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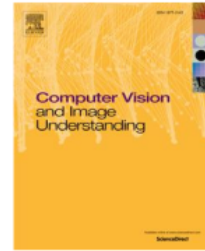

Exploring the Influence of Font Style, Size, and Medium on Text Comprehension: A 2³ Factorial Design Experiment

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Abstract

College students rely heavily on course materials provided by their professors to excel in class. Owing to technological advances, students now have the flexibility to access and study these materials either in print or digitally. However, the debate over which medium is more conducive to student understanding remains contentious. Moreover, how the presentation elements, such as font style and font size, impact student learning is also an interesting question that educators want to address to design lecture notes and course materials more effectively. To investigate how typographical factors and medium contribute to or hinder students' understanding of textual content, a 2^3 factorial design was implemented, with font style, font size, and medium as the focal factors. Three students from varying academic backgrounds at Miami University were recruited for this study. These three students were presented with texts featuring different combinations of these factors across a wide range of topics and were subsequently required to

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answer ten multiple-choice questions based on the texts they had just read. Participants' comprehension of the texts was assessed based on the number of correct answers they got out of ten questions. The collected data was then organized and stored in an Excel file for analysis. The results from the SAS analysis revealed no significant influence of font style, size, and medium on text comprehension. Nonetheless, these results carry implications for educational strategies and practices that will optimize students' learning experiences.

Introduction

In the field of academics, study materials are made available to students to provide knowledge and understanding in their respective areas of study. Irrespective of how these study materials are designed, the main goal is to provide relevant information and students will only use materials that enable them understand courses easily. Provided the contents of different documents are the same, the features of the document could influence the readability and thus the comprehension of the text they contain. Students' ability to excel in their studies is largely dependent on their understanding of the course content, which is related to their ability to read and comprehend the information in the course materials. According to Dressler (2019), reading is frequently a crucial mechanism by which knowledge is obtained, however, the subjective cognitive experience that occurs during text comprehension is seldom highlighted. Within the domain of scholarly conversation, the complexities of typography are frequently neglected, eclipsed by the significance of empirical evidence and theoretical frameworks. Despite this, it is impossible to overstate the importance of font size, style, and medium in influencing text comprehension. In an effort to establish a connection between cognitive psychology and typographic design, this article analyses the intricate interplay between these factors and text comprehension.

The development of reading skills is influenced by a multitude of student factors, including socioeconomic factors such as the educational background of parents and linguistic variables such as understanding of vocabulary (Lervag et al., 2019; Nouwens et al., 2021; Oakhill et al., 2019). While certain aspects of these factors are correctable, others are not. However, according to Sheppard et al. (2023), if the ultimate typographical factors that impact reading comprehension can be identified, they are more likely to enhance pre-lexical methods, which facilitate easier understanding and recall. Font size, which is one of the most important characteristics of typographic presentation, has a profound impact on the legibility and accessibility of text as demonstrated by studies such as Missaglia et al. (2017) and Sheppard et al. (2023). Although increased font size may improve legibility for specific demographics, improper calibration can result in cognitive fatigue and impaired comprehension. On the other hand, individuals who have visual impairments or reading difficulties may find it difficult to discern the intended meaning of the text due to the reduced size of the fonts. Font style, which includes a wide range of

typographic variations including serif and sans-serif, has a profound yet nuanced impact on the comprehension of texts (Beier et al., 2021). Beier et al. posit that the legibility of text is enhanced by the utilization of wider fonts; this is because increased inter-letter spacing and wider letters may both aid in mitigating the effects of congestion (Sheppard et al., 2023). Different aesthetic qualities, the thickness of strokes, and the presence or absence of serifs can elicit unique cognitive and emotional reactions from readers. Few studies have examined how font style could influence text comprehension and retention (Halin, 2016; Huang, 2019; French et al., 2013; Rello & Baeza-Yates, 2016).

