Analyzing the Effect of Reading Patterns using Eye Tracking Measures

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ABSTRACT

Scientific literature is crucial for researchers to inspire novel research ideas and find state-of-the-art solutions to various scientific problems. This paper presents a pilot study of a reading task for novice researchers using eye-tracking measures. The study focused on the scan path, fixations, and pupillary activity of the participants.

CCS CONCEPTS

• **Applied computing** → **Psychology**; • **General and reference** → Experimentation.

KEYWORDS

Eye-Tracking; Index of Pupillary Activity; Reading Tasks

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1 INTRODUCTION

The information seeking behavior when reading scientific literature varies from one person to another. Intuitively, common patterns may exist among individuals having similar expertise in a particular area. For instance, novice researchers may exhibit different reading patterns compared to more experienced researchers. If their reading patterns are quantified using eye-tracking measurements, a difference in scan paths and pupillary activity could be expected.

The reading process of a researcher is determined by their ability to grasp the important facts from different sections of the research paper efficiently. Thus, the level of expertise is expected to play a major role when interacting with scientific literature. Some researchers may read the research papers from start to end at a stretch to gain insights on its content, whereas others may read them in a different order than presented. Moreover, they may exhibit a change in their reading patterns over time as they familiarize with the content and structure of the paper. In general, during initial stages of visual information processing, shorter fixations and longer saccades are observed. However, during later stages of visual information processing, longer fixations and shorter saccades are observed after identifying the target [3].

In this study, we focus on gaining insight for the eye movements of novice researchers using multiple eye-tracking measures while reading a research paper. We explore three aspects of the reading task; (a) the order of the sections of the research paper read by the researcher, (b) fixation counts made on each section, and (c) cognitive load of the researcher when reading each section of the research paper. We hypothesize that the cognitive load differ with respect to various sections of the research paper.

2 METHODOLOGY

2.1 Participants

For our pilot study, we recruited three early-career researchers (2 M, 1 F) in the field of Computer Science. They were all Ph.D. students in their first or second year in a doctoral program. All participants were aged between 18–30 years, with no history of psychotic symptoms. They had normal or corrected-to-normal vision, and verified it through a simple visual acuity test. Their familiarity of reading and reviewing research papers in various journals and conference venues was confirmed verbally.

2.2 Reading Task

We selected a 2-page publication from a prior JCDL conference as the reading material for this study. Participants were asked to read

Figure 1: A participant reading the research paper while wearing the PupilLabs Core eye tracker.

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the research paper while wearing the PupilLabs Core[1] eye tracker (see Figure 1). The eye-tracker had a sampling frequency of 120 Hz and an accuracy of 0.60°. Each participant was calibrated using the screen marker calibration in Pupil Capture[2] before recording their eye-movements. We specified five areas of interest (AOIs) on the selected research paper to analyze the eye-movements of participants. Each AOI corresponded to a particular section of the research paper: (1) title, (2) abstract, (3) motivation, (4) methodology, and (5) conclusion.

2.3 Analysis

We used Pupil Player[3] to extract raw gaze recordings. To observe how the eye-tracking measurements change over the course of the reading task, we used our RAEMAP [4] eye movement processing pipeline, which is a modified version of gaze analytics pipeline [1]. It facilitates computation of various complex eye movement measurements such as pupillometry measurements which indicates the cognitive load (i.e. Index of Pupillary Activity (IPA)). The architecture of RAEMAP is shown in Figure 2. We applied RAEMAP to calculate the fixation counts, fixation duration, and IPA counts for each participant during the reading task.

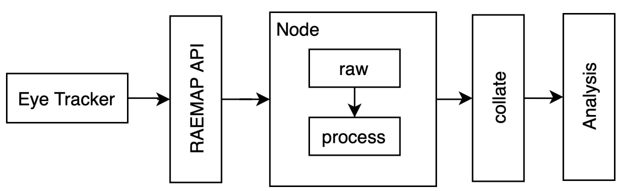


Figure 2: The Architecture of the RAEMAP [4].

