research on the differences between movements during oral and silent reading is lacking. *Methods*: The eye movements of thirty-four third year students from the Michigan College of Optometry during a silent and oral reading task were measured using the Visagraph II system. Two different age appropriate passages of the same reading level were selected to compare the difference in eye movements in oral versus silent reading. The students were then asked to answer 10 questions to assess comprehension of the passage. *Results*: T-test comparison revealed statistically significant differences in eye movements between oral and silent reading. There were more fixations per 100 words, regressions per 100 words, and a higher average duration of fixation in oral reading compared to silent reading. The reading rate was also found to be faster in silent reading compared to oral reading. *Conclusions*: Silent reading emerged as the more efficient mode of reading compared to oral reading. Silent reading led to fewer fixations, and regressions as well as smaller duration of fixations and increased reading rates when compared to oral reading. These findings may lead to future research in understanding the effects of silent versus oral reading on comprehension.

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CHAPTER ONE

INTRODUCTION TO DIFFERENCES IN EYE MOVEMENTS BETWEEN ORAL AND SILENT READING

The history of eye movement research has progressed through many eras with the earliest research being conducted by Javal in 1879. It was during this scientific first era where basic eye movements were discovered.[1] With these newly discovered eye movements, research during the second era was largely devoted to education with an emphasis on applying new knowledge about eye movements.[2] It was not until the third era, beginning in the mid-1970's, that research on basic eye movements began to advance. The revolution was largely due to new technological innovations that allowed for more accurate and precise measurements of eye movements.[1]

Technological advancements to record eye movements have drastically improved from direct observation with a mirror during the first era, to the corneal reflection method during the end of the second era. Corneal reflection photography became the most popular method to record and study eye movements and allowed for more detailed eye-tracking calculations.[1,3] During the beginning of the third era, electronic methods of recording ultimately allowed for greater precision of tracking and recording eye movements. These advancements have allowed increased

understanding about the complex relationship between eye movements and reading.

Eye movements are fundamental during the reading process. On the surface, it appears as though our eyes move swiftly from left to right during reading. However, with careful observation one can see there is an intricate relationship between eye movements and reading that involves more than just the eyes sweeping across a page. In reality, reading involves accurate and precise eye movements. These movements are known as fixations, regressions and saccades.

When reading continuous text, the eyes make quick and precise jumps from one word to the next. These jump like movements are known as saccades and are important in order to bring new areas of text onto the fovea for further visual processing during reading.[4] Saccadic eye movements last approximately 25-60 milliseconds and can vary depending on the size of the movement.[5] In order for this processing to occur the eyes must pause before making another saccadic eye movement. These inter-saccadic pauses are known as fixations and involve the eyes remaining relatively stable in order for neuronal translation to occur.[4,6] While reading, fixations can last from 200-250 milliseconds.[5] Another component of eye movements that occurs during reading involves right to left eye movements, known as regressions. These reverse saccades are normal movements that occur during the reading process and make up 15-25% of eye movements when reading. While the exact function of regressions is still largely unknown, these movements are thought to play a role in re-reading words or to aid in reading comprehension.[4,7]

Ultimately, it is well known that saccades, fixations and regressions occur during reading, whether it be an oral or a silent reading task.

During elementary school years, much emphasis is placed on oral reading fluency as this mode of reading has a strong correlation with increased reading comprehension.[8] This focus rapidly shifts toward silent reading through later school years and becomes the dominant mode of reading into adulthood.[9] Many studies have been conducted comparing oral and silent reading in relation to comprehension in order to elucidate any significant differences between the two. In a recent study by Boer et al, the authors compared the two modes of reading and found that rapid naming was strongly correlated with oral rather than silent reading skills.[9] Short-term memory, phonological awareness, and visual attention span did not differ significantly between oral and silent reading.[9] The authors also reported that reading fluency was higher during silent reading than during oral reading and that children read more fluently and comprehend more material when reading silently versus orally.[9] In a study conducted by McCallum et al, silent readers took significantly less time to complete a passage compared to oral readers.[10] The study also reported that silent reading is superior to oral reading as it results in equal comprehension but shorter reading times.[10] In a study conducted by Prior et al comparing comprehension after oral and silent reading using different grade levels of students, a clear grade-related correlation was reported.[11] Oral reading was the superior mode for comprehension from first to fifth grade while silent reading was superior beginning in seventh grade.[11] As evidenced by these studies, it is clear there are differences between reading orally versus reading silently.