Dressler (2019) argues that one noteworthy conclusion across all relevant studies was that individuals who read with sans serif had significantly superior memory and recall than those who read with serif. Dressler argues on the fact that most studies imposed either unnecessary or no time constraints on participants during the reading and testing phases. One possible issue is that participants assigned serif may unconsciously devote more time to reviewing the material compared to those assigned sans serif. This could be attributed to the text's tangible attributes, which might require greater attention. If this is the case, participants' higher scores on serif passages may be due to the increased time required to read each one, rather than the font itself enhancing the memorability of the text. This presents a methodological gap in literature which this study sought to tackle.

Additionally, the media used to deliver text, be it in print or digital form, adds an additional level of intricacy to the typographic dilemma. Print media provide distinct benefits in terms of physical touch, understanding of space, and engaging reading encounters. Nevertheless, digital platforms provide unparalleled flexibility, interaction, and accessibility, completely transforming the way textual material is distributed. In recent decades, researchers in the field of reading have shown a growing interest in studying the possible impact of technology interfaces on many elements of reading and learning. Numerous empirical studies have been conducted to compare reading on digital screens with reading on paper. These papers explore various fields of study and use different methods to examine the impact of screen properties on perceptual processes, memory and recall, comprehension, and metacognition/calibration (see Hermena et al, 2017; Porion et al., 2016; Roschke & Radach, 2016; Salmerón et al., 2018; Xu et al., 2017). Nevertheless, the impact of the medium on reading comprehension is still a topic that has not been fully resolved (refer to Hermena et al., 2017; Xu et al., 2017). Some empirical research has demonstrated that better comprehension when reading is done on paper (Delgado et al., 2018, Mizrachi et al., 2018). However, other studies have also revealed no significant differences in reading comprehension between paper and screen (Engdal Jensen, 2020; Porion et al., 2016). The varied results in the effect of medium on text comprehension could be due to the use of varying font styles and sizes for the various experiments. These varied results coupled with the few studies leave a knowledge gap which does not help to provide adequate evidence to support the

design of reading materials to promote student performance and the proper dissemination of knowledge which is the main goal of education.

This study therefore sought to provide more nuanced evidence that can promote the ideal design of study materials for university students by examining the effects of font style, size and medium and their interactions on text comprehension of students. The study provides insights into the complex relationship between font size, style, and medium on text comprehension by analyzing empirical data, theoretical frameworks, and practical implementations. This study aims to shed light on the fundamental processes that influence how typography affects cognitive processes. The findings from the paper may be used to improve teaching methods, design principles, and technology advancements in order to make written communication more accessible and effective in academic and real-life situations.

1.1. Text Comprehension

Effective text-based learning relies on the ability to understand and accurately assess one's own comprehension of the text. Text comprehension as defined by Golke et al. (2022) is an intricate cognitive process that involves constructing and intellectually interpreting the concepts of a written passage. This refers to the ability of an individual to identify the key concepts in the text, establish relationships between information within and across sentences, and connect the text information with their existing knowledge (van den Broek et al., 2002). Thus, learners must diligently observe and assess these cognitive processes with precision in order to determine their level of understanding. However, this ability depends on the cognitive process, hence Dressler (2019) argues that if individuals are unable to perform the cognitive processes during reading with efficiency and regularity, they will have less cognitive capacity for comprehension. Therefore, any elements that impede cognitive processes also obstruct the precision of text comprehension. The elements that influence learners' reading comprehension can be categorized into three main areas: the learner's skills and resources (such as ability to read, previous text knowledge, and reading motivation), the qualities of the text (such as its level of difficulty and appearance), and the purpose for reading (such as whether the reading is for comprehension, for memorizing facts, or for fun) (Golke et al., 2022).

1.2. Theoretical Underpinning

1.2.1 Cognitive Load Theory (CLT)

Cognitive Load Theory (CLT) offers a beneficial framework for understanding the cognitive processes involved in studying the impact of font size, style, and medium on text comprehension. The CLT developed by Sweller describes how information is processed by the human brain.

Cognitive Load Theory (CLT) suggests that the process of learning is affected by the amount of mental effort required by learners working memory, as proposed by Sweller in 1988.

