Do Females Read Faster than Males? An Empirical Study Using Eye Tracking Systems

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Abstract

Most people believe that the slower we read the better we comprehend. However, a lot of novel rapid reading techniques and methods were developed to increase the reading speed without diminishing the comprehension. In this research an empirical study was performed to investigate if there is a difference in speed reading between males and females. The initial hypothesis in this research was the assumptions that there is NO difference between male and female in reading speed. Ten undergraduate and graduate students participated in achieving this experiment; five females and five males using head mounted eye trackers ASL 6000 series. The experiment results showed that there is a difference in speed reading between males and females. Females spend longer time between consecutive segments than males and they spend longer time on each segment than males in the reading process.. Females might have taken long time to focus and concentrate on understating the topic while males might have read fast without guarantee to comprehend. These results help psychology and computer science researchers to develop adaptive reading materials and devices.

Keywords: *Eye movement, Eye Tracking Process, Reading Process, Eye Tracker, Reading Speed.*

1. Introduction

Reading is a complex task that takes as its input a body of text in a natural language and produces as its output an understanding of the content of that text. The first question to the reading process is how the reader can understand "real" natural language texts such as textbook, stories, newspaper and articles. The reading process can be viewed as a series of sequential tasks. The first task is choosing starting points for reading. This task contains words in a sentence, word by word, sentence by sentence, which has known as low level sentence processing. There are several issues related to this task such as word meaning, semantic and ambiguity of words, and when and how a reader might go back and reread some text. The second task is drawing inferences, where the reader must carry out and determine hidden meanings. The reader must draw these hidden meanings based on the context provided by the text, background knowledge about the world in general, and how the knowledge is organized and encoded into the memory which is called knowledge representation. The third task is dealing with novelty which mainly introduces novel words and how to reuse of words in new contexts. The fourth task is controlling the reading process, which describes the purpose of the reading such as entertainment, information seeking, or communication. In general, the reading process can be expressed in terms of a functional-computational-representational model. Functional means that the process will be defined in terms of its inputs and outputs, computational means that this transformation will be described using an information processing, and representational means that the reading process is expected to make use of extensive background knowledge in order to understand a text and produce as its output [1].

There are large research works on eye movement control in reading process but the issue of reading speed has hardly attracted a single scientific study during the last decade. Eye trackers are designed to accurately measure a people's pupil diameter and point of gaze on a fixed scene space (computer screen). The use of eye tracking technology in Human computer Interface/interaction (HCI) research has recently got a lot of attentions and it has been applied to many systems. Several big challenging problems and solutions have been identified by using eye tracking systems. Eye tracking systems have been adopted in many research areas, for example, in neuro-scientific research such as investigating neuronal activity related to fixational eye movements and brain imaging, in psychology research such as reading process, scene perception, and auditory language processing, in industrial engineering and human factors research such as aviation, driving, and visual inspection, in marketing/advertising research such as print advertising, copy testing, and in computer science research such as eye-based interaction and usability, input device tool [5], and systems for the disabled [3].

Eye Tracking Technology can be classified as four broad categories based on eye movement methodologies: Electro-Oculography (EOG), Scleral Contact Lens/Search Coil(SCLSC), Photo-Oculography (POG) or Video-Oculography (VOG), and Video-based combined pupil and corneal reflection. Since the human eye has sharp vision within one degree of visual angle and it can fixate on an object within one degree, we decided to use an eye tracking system that uses Video-based combined pupil and corneal reflection, which is an ASL Series 6000 eye tracking system. The basic idea behind the eye tracker is that eye will be illuminated by a near infrared light beam and the optical system focuses an image of the eye onto an eye camera. The illumination beam and the eye image are reflected from the monocle which is coated to be reflective in the near infrared region. Figure 1 shows the main components of the eye tracking system and the red arrows shows the infrared beam.