There have been many previous studies that have demonstrated differences in oral and silent reading and compared these two modes in relation to comprehension. Most of these studies have focused on students in elementary school years and little research has been conducted studying eye movement differences in the graduate population. The aim of this study is to report if there are any significant differences in eye movements within the graduate population between the two modes of reading. The Visagraph II system was utilized to evaluate and report any differences in fixations, regressions, duration of fixation and reading rate between oral and silent reading

CHAPTER TWO

METHODS

Participants

Participants were thirty-four third professional year students from the Michigan College of Optometry. All participants were fluent in English with corrected normal vision and none had been diagnosed as reading disabled. The students gave informed consent and agreed to participate without compensation.

Protocols

This study was approved by the Ferris State University Institutional Review Board committee. The procedures used in this study followed the standard protocols outlined in the Visagraph II user's manual. Eye movements were recorded using a head mounted apparatus that was placed over the participant's correction and adjusted according to each student's near interpupillary distance (Figure 1). A brief orientation was provided before the participant was seated in a room with controlled lighting and asked to hold the reading material at ~30 cm. Each student read the same passage (Passage 89) silently and then read another passage (passage 90) orally. The paragraph for each passage consisted of 13 lines and text was

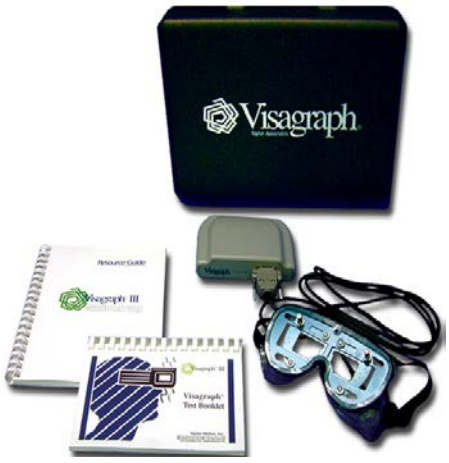

Figure 1: Visagraph System displaying head apparatus and materials

displayed in black on a white background. The Visagraph II creators took care in design to ensure that the difficulty of the text was equivalent for the same grade level text samples.

During the first phase, the same age-appropriate reading passage was selected for each participant to read silently with no time limit. After reading the assigned paragraph, the student answered 10 "yes" or "no" questions to assess comprehension of the passage. The second phase was identical to the first phase except that the students were asked to read an age appropriate passage orally instead of silently. Comprehension was also assessed following the oral reading task.

After completing the two phases, data from the thirty-four participants were screened to include only those that had at least 70% comprehension during both oral and silent reading sessions. As a result, four participants were excluded from the study. The Visagraph II system software employed infrared technique to analyze and display information (Table 1). The software calculated the following information: fixations per 100 words, regressions per 100 words, mean fixation duration, span of recognition, reading rate and the grade level efficiency. For the purpose of this study only data regarding fixations, regression, duration of fixation and reading rate were collected. Data was collected for the right and left eyes for both silent and oral reading tasks. Only the right eye data was analyzed for this study.