According to Sweller (2010), there are three types of cognitive loads – Intrinsic, Extraneous, and Germane Cognitive Loads. Intrinsic cognitive load relates to the inherent complexity of the learning material itself and can be influenced by the learner's existing understanding of the subject. 2) Extraneous cognitive load pertains to the cognitive burden caused by the way learning materials are presented. 3) Germane load refers to the mental resources allocated towards accumulating and automating schemata in long-term memory (Sweller, 2010; Zhou et al., 2022).

The CLT shows that varying font sizes, and styles can impact the inherent cognitive load of reading by modifying the perceptual and cognitive processes necessary for comprehending textual content. For instance, reading text with a small font size can raise intrinsic cognitive load as it demands more work to comprehend individual letters and words. Conversely, reading text in a bigger, clearer font size can lower intrinsic load by making word recognition easier. Similarly, using mediums that could be distractive or make it difficult for reading could influence how easily the information communicated could be comprehended.

Thus, the cognitive burden experienced by readers can be influenced by several font features, including size and style, and the text medium. These factors might have an impact on readers' capacity to process and comprehend textual information (Zhou et al., 2022). This study as recommended by Chen et al. (2016) and Zhou et al. (2022) utilized the principles of Cognitive burden Theory (CLT) to design an experiment to examine the impact of font variations and medium on intrinsic, extraneous, and germane cognitive burden during reading tasks. This helps to explain the effects of font size, style and text medium on the comprehension ability of students. The knowledge acquired from this research can be used to improve the design of teaching materials and strategies for presenting information in order to enhance the understanding of written text among different readers and communication situations.

1.3 Empirical Review

Studies have explored the effect of font size on the ability of individuals to comprehend text content and various findings have been made. Research conducted by Tavakoli and Kheirzadeh (2011) examined the impact of font size on the ability to recognize important terms in a text. The study aimed to establish if students could more easily locate answers to multiple choice and true/false questions whether the text was written in a bigger or smaller font size. A total of forty students, both male and female, were chosen based on their performance in the institute's placement exam. The assessment of reading comprehension focused on the ability to scan for important words and grasp the basic concept. This was done by utilizing two reading texts with various font sizes (10 and 16), but with the same degree of difficulty as determined by the Fog index of readability. In order to reduce the impact of the ordering effect, a counterbalanced test design was used during the delivery of the test. The research concluded that there was no

noticeable impact of font size on text comprehension. This was determined by analyzing the Pearson Product Correlation, which did not reveal any significant correlation between the scores of the two font sizes.

In addition, Huang (2019) conducted an experiment to investigate the effects of font size, display resolution, and task type on reading Chinese typefaces on mobile devices. Participants were assigned text-reading tasks and visual searching task. The readability of Chinese fonts was assessed using both objective and subjective methods. Participants' reading performance and preference for font sizes and display resolutions showed notable variations. Subjective measures were determined to possess more sensitivity compared to objective measures. They concluded that there are ideal font sizes that ensure clear legibility of Chinese characters across four distinct resolutions. The discussion revolved around suggestions for improving the legibility of Chinese typefaces on mobile devices.

Subsequently, using an eye-tracking experiment involving 104 individuals who completed reading tasks on Wikipedia, the most widely used text-based website on the internet. Rello et al (2016) employed a hybrid-measures approach to compare the objective and subjective measures of reading and comprehension for articles with font sizes ranging from 10 to 26 points, and line spacings ranging from 0.8 to 1.8 using Arial font. The results of the study indicated that the readability of text, primarily evaluated by the average time of fixation, greatly improved when the font size was increased. In addition, font sizes 18 and 26 yielded a far higher number of accurate answers for comprehension questions. Rello et al., thus suggested that websites with a lot of content should use fonts that are at least size 18 and maintain the usual line spacing in order to ensure that the web page is easily readable and understandable.

Ralekar et al. (2018) investigated how different font styles impacted readers' reading comprehension. A total of fourteen individuals were used in an eye-tracking study that aimed to comprehend reading habits by having them read twenty-two pages displayed on the computer using three distinct font styles. Total reading time, comprehension score, fixation count, fixation length, and regression count were the metrics used to evaluate the readers' performance. They found that various font styles significantly affect fixation duration, number of fixations, and comprehension score when reading the same document. Thus, changing the document's physical qualities without altering its content could potentially boost reading comprehension, according to their suggestion.