3 RESULTS

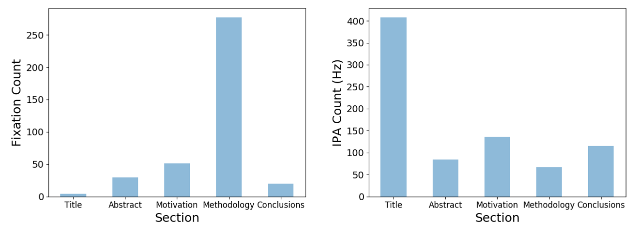
3.1 Analysis of Scan Path

When analyzing scan paths, we observed that all researchers started reading from the title section of the paper. Following this, two out of three participants read the abstract and scanned the images of the paper, whereas one participant scanned the images of the paper and then read the abstract. Afterwards, two out of three participants read the motivation of the paper, whereas one participant read the conclusions of the paper. Among the two participants who read the motivation, one proceeded with reading the methodology and conclusions, whereas the other proceeded with reading the conclusions and methodology. The participant who read the conclusions instead of the motivation, proceeded with reading the motivation and methodology. Overall, we observed three different scan paths among the participants.

3.2 Analysis of Fixations

Fixation count indicates the number of times that the eyes fixated on an AOI. We calculated fixations counts and fixation duration of the participants using RAEMAP.

The average fixation counts and fixation duration of participants on AOIs suggested that participants preferred to fixate more on the



(a) Fixation Count (b) IPA Count

Figure 3: Average fixation count and IPA count on each AOI.

methodology section and spent more time reading it compared to the other sections (see Figure 3(a)).

3.3 Analysis of IPA counts

IPA is calculated using a wavelet decomposition of the pupil diameter signal. For the IPA calculation, we used Symlet-8 wavelet for a 120 Hz signal as suggested in [2]. Low IPA counts reflect low cognitive load and high IPA counts reflect strong cognitive load [2].

Since we observed the highest number of fixations on the methodology section, we expect cognitive demands on participants to be greater when reading that section. Contrary to our expectation, we observed a higher cognitive demand on participants when reading the title section of the paper (see Figure 3(b)). This indicate that participants experienced a higher cognitive demand prior to exploring the research idea presented in the paper. The least IPA counts were observed on the methodology section, which indicates a lower cognitive load when reading that section.

4 CONCLUSIONS AND FUTURE WORK

The purpose of this study was to gain insights into the scan paths of novice researchers while reading a research paper, through eye-tracking measures. We observed different scan paths among participants for the reading task. Our analysis showed that participants spent most time on reading the methodology section, with a comparatively low cognitive load. Their cognitive demands were higher when reading the title section of the paper.

We anticipate exploring the scan paths of both novice and experienced researchers in terms of advanced eye movement metrics, on a larger population of researchers.

REFERENCES

[1] Andrew T Duchowski. 2017. The Gaze Analytics Pipeline. In *Eye Tracking Methodology*. Springer, New York, NY, 175–191.
[2] Andrew T Duchowski, Krzysztof Krejtz, Izabela Krejtz, Cezary Biele, Anna Niedzielska, Peter Kiefer, Martin Raubal, and Ioannis Giannopoulos. 2018. The index of pupillary activity: measuring cognitive load vis-à-vis task difficulty with pupil oscillation. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. ACM, Montréal, QC, Canada, 282.
[3] Jens R Helmert, Markus Joos, Sebastian Pannasch, and Boris M Velichkovsky. 2005. Two visual systems and their eye movements: Evidence from static and dynamic scene perception. In *Proceedings of the XXVII Conference of the Cognitive Science Society*, Vol. 27. Erlbaum, Stresa, Italy, 2283–2288.
[4] Gavindya Jayawardena. 2020. RAEMAP: Real-Time Advanced Eye Movements Analysis Pipeline. In *Symposium on Eye Tracking Research and Applications 2020*. ACM, Stuttgart, Germany, 4.

[1] https://pupil-labs.com/products/core/
[2] https://docs.pupil-labs.com/core/software/pupil-capture/
[3] https://docs.pupil-labs.com/core/software/pupil-player/