Fig. 1: Eye Tracker ASL6000 Model

The future of reading research is to adopt an advanced technology to make it easy to measure and understand eye movement control in reading. There is a large number of researchers investigated individual variations in reading on both intra- and inter-individual variations but the total amount of empirical work in the field is surprisingly small. Intra-individual factors, such as reading intention, motivation, or global strategy are widely assumed to affect comprehension, but little is known in detail about the way reading processes may be modulated. The differences in eye movement behavior in reading sentences, compared to paragraphs or much longer segments of connected text are still unquantified and it remains an open question whether text processing within new media environments has any specific impact on the reading process. Factors such as the defined reading task and the format of material are likely to affect reading speed and level of linguistic processing. There is a large research work on eye movement control, particularly with respect to individual differences, but the researcher's community has not given any attention to some important issues, for example, it is surprising that the issue of "reading speed" has hardly attracted a single scientific study during the last decade. Therefore the goal of this research is to study reading speed which will eventually help psychology and computer science researches to find out how it affects the reading process.

2. Eye Movement and Reading

Human eye moves around a scene to locate the interesting areas of the scene and then build up a mental diagram corresponding to the scene. A saccade is a fast movement of an eye [2] and the center of the human eye is called fovea which plays a critical role in resolving objects. The human eye moves back and forth with a constant vibration rate to refresh the image being cast onto the rod cells and cone cells at the back of the eye. Reading is a complex skill that involves many different stages of information processing. When the human eyes move in printed page, the visual features of the text are converted into orthographic and phonological patterns, which are then used to guide further language processing which lead to understand the content of the text [2].

The human eyes do not move smoothly across the printed page during reading but they make it in short and rapid movements known as saccades. A typical saccade moves eyes forward about 6-9 character spaces within 20-60 ms and is completed depending upon the length of the movement. The period of time between consecutive saccades is known as fixation time which can be 100 to 400 ms. There are limited visual information that can be processed during a fixation, in order to have constant eye movements while reading. Visual acuity can help to find out the visual features that make up individual letters to be encoded from a very narrow window of vision, so it is necessary to fixate on most words so that they can be identified.

The time between the process of identifying words and the plan for early saccade for future fixation is about 180-250ms and it is called saccadic latency. Saccadic latency considered bottleneck constraint because it requires reading certain number of words per minute. However, word recognition is a major part of driving eye movements during reading because most estimates indicate that lexical access requires 100-300 ms to complete. The reading process will be straightforward and easy if text is available for processing in first 50 to 60 ms prior to a fixation. Out of all saccades in a text segment, 10-15% moves back to previous parts of the text which is called backward movements and this inherent difficulty is known as regression. Some readers perform regressions back to the point of difficulty to understand the sentences and then reinterpret the sentence. There are two different activities associated with eye movement control that need to be highlighted: where the reader decides to look next and what determines when the reader moves his/her eyes either forward or backward in the text.

The study of eye movements gets a lot of attention from researchers as well as industries during last decade. Eye movement's research has a solid theoretical and practical foundation in experimental reading research. Eye movement has played an essential role because it is an inherent behavioral of the reading process and provides a method of studying the functionality of the human brain. Eye movement research provides a wide understating of computational models of reading that combine mechanisms of oculomotor control. There have been literally tons of studies exploiting the potential of temporal measures like fixation and gaze durations as online indicators of processing load, and spatial measures like fixation position and saccade amplitudes as indices of the direction and sequence of processing. Most of the methodology used in eye movement studies of fluent reading involves the construction of experimental sentences or short passages of text that includes critical target words. Relevant independent variables can then be systematically manipulated and the consequential effects on eye movement measures are observed.

Dodge in 1903 [11] stated that during reading our eyes moves in a sequence of very fast movements called saccades. These movements are interrupted by fixations, periods of relative stability in the position of the visual axis, during which visual information can be extracted. Saccades metrics of reading has shown that fixations are positioned in a very systematic word based fashion. There are systematic relations between the duration and number of fixations on a given segment of text and its visual and linguistic processing. Word based eye movement measures reflect three aspects of oculomotor behavior: the fact that a word is fixated or not, the position fixated, and the amplitude of incoming and outgoing saccades.