Derssler (2019) assessed how reading comprehension was affected by font type and time. Twenty-four students from Yeungnam University's undergraduate and graduate programs participated in the experiment. From the website; CrackACT, two passages similar in characteristic but different in font style (Times New Roman and Haettenschweiler) were randomly assigned to each participant. Respondents were given ten multiple-choice questions to complete after reading the assigned texts. Results from the study showed that the passage with Times New Roman had better comprehension than that of Haettenschweiler. It was therefore

concluded that font style influences reading comprehension - Times New Roman is, thus, the superior typeface for enhanced reading comprehension and memorization of lengthy texts compared to Haettenschweiler.

Tajuddin & Mohamad (2019) conducted a quasi-experimental study to examine the impact of paper vs screen on reading comprehension and speed among undergraduate students at a public university in Sarawak. The primary aim of the research was to examine the formats that promote efficient reading and comprehension skills among undergraduate students. The experiment used a series of surveys, a collection of general interest articles, associated comprehension questions, and an online timer. Following a brief period of reviewing the interest articles, participants' understanding of the texts was evaluated via the use of relevant comprehension questions and questionnaires. The results indicated that students exhibited enhanced reading comprehension while reading from electronic screens. In contrast, pupils demonstrated increased reading speed while using the physical paper format. The data also indicated a substantial disparity between paper and screen forms in terms of both reading comprehension and reading speed.

Additionally, to enhance the general understanding of the impact of different reading media, a longitudinal study carried out by Florit et al (2023) explicitly examined the influence of antecedents on the comprehension of narrative and expository linear texts in first-grade novice readers. The study compared the impacts of reading on paper and computer screens by conducting an experiment involving 63 first-grade children. At the close of preschool, the ability of participants to make inferences and their working memory were collected as a measure of their prior cognitive ability. Their fundamental digital skills were also measured at the same time. The first-grade students engaged with four texts, consisting of one narrative and one expository piece, presented in print and digital formats in a counterbalanced format and their reading-text comprehension and word reading abilities were measured at the end of first grade. The results indicated that individually, the reading medium or text type had no significant effects. However, there was a substantial interactive effect between both variables. It was found that after grade 1, the students demonstrated improved comprehension scores while reading narrative texts compared to descriptive literature on paper. Furthermore, participants showed a preference for reading from the screen during the post-test, once all texts had been provided. Working memory and inference skills served as predictors for both printed and digital text comprehension. However, after taking into account factors such as medium, text genre, and word reading, it was shown that only fundamental digital skills were able to predict digital text understanding.

Xu et al. (2017) performed a meta-analysis using data from 27 published studies to examine the effectiveness of digital devices in supporting reading comprehension. This was conducted to offer a thorough judgement on the dispute regarding the impact of digital media on reading comprehension. The study determined that the use of computers and iPads has a beneficial impact on reading comprehension, while other devices do not. Furthermore, it was found that the

genre of the text and the grade level of the participants played a significant role as moderators. However, this study failed to provide knowledge of how digital performs against the paper medium.

Furthermore, Hermena et al. (2017) challenged prior claims that reading on tablets is associated with lower reading ability and comprehension but rather showed the need for regulating text presentation parameters for optimal results. The study utilized Arabic text, which significantly deviates from the languages previously employed, to examine the impact of tablet and paper on reading to provide a unique assessment of how these two media affect reading performances. The findings indicated that when the settings for displaying text are similar, there is no consistent variation in reading ability between the two mediums. Furthermore, the sequence in which one reads from a tablet or paper, as well as one's level of experience with using a tablet, have a minor impact on reading ability.

The variation in reading time between tablet and paper observed in certain studies according to Mangen and Kuiken (2014) may be attributed to the variation due to font sizes and types as well as other factors across the two reading mediums. Hence, the varied result from previous study requires validation. Most of the studies reviewed were found to concentrate on the effect of text font qualities on comprehension or reading ability either in print or digital medium. Some also were found to compare the compare comprehension due to paper to that of digital medium by using a single font size. This does not provide a clear understanding of how these factors interact to influence text comprehension. The current study therefore enhances the methodologies used in previous studies by combining two different font sizes, font styles and text mediums to provide a better understanding of the topic.

