

Multidisciplinary Reading Patterns of Digital Documents

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ABSTRACT

Reading plays a vital role in updating the researchers on recent developments in the field, including but not limited to solutions to various problems and collaborative studies between disciplines. Prior studies identify reading patterns to vary depending on the level of expertise of the researcher on the content of the document. We present a pilot study of eye-tracking measures during a reading task with participants with different domain expertise to characterize their reading patterns.

CCS CONCEPTS

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

KEYWORDS

Eye Tracking, Reading Patterns, Multidisciplinary Research

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1 INTRODUCTION

The reading patterns of digital documents (scholarly articles) vary from person to person across various disciplines. Despite the consensus that reading patterns are stochastic, recent studies identify similarities between individuals with common expertise. The studies by [Jayawardena et al. 2020; Mahanama et al. 2021] identify that participants spend the most time in the methodology section, with a relatively low cognitive load.

However, these studies only rely on pilot studies of participants from the computer science domain. As a result, the findings of the studies can be questionable for other disciplines. Therefore, we present a dataset¹ that includes eye-tracking behaviors of researchers from multiple disciplines. Our contributions are,

¹<https://github.com/nirdslab/Multidisciplinary-Reading-Patterns>

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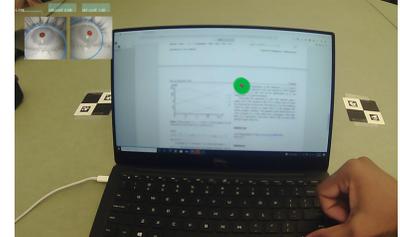


Figure 1: Experimental setup. Left: Participant during reading task, Right: Sample recording.

- (1) Conduct a preliminary analysis on the generalizability of claims of previous studies across domains.
- (2) Discuss implications of our preliminary results and potential research avenues.

2 METHODOLOGY

We recruited seven (6 F, 1 M) graduate students as researchers in Computer Science (CS) (2), Mathematics (2), and Physics (3). The participants aged between 25 and 35 years, with research experience ranging from one to five years. We verbally confirmed their experience in reading research papers and verified their vision through a visual acuity test.

We selected two articles of two pages in Computer Science and Physics for the reading task. After reading each paper, each participant briefly summarized the article verbally and answered queries by the proctor to confirm their understanding. We allowed the participants to perform the task in a laboratory setting with their preferred lighting, brightness, and zooming levels (See Figure 1 for the experimental setup). On a given day, we limited the experiment to a single paper per participant to eliminate the effects of fatigue in the dataset.

We used PupilLabs Core² eye-tracker to record eye-movements at a sampling frequency of 120 Hz with an accuracy of 0.60°. Each participant was calibrated using the 5-point calibration in Pupil Capture³ and confirmed the accuracy through manual tests. For each paper, we annotated five sections: (1) title, (2) abstract, (3) introduction and related work, (4) methodology, and (5) figures. We contacted the author and confirmed the section classification for the articles without explicitly defined sections.

For each user session, we replayed the gaze positions using Pupil Player and annotated the eye movements in each of the