Rayner and Pollatsek in 1981 [12] found that the behavior of the eyes mirrored what was seen on a fixation. For example, if the area on the current fixation was small, the eyes only moved a few characters, while if it was large, the eyes moved further. Rayner introduced E-Z Reader model which is a processing model that assumes ongoing cognitive processing influences eye movements during reading and considered it as the default reading process model. In general, E-Z Reader can be an explanation of what happens during reading when higher-level linguistic processing is running smoothly. E-Z Reader 7 consists of small number of cognitive processes that determine when and where the eyes move during reading. The seven phases of E-Z Reader are: lexical processing (signals the oculomotor systems to begin programming a saccade to the next word), word identification (causes attention to shift to the next word), early processing, saccadic shifts of attention, the first labile stage (initiation can be canceled), the second non-labile stage, and saccades execution.

Visual features from the printed page are projected from the retina to the visual cortex so that the individual words on the page can be identified and this processing of retina neural transmission to brain takes approximately 90 ms to complete. The time needed to encode a word increases as the distance between its center and the fovea increases and word length increases due to the individual letters of long words. Finally, it should be mentioned that by adding the early visual processing stage to E-Z Reader 7 model, the minimal time needed to identify words in the model is very plausible (the time needed to identify most frequent word in English text context is 148 ms and that for lowest frequency words in completely unpredictable contexts is 432 ms). Also, attention is allocated serially during reading because readers need to keep word order straight due to the fact that they need to identify each word in its correct order.

Inhoff in 2002 [14] suggested that properties of two words can sometimes be encoded in parallel. Models of eye movement control during reading can be classified as either oculomotor or cognitive/processing. Most of researchers can adopt one of the following approaches: cognitive/attentional or visual/oculomotor. The people who appreciate oculomotor models claim that properties of the text (word length) and operating characteristics of the visual and oculomotor systems largely determine saccade accuracy and fixation locations. The cognitive/processing models tend to emphasize the role of language processing in guiding eye movements during reading. According to this view, the decision about how long to fixate is determined by ongoing linguistic processing, whereas the decision about where to fixate is jointly decided by linguistic, visual, and oculomotor factors.

Most of the researchers faced severe problems in analysis of eye movement data that can be remained on the critical world until several solutions were provided such as proceeding with a progressive saccade (increase in viewing time measures) or executing a regressive saccade to reread segments of text. The analysis of eye movement data can be achieved by focus on cumulative region reading time, scope of sentence processing to describe phenomena such as shift of topic within a text or detection of global semantic inconsistencies [13]. Another way to analyze the eye movement data is processing the position fixated at any point in time. This processing starts at the point of fixation and continues until all possible analyses are completed. Since, the mind is sometimes a bit ahead or little behind of the eyes this will lead to the relationship between fixation positions and durations, and local processing is strong enough to produce reliable effects on eye movement. There is no straightforward way to determine how much visual information is available during a fixation or the type of information available. McConkie and Rayner in 1975 [16] introduced a technique to detect the changes of eye movement-contingent display and the basic idea is that little or no visual processing normally takes place during saccades. Therefore, movements of the eyes can be used to trigger changes in the display being processed which can gives control visual and linguistic information.

In the last decade, the researchers tried hardly to answer big questions such as: When and Where eye movement is controlled in reading, which means to highlight the following questions: how eye movement is controlled, how saccades are generated during reading, and where the position of fixations in word based space is. Word targeting decisions are primarily based on low level information like word length and saccade launch distance, but cognitive factors such as word frequency and predictability also play a significant role. The selection of which word to fixate on is the specification of the precise saccadic amplitude needed to bring the eyes to the selected target. The centre of the selected target word (locations near the word centre) is considered as the optimal for saccade targeting, while the eyes are systematically deviated from this target location. The time course of processing events and control decisions occurring during a fixation can answer the question: when the eye will move. The control decisions can be based on information acquired during the ongoing fixation with considering the contextual constraint (local word associations or global context).

Henderson and Ferreira in 1990 [15] introduced an attention based sequential processing model which stated that, eye movements in reading are largely controlled by lexical processing. The lexical access determines the position of fixations, their duration, and the probability that a word will be skipped. The Lexical access on a word causes a shift of visual attention to the next word, followed after certain latency by a saccade and a second attention shift can take place if the next word is easy to process. Some researcher developed a computational model for eye movement control using a simple heuristic (fixate on the largest word within a window of 20 letter spaces) and others use basic visual heuristics. Yang [17] in 2001 stated that it may be more productive to view those eye movement patterns which are determined by purely visuomotor processing as providing a “carrier signal”. This signal can then be modulated by cognitive influences and presented with a realistic algorithmic attention shift model of eye movement control in reading in the form of their E-Z Reader model.