Table 1: Value and Definition of data calculated by the Visagraph II

Value	Definition
Fixations	Number of eye pauses per 100 words read
Regression	Number of right to left eye movements (reverse saccades)
Duration of fixation	Total reading time (sec) divided by number of fixations made
Reading rate	Words read per minute

CHAPTER THREE

RESULTS

Results

A paired two-sample t-test was conducted to independently compare reading rate, average duration of fixations, number of fixations per 100 words, and number of regressions per 100 words in oral and silent reading conditions. Means, standard deviations, confidence interval, margin of error and upper and lower bounds are displayed in Tables 2 and 3. Among the students (N = 30), there was a statistically significant difference in reading rate (RR) between the two modes of reading, oral (RR = 194.27) and silent (RR = 271.77) reading conditions; t(29)=2.05, p=6.72E-07. These findings suggest that reading rates are faster when the students read silently versus orally. Analyses also demonstrated a statistically significant difference in average duration of fixation (DF) between oral (DF=0.0011) and silent (DF=0.00075) reading conditions; t(29)=2.05, p=0.029. These results suggest that subjects focused on words for longer periods of time or took extended pauses during oral reading versus silent reading. The shorter durations of fixations during silent reading may account for why reading rates were faster in silent reading versus oral reading. Results also revealed a statistically significant difference in the number of fixations (F) per 100 words between oral (F=116.37) and silent (F=99.17) reading; t(29)=2.05, p=0.0046. Oral reading was found to have an

increased number of fixations when compared to silent reading. Finally, T-test analyses also found a statistically significant difference in the number of regressions (R) per 100 words in oral (R=16.13) and silent (R=10.63) reading; t(29)=2.05, p=0.0076 with an increased number of regressions occurring during oral versus silent reading.

In all four T-tests analyses the P value found was less than an alpha value of 0.05. Therefore the null hypothesis stating no difference in eye movements between oral and silent reading was rejected for all variables tested in this study. In conclusion, our results deemed silent reading to be superior in reading rate, fixation duration, number of fixations and number of regressions in the graduate population per 100 words when compared to oral reading.

Table 2: Data for reading rate and duration of fixation for oral and silent reading

	Silent	Oral	Silent	Oral
	Reading Rate	Reading Rate	Duration of Fixation	Duration of Fixation
MEAN	271.77	194.27	0.25	0.27
Standard deviation	72.96	33.17	0.03	0.03
Confidence Coff.	1.96	1.96	1.96	1.96
Margin of error	26.11	11.87	0.01	0.01
Upper Bound	297.88	206.14	0.26	0.28
Lower bound	245.66	182.40	0.24	0.26

Table 3: Data for fixations/100 words and regressions/100 words for oral and silent reading

	Silent	Oral	Silent	Oral
	Fixations	Fixations	Regression	Regressions
MEAN	99.17	116.37	10.63	16.13
Standard deviation	21.13	25.98	6.92	9.88
Confidence Coff.	1.96	1.96	1.96	1.96
Margin of error	7.56	9.30	2.47	3.53
Upper bound	106.73	125.67	13.11	19.67
Lower bound	91.61	107.07	8.16	12.60

CHAPTER FOUR

DISCUSSION

The aim of this study was to explore the differences in eye movements between oral and silent reading in the graduate population. The results demonstrated that during oral reading the number of fixations and regressions per 100 words increased, as well as the duration of fixation, when compared to silent reading. It was also found that the reading rate was faster when subjects read silently versus orally. In fact, students took 40% longer to read orally than silently, on average. Our results suggest that silent reading is superior in efficiency to oral reading in the graduate population and that there are, indeed, significant differences in eye movements between oral and silent reading.

Some limitations exist that may have limited this study. One possible flaw of this study is the small participant population selected. The original number of participants was decreased from 34 to 30 as four of the participants did not meet the comprehension criteria to be selected. A greater sample size is needed in order to analyze whether oral or silent reading significantly affects reading eye movements. Second, this study chose to analyze the difference of silent and oral reading on a very specific subset of the general population. All participants were graduate students with an assumed high comprehension level. Thus, the data measured may not be an accurate representation of the general population.