²<https://pupil-labs.com/products/core/>

³<https://docs.pupil-labs.com/core/software/pupil-capture/>

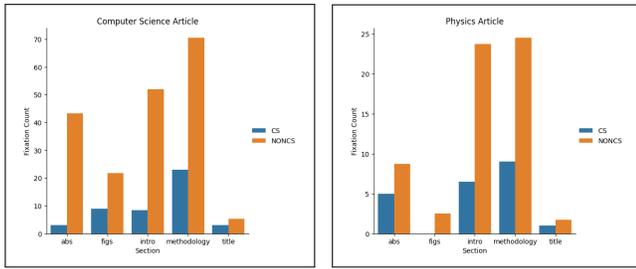


Figure 2: Average Fixation Count

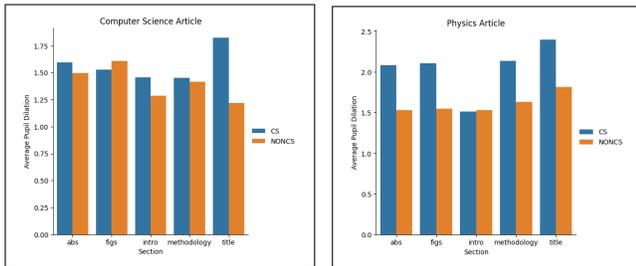


Figure 3: Average Pupil Dilation

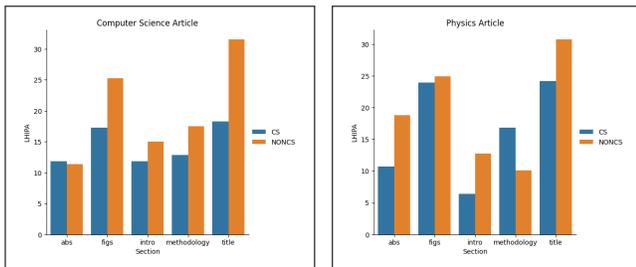


Figure 4: Low/High Index of Pupillary Activity (LHIPA)

sections with a forum of three manual annotators. Then we extracted the annotated data from Pupil Player software and utilized x , y , $timestamp$, and $pupil\ diameter$ within each section to generate multiple eye gaze metrics. Based on the annotations, we computed fixation count, fixation duration, Low/High Index of Pupillary Activity (LHIPA) [Duchowski et al. 2020], and average pupil diameter. We calculated the aforementioned eye gaze metrics for each participant, for each paper, for each section including revisits to the same section.

3 RESULTS

Our preliminary results indicate the participants fixated more on the methodology sections of the paper irrespective of the domain consistent with the past studies [Jayawardena et al. 2020; Mahanama et al. 2021]. Considering the computer science article, Non-CS participants have more fixation counts across all sections than CS participants. We suspect familiarity with the content as a possible reason for the behavior. Moreover, we observe similar behavior

(fixation count ranking) among Non-CS participants while reading the physics article, with much lesser fixations.

Following the behavior of Non-CS participants, we expected CS participants to exhibit a higher number of fixations while reading the physics article. On the contrary, we observed the number of fixations decrease while being lesser than Non-CS, indicating less time spent. We presume the CS participants have only skimmed through the content combined with the unfamiliar content.

While reading the physics article, we observed that CS participants have comparatively larger pupil dilation than Non-CS participants, potentially indicating domain unfamiliarity increasing their cognitive load. However, we did not notice much difference between participants while reading the computer science article.

While reading the physics article, CS participants have experienced a higher cognitive load (lower average LHIPA) with the highest during the introduction. In contrast, Non-CS participants have experienced the highest in the methodology section with lesser cognitive load in other sections. In contrast, CS participants have undergone a higher cognitive load throughout the computer science article except abstract than Non-CS participants, despite our expectation of domain familiarity yielding a lower cognitive load.

4 DISCUSSION AND CONCLUSION

We did not observe domain familiarity impacting cognitive load expressed through pupillometric characteristics based on the results. However, we observed higher fixations in abstract, introduction, and methodology irrespective of the domain familiarity. Moreover, we noticed a higher cognitive load during introduction and methodology irrespective of participant and article.

Our preliminary results have multiple limitations. Firstly, we expect the observations to include potential biases resulting from the lack of diversity in our study sample due to the early stage of the study. We expect more generalizable gaze and pupillometric characteristics to emerge by diversifying the study participants. Further, we present only the most widely used measures in this study, while metrics beyond our study may uncover novel findings.

In the study, we performed manual annotations for mapping the gaze positions of the users to the sections of the paper, which is tedious and time-consuming for an experiment of large scale. As presented in prior studies [Jayawardena and Jayarathna 2021; Mahanama et al. 2021], automated annotation approaches can help overcome the issue and form a novel research avenue. However, our experimental setup requires a clear point of view imagery and distinctive features in the digital documents to use those approaches effectively. Further, such an automated approach must be resilient to potential false positives in categorization.

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