3. Literature Review

There have been a lot of research conducted to study the relationships between reading behavior and eye movement of the reader through eye tracking systems. In [6] the authors used eye movement to study the effect of inserting boundaries between words in Chinese texts on the reading of Thai students. A Chinese text differs from other languages’ texts in that it does not have obvious boundaries (e.g., spaces) between words. Thus, the text is formed by a sequence of adjacent characters. Non-native Chinese reader often have difficulties recognize words in a Chinese text. The research aimed to answer the question “would foreign students’ reading proficiency improve if words boundary marks are inserted in Chinese textbooks?”. In order to answer this question, the authors conducted experiments on 30 Thai students (15 male and 15 female) who were asked to read Chinese texts in four models of presentation, normal unspaced, word spacing, single character spacing and non-word spacing. The SR Research Eyelink 2000 eye tracker was used during reading to measure mean fixation duration, total sentence reading time, mean saccade length, forward saccade length, regressive saccade length and fixation count. The results showed that inserting spaces between words has improved Thai language learners’ reading efficiency while inserting these spaces in non-word boundary positions hinders their reading.

In [7] the authors applied eye tracking technology to study how Arabic language affects reading English for Arab English as a Foreign Language (EFL) learners. Arab EFL learners may encounter substantial problems when reading English due to its many irregularities and inconsistencies compared to Arabic Language. For example, in English the correspondence between graphemes and their phonemes is complex and inconsistence, while in Arabic this correspondence is simple and consistent. The authors aimed to study how this difference in orthography affects the reading of English of Arab EFL students. In their experiments, the subject was 23 female EFL students who are native Arabic speakers. Their ages ranged between 18 and 19 years. The stimuli was a reading test for two groups of words: regular words (“are those in which every letter represents its most common sound”) and irregular words (“are those in which one or more letters do not represent their most common sound”). Tobiix120 stand-alone eye tracker was used to record eye movements and measure eye-gaze, fixation count and fixation duration while reading the words. The results showed that the students apply Arabic language rules (read letter by letter) to read unfamiliar English words. This reveals that the way Arabic is read affects the reading of English for Arabic EFL learners.

In [8] the authors introduced a study of how children interacts with digital books. The study used eye tracking technology to measure the “User Experience” of the children as they interact with online digital books. User eXperience (UX) includes usability measure of efficiency, accuracy and satisfaction. Eight children participated in the study (4 male and 4 female) with average age 9.8 years. All children were native Arabic speakers. The children were asked to read two Arabic online books. After reading each book, every child was asked to complete ranking scale that measures their experience and emotional reaction to the digital book. While reading, a Tobii 120 eye tracker was used to record eye movements of the children and measure fixation count and duration. The study showed that eye tracking can provide us with rich information about children behavior and attitudes, hence, it is an effective tool for measuring children experience in interacting with interfaces in general and with digital books in particular.

In [9] the authors conducted a study that investigates the effect of different forms of statistical information on people’s understanding to these forms using eye tracking technology. Basically, statistical information can be represented in three forms, text, graph and graph with text. The author studied the impact of these different forms on reading efficiency (time), reading effect (accuracy) and mental workload (pupil diameter). In their experiments, the subjects were 31 students (15 female and 16 male) with average age of 24 years. Tobii T120 eye tracker was used to record eye movements of the students while reading the forms. The students were asked to read three types of stimuli, statistical text, statistical graphs and statistical graph with text. The results, as reported by the authors, showed that the reading time for statistical graphs was significantly shorter than that of the other two forms. For reading effect there was no significant difference between the three forms. Finally, the mental work for both statistical graphs and graphs with text was significantly lower than that of statistical text.

In [10] the author conducted a preliminary eye tracking experiments to understand how people read graphs and how crossing affects their reading performance. Sixteen subjects participated in two experiments: path search and node location. The stimuli was six drawings grouped into two 3-drawings sets, one for testing cross angles and the other for testing geometric path tendency. Eye movements of the subject were recorded during reading the graphs using iViewX eye tracker. The results of the experiments, as the author mentioned, showed that crossing has little impact on node location tasks, however, small angles may cause delay in path search due to extra eye movements. Geometric path tendency indicated that when many branches go towards the target node the path between nodes can become harder to follow.