This particular study would be beneficial if it were conducted across all grade levels. The results of this study would provide a way to guide and shape education plans from elementary to high school years. The study could be performed on an individual basis to test whether a child is a more efficient oral or silent reader. Individual learning plans could then be formulated in order to more accurately tailor a learning plan that best suits the need of each student. A study conducted by Hale et al., assessed comprehension in oral versus silent reading in elementary and high school students.[12] The authors reported that there were no significant differences between grade levels and reading mode; however, comprehension was significantly higher when students read aloud as opposed to reading silently.[12] Contrary to the previous study, newer studies report that there are indeed differences between grade levels in oral versus silent reading.[11,13,14] These studies suggest that oral reading is superior in elementary years while silent reading is superior in higher grade levels as the better mode for comprehension.[11,13] Regardless, this information may be beneficial in understanding the relationship between reading and comprehension across all grade levels; especially during standardized testing. All standardized test takers are required to read silently which may be unfair to those who comprehend better when reading out loud. In fact, Hale et al., reported that students in both elementary and high school levels answered significantly more comprehension questions correctly when reading aloud versus reading silently.[12] This finding suggests that reading aloud does not reduce and may actually improve comprehension levels. In future studies comparing eye movements between oral and silent reading, it would be helpful to evaluate differences between different grade levels using the Visagraph II system. This would allow for cross comparison between the grade levels in order to

report any significant differences. It would be interesting to see if the Visagraph II supports the research that oral reading is superior to silent reading during the elementary school years and if there is in fact a significant difference as a child progresses through the education system.

Our results suggest that silent reading results in more efficient eye movements when compared to oral reading. One factor that may account for these results is that oral reading creates a more stressful environment for the reader, as the examiner will hear the reading skill of the tested subject. Therefore, the subject is more likely to take his or her time to ensure overall reading skills are judged as adequate. It would be interesting to repeat the study on graduate students who are alone in a room without an examiner when oral or silent reading to determine whether the presence of the examiner changes the reading performance, particularly under the oral reading condition. Another theory as to why reading rates decreased when participants read out loud is that the participant's cognitive resources were being applied to achieving phonological accuracy more than when they were reading silently.[15] When reading aloud, the participant is increasingly focused on correct pronunciation whereas pronunciation is not taken into consideration during silent reading. This theoretically allows subjects to devote more brainpower to reading faster silently and thus potentially improving comprehension. In other studies, the correlation of phonological awareness was found to be similar between oral and silent reading thus suggesting that phonology is of equal importance both modes of reading.[9] Further research is required in order to explore the relationship of phonology to both oral and silent reading.

While the results from this study revealed significant differences in eye movements between the two modes of reading, it did not evaluate the effects of these differences on comprehension levels. Future studies are needed in order to more accurately assess the differences in comprehension levels between oral and silent reading.

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APPENDIX A

IRB APPROVAL

FERRIS STATE UNIVERSITY

Institutional Review Board for Human Subjects in Research

Office of Academic Research, 220 Ferris Drive, PHR 308 · Big Rapids, MI 49307

Date: May 5, 2015

To: Dr. Sarah Hinkley, Navpreet Hehar and Johanna Mauk

From: Dr. Stephanie Thomson, IRB Chair

Re: IRB Application #150501 *(Saccadic Differences between Oral and Silent Reading)*

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, "*Saccadic Differences between Oral and Silent Reading*" (#150501) and determined that it meets Federal Regulations *Expedited-category 2D*. This approval has an expiration date of one year from this letter. **As such, you may collect data according to the procedures outlined in your application until May 5, 2016.** Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Your protocol has been assigned project number (#150501), which you should refer to in future correspondence involving this same research procedure. Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and non-compliance issues.

Understand that informed consent is a process beginning with a description of the study and participant rights with assurance of participant understanding, followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document and investigators maintain consent records for a minimum of three years.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,

S. Thomson

Ferris State University Institutional Review Board

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