2. Materials and Methods

2.1. Participants

Three individuals (2 males and 1 female) took part in this study. Age was not systematically assessed, but the subjects were selected to be between the ages of 20 and 25. The participants were advanced readers of English, had normal or corrected-to-normal vision, and had not been previously diagnosed with any reading or learning disability. The participants were recruited from Miami University - a Masters' level student, a combined Masters' and undergrad student, and an undergraduate student. This selection aimed to capture a comprehensive range of perspectives across different academic disciplines and educational levels.

2.2. Materials

Eight experimental passages covering a diverse array of topics including health, environment, history, science, relationships, mindfulness, current affairs, and social studies, were chosen for the experiment. The texts ranged between 250 to 400 words long. The presentation of texts was randomized such that each was presented in each position of order, using the 8 versions. The same 8 texts were presented via both media platforms – standard size A4 paper condition and PDF document in the computer condition. For the paper condition, the texts were presented on a standard 8.3 x 11.7 in. white A4 paper using the different combinations of font style and size in black set to a 100% scale. Whereas for the computer condition, the texts were displayed in PDF format on the same type of computer desktop - 17-in. Dell OPTIPLEX 380, equipped with an Intel Core 2 Duo 2.93 GHz processor. The participants were permitted to use either a mouse or the arrow keys on the keyboard to scroll through the document.

2.3. Procedure

The participants were randomly assigned to each of the eight combinations. The experiment took place at the King's Library with all authors and participants present at the library, where participants had simultaneous access to the same model of computers, ensuring uniformity and minimizing potential biases. Each participant was provided with clear instructions for the experiment. After receiving the instructions, each participant was then given an opportunity to ask questions before beginning to read the first text. Participants were presented with a set of texts on the same topic in a randomized order to minimize potential biases. To mitigate the influence of prior exposure, unique text passages were presented to each participant in each experimental run, mirroring the methodology employed in national reading assessments. Participants were allocated five minutes to carefully read the assigned texts, followed by a five-minutes break to alleviate potential fatigue. Subsequently, participants were tasked with completing a test comprising ten multiple-choice questions related to the text content within a five-minute period. For each viewing situation, reading of text was followed by corresponding multiple choice comprehension questions with four possible answers. For each text, ten multiple choice comprehension questions were created to assess the reading of the texts. All participants recorded their answers to these multiple-choice questions on a paper answer sheet. Questions were developed to ascertain thought and reflection, in addition to being able to recall the text.

Each run lasted approximately fifteen minutes before transitioning to the next run, ensuring consistency, and minimizing variability across experimental sessions. Responses were meticulously graded out of 100, and an Excel file was created to organize and store participants' grades for subsequent analysis. Each participant was then debriefed and thanked for their participation. The entire session lasted approximately four hours.

2.4. Design and Analysis

The experiment was conducted using 2^3-factorial design, with the 3 factors being font style (Calibri or Times New Roman), font size (10pt, 12pt) and medium (computer or paper). The response variable was defined as the number of correct answers out of ten that each participant scored for each of the eight tests. With eight responses collected per participant, totaling 24 responses in total, the data collected from the experiment was examined using SAS 9.4 by employing Generalized Linear Models (GLM) technique. Additionally, model assumption checks were conducted to validate the robustness of the study results. A probability percentage plot was also created to visualize the distribution of effects across different levels of the experimental factors. These analyses allowed us to gain a deeper understanding of how font characteristics and medium influence text comprehension, laying the groundwork for our subsequent findings and conclusions.

2.5. Model Specification

This research used a 2^3-factorial design, incorporating 3 factors: font style (Calibri or Times New Roman), font size (10pt, 12pt) and medium (computer or paper). The primary response variable, text comprehension ability, which was proxied by the number of correct answers obtained for each of the eight comprehension tests, was modeled using the equation below:

$$Y = \beta_1 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_1 X_2 + \beta_4 X_1 X_3 + \beta_4 X_2 X_3 + \varepsilon \qquad (1)$$

Where:

$\varepsilon \sim NID\ (0,\ \sigma^2)$

Y = number of correct answers

X_1 = font style

X_2 = font size

X_3 = medium

The covariates are specified as follows:

$X_1 = -1$ if font style is Calibri and $+1$ if font style is Times New Roman.