4. Research Method

Our research methodology is composed of four steps: setup the hypothesis, select the participants, select the text, and calibrate the system for each participant.

Hypothesis
The first step is to setup the initial hypothesis. Our initial hypothesis assumes that there is NO difference between male and female in reading speed.

Participants
The second step is to select and find the participants. Finding participants is a very hard task especially if it is a voluntarily work. Five undergraduate and graduate female students are selected to be 50% of the participants. The other 50% was five undergraduate and graduate male students. All students were between 19 and 26 years old.

Stimuli
The third step is to select the text for the experiment. The selected topic was how to rob a bank as described in fig. 2.

> Imagine you are robbing a bank, you enter
> the bank and then announce there is a
> robbery. If the alarm is triggered, you try to
> run; if not, you steal the cash from the vault
> and try to escape before the cops come.
> You may be able to run away and you may
> get arrested

Fig. 2: Example of Robbing Bank Scenario

Apparatus
We used an eye tracker system with Video-based combined pupil and corneal reflection, which is an ASL Series 6000 eye tracking system [17].

Calibration
The last step is to calibrate the eye tracker for each participant. In general, eye tracker calibration is really

difficult and error prone. ASL eye tracker uses a technique called Bright Pupil Image (BPI) for measuring eye movements as described in section 1. The amount of light being put out by the illuminator LEDs is controlled by the Illuminator slider bar in the User Interface Software. So, the brightness of the pupil varies by the amount of light shined on it. As the first step of setup the apparatus of the experiment, brightness of the illuminators is set to a level where brightly lit pupil can be distinguished from the background and corneal reflection (CR) can be distinguished from the pupil. The process that the computer uses to detect the pupil and the CR is called discrimination. This process requires the detection threshold to be set for both the pupil and CR. Since this sensitivity differs between people, environmental features, and other factors. The actual settings will differ and need to be monitored. It is not preferable to use Auto mode because it is not 100% effective and is not available for all modes of operation. Therefore, manual discrimination is mandatory by the user, this operation is called calibration.

Calibration step needs to be performed with every participant and should be performed every time a participant sits down with the system with every experiment. The gaze calibration is the most difficult part for any experiment because the system should keep track of the pupil and the corneal reflection by this process. The eye tracker can make valid measurements when the subject looks within about 25 degrees visual angle. For example, if the participant was looking at a computer monitor (scene), data values that would indicate gaze points many feet from the scene are unlikely to be valid data. The ASL system divides any scene plane into a grid space of 260 by 240 (top:10, left -10, right 270, and bottom 270) thus all gaze coordinates reported beyond (0,0) and (260,240) are theoretically outside the plane of interest. The most common calibration method is the 9-point calibration, which projects a bit map on the participant computer with nine numbered dots ordered in 3 rows and 3 columns. Figure 3 below shows the calibration step [17].

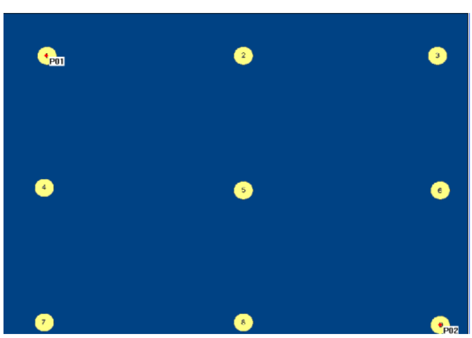

Figure 3: Calibration step [17]

5. Experiment Results

The most irritating and time consuming step in the experiment was the calibration step. Table 1 shows the results of segment duration time in ms (a segment is a continuous section of recorded data), number of fixations during segment time (fixation refers to a person's point-of-regard as one looks at a stationary target in a visual field), segment loss in second (time during which the eye tracker did not recognize the pupil and this includes some blink time), and fixation frequency (average number of fixations per unit time (ms)) during the data segment [17].

Figure 4 shows the segment duration time for males and females. The mean segment duration time for males is 15.983 ms while the mean segment duration time for females is 16.443 ms, which indicates that females spend more time between consecutive segments by 3%.

Table 1: Data collected from for selected subjects

Name	Segment Duration Time (ms)	Num. of fixations	Segment Loss_sec	Fixation Frequency
SM1	14.364	50	3.660894	3.480924534
SM2	12.513	41	7.064048	3.276592344
SM3	25.509	64	2.938700	2.508918421
SM4	13.130	47	3.695821	3.579588728
SM5	14.398	37	3.543262	2.569801361
SF1	17.401	56	3.817946	3.2182059
SF2	17.201	58	3.770480	3.371897
SF3	12.346	48	11.605320	3.8878989
SF4	18.669	59	12.816846	3.1603192
SF5	16.600	40	6.578086	2.4096386

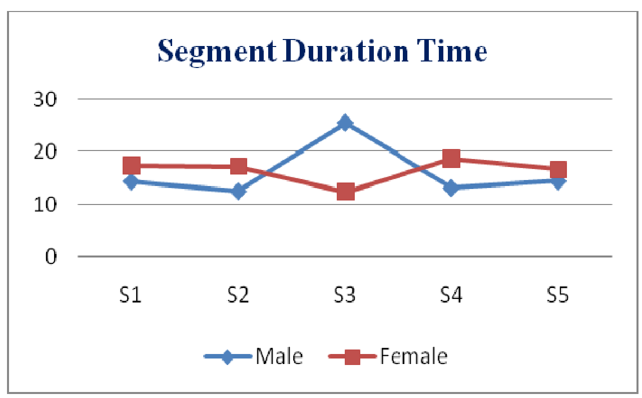

Figure 4: Segment Duration Time for male and female

Figure 5 shows number of fixations for males and females. The average number of fixations for males is 48 while for females is 52 during the reading process, which indicates that females do more fixations than males by 8%.

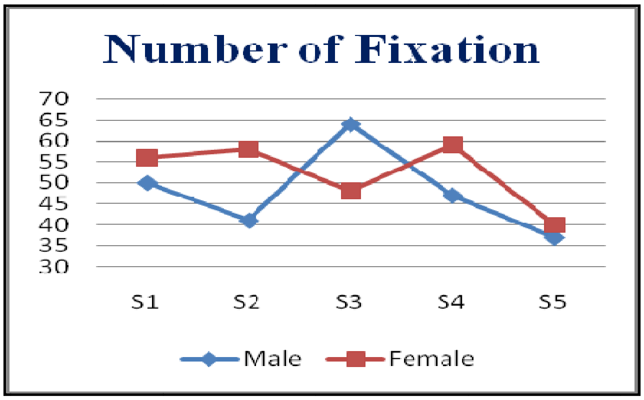

Figure 5: The number of Fixation during reading process

Figure 6 shows segment loss in second for males and females. The average segment loss for males is 4.181 while for females is 7.718, which indicates that females may lose concentration faster than males.

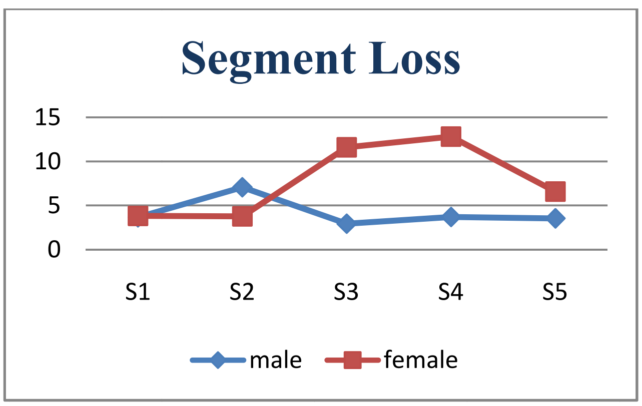

Figure 6: Segment Loss in sec for males and females

Figure 7 shows the fixation frequency (fix/ms) for male and female. The mean fixation frequency for males is 3.08 while it is 3.21 for females, which indicates that the females do fixations more frequently than males.

The correlation coefficient between segment duration time and segment loss in second is -0.2, which indicates that when the participant focus too much in the fixation he/she may lose the correct next position of eye movement. Also, the ratio between number of fixations and segment loss for male is 11.433 and that for female is 6.764 which indicates that fixation loss rate for females is smaller than that for males.

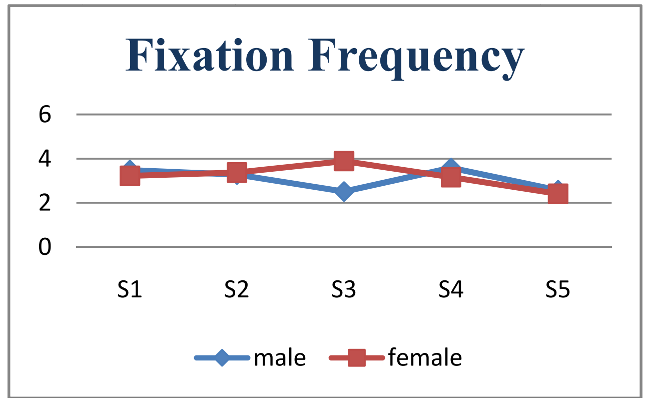

Figure 7: Fixation frequency for male and female

Figures 8 and 9 show a sample of eye tracking for males and females, while figure 10 shows an interesting and unusual behavior using eye tracking where the participant look outside gaze.

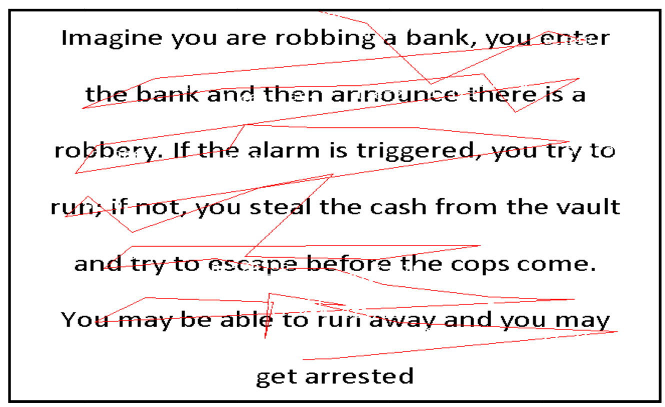

Figure 8: Sample males reading style

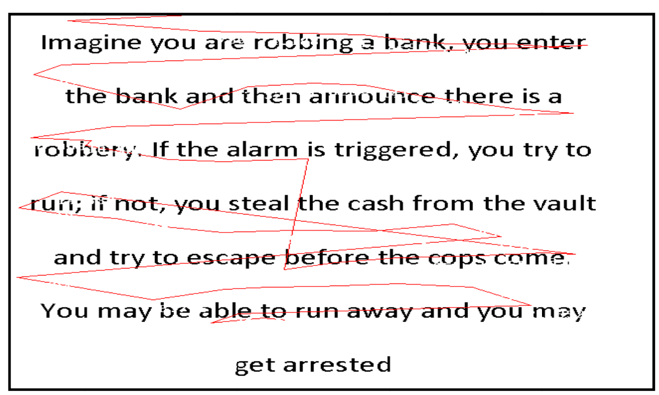

Figure 9: Sample females reading style

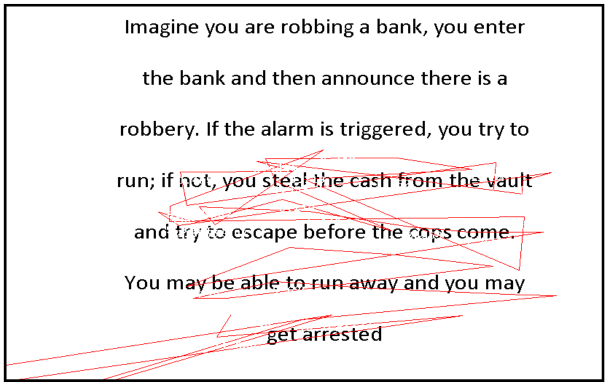

Figure 10: Sample of unusual reading style

6. Conclusion and Future Works

Most of people believe that the slower we read the better our comprehension is. In the past decades, the reading speed research shows that the techniques of reading used by most adults create fatigue and cause them to lose the context of the text (lousy reader's phenomena). Reading speed has a strong association with understanding the context of the text. There are many developed techniques and methods for rapid reading, most of them do not have a scientific based foundation but are based on individual's experience. In this research we investigated one of the many ways how females read compared to males. The conducting experiments showed that there are differences of reading speed between male and female. Females may take much time to focus and concentrate to understand the topic while males can read fast without guarantee to comprehend. Using eye tracker in reading process will help psychology and computer science researchers to develop adaptive reading materials and devices. In future work, a general profile for female and male reading speed will be created and associated with a set of applications such as Jaws or reader devices.

Acknowledgments

This work was supported by the Research Center of College of Computer and Information Sciences, King Saud University. The authors are grateful for this support. I would like to thank Western Kentucky University-Computer Science Department for their support and collaboration.

References

[1] Ashwin Ram and Kenneth Moorman, "Towards a theory of reading and understanding, Understanding Language Understanding: Computational Models of Reading, MIT Press.

[2] Erik D. Reichle, "Comparing Models of Eye Movement Control in Reading", Department of Psychology, University of Pittsburgh, (http://www.bbsonline.org/Preprints/Rayner/Referees/)

[3] Andrew T. Duchowski, "A Breadth-First Survey of Eye Tracking Applications", Behavior Research Methods, Instruments, and Computers Journal, 2002

[4] Ralph Radach and Alan Kennedy, "Theoretical perspectives on eye movements in reading: Past controversies, current issues, and an agenda for future research" ,European journal of cognitive psychology, 2004

[5] Andrew T. Duchowski, "Eye Tracking Methodology: Theory and Practice", 2nd ed., Springer Verlag, 2007, ISBN: 978-1-84628-808-7

[6] Jiao, Yumei and YU, Peng, "A study on Eye Movement of Thai students reading Chinese text with or without Marks for Boundaries", 2011 International conference on Asian language Processing

[7] Al-Khalifah Kholid and Al-khalifa Hend, "The effect of Arabic Language on Reading English for Arab EFL learners: An Eye Tracking Study" 2011 International conference on Asian language Processing

[8] Al-Wabil Areej, Al-abdulqader Ebtisam, Al-abdulkarim Latifa and Al-Twairesh Nora, "Measuring the User Experience of Digital Books with Children: An Eyetarcking Study of Interaction with Digital Libraries" 2010 International Conference for Internet Technology and Secured Transactions (ICITST).

[9] Zhong Ning, Li Mi, Wu Yue and Lu Shengfu, "The Impact of Different Forms of Statistical Information on Reading Efficiency, Effect, and Mental Workload: An Eye-tracking Study", 2011 IEEE/ICM International conference on complex medical engineering.

[10] Huang Weidong, "Using Eye Tracking to Investigate Graphs Layout Effects", Asia-Pacific Symposium on Visualization 2007.

[11] Dodge, R. (1903). Five types of eye movement in the horizontal meridian plane of the field of regard. American Journal of Physiology, Vol.8, pp: 307–329.

[12] Rayner, K., & Pollatsek, A., "Eye movements and scene perception", Canadian Journal of Psychology, Vol.46, pp: 342–376.

[13] Mike Rinck, Elena Gámez, José M. Díaz, and Manuel De Vega, "Processing of temporal information: Evidence from eye movements", Psychonomic Society, Memory & Cognition Journal - 2003, 31 (1), 77-86

[14] Albrecht W. Inhoff , Cynthia Connine, and Ralph Radach", A contingent speech technique in eye movement research on reading", Psychonomic Society, Behavior Research Methods, Instruments, & Computers 2002, Vol.34 (4),pp: 471-480

[15] Henderson, J.M., & Ferreira, F., " Effects of foveal processing difficulty on the perceptual spin in reading: Implications for attention and eye movement control", Journal of Experimental Psychology: Learning, Memory and Cognition 1990, Vol. 6, pp: 417-429.

[16] McConkie, G.W. and Rayner, K., "The span of effective stimulus during a fxation in reading.", Perception & Psychophysics 1975, Vol.17 , pp: 578-586.

[17] ASL Reference manual (http://techsupport.a-s-l.com)

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