$X_2 = -1$ if font size is 10 and $+1$ if font size is 12

$X_3 = -1$ if medium is Paper and $+1$ if the medium is computer screen.

β_1, β_2, β_3 are the coefficients related with main effects of font style, font size, and text medium respectively.

β_{12} = coefficient of the interaction effect of font style and font size.

β_{13} = coefficient of the interaction effect of font style and medium.

β_{23} = coefficient of the interaction effect of font size and font medium.

β_{123} = coefficient of the interaction effect of the three factors.

2.6. Ethical Considerations

Although the study did not involve anything that could potentially harm participants, it adhered to acceptable ethical guidelines. To ensure that participants were not coerced into participating, researchers sought verbal consent from them after briefing them on the study's purpose. Participants were also assured of confidentiality regarding study results and the freedom to withdraw from the study at any point if they no longer wished to participate. The researcher ensured that identifying characteristics, such as participants' names, email addresses, or phone numbers, were not collected or included in any part of the data collection and analysis stage. Therefore, all data collected during the study were anonymized during analysis.

3. Results and Discussion

This section reports and discusses the findings from examining the effect of font size, font style and medium on text comprehension. It includes descriptive and inferential analysis.

3.1 Results

The empirical results present the main effect and interaction effect estimates of the factors on the response variable. Prior to estimating the effects of the factors, the study assessed the model assumptions - Normality and constant variance assumptions. From Fig 3.1, it was found that the normality assumption was satisfied as seen in the Q-Q plot and histogram in Fig 3.1a and 3.1b respectively, however, there was an issue of heteroscedasticity as the points in the residual vs predicted value plot in Fig 3.1c were seen to show a fanning trend. Thus, the Box-Cox transformation was employed to deal with this issue, and this showed a selected lambda value of 5 (See Fig.3.2). Although the transformation resulted in a slightly better dispersion of the points in the residual plot which is displayed in Fig 3.3c, it still showed a trend which suggests that heteroscedasticity still existed. This could be because of the small number of observations - 24, from the three replicates used for the study. Therefore, the results presented below must be analyzed with caution.

Analyzing the data collected from the 2^3 factorial design experiment, it was found that none of the factors (font size, font style, medium) has any significant effect on the comprehension of text by students. Table 3.1 shows an F-value of 0.85 with an overall p-value of 0.5632 which is very much larger than 0.05. This reveals the statistical insignificance of the model. Moreover, the p-values associated with each of the factors were all found to be larger than 0.05 which

suggests the insignificance of the predictor variables as shown in table 3.2. Subsequently, the interaction terms were also found to be insignificant. The factor effects table showed high effect values for font style (3219.08), the two-term interactions between font size and medium (-4052.15), font style and medium (-1907.08), font style and font size (5024.25) and the three-term interaction (2938.22) (see table 3.3). The percentage probability plot in Fig 3.4 also showed that none of the factors is significant as they were all seen to follow the same line.

3.2 Discussion

This result could be due to the small sample size. However, the result appears to be empirically consistent with the findings of some previous studies which used large and small sample sizes. For instance, the study by Tavakoli and Kheirzadeh in 2011 found no significant effect of font size on text comprehension. Just as was done in the current study, Travakoli and Kheirzadeh used two different font sizes and different text with the same degree of difficulty. The study aimed to establish if students could more easily locate answers to multiple choice and true/false questions in texts with bigger fonts than those of smaller fonts. A total of forty students, both male and female, were chosen based on their performance in the institute's placement exam. The assessment of reading comprehension focused on the ability to scan for important words and grasp the basic concept. On the other hand, other studies such as Rello et al (2016) found a significant difference in the effect of font size on text comprehension when a hybrid-measures approach was employed to compare the objective and subjective measures of reading and comprehension for articles with font sizes ranging from 10 to 26 points. Their results indicated that the readability of text greatly improved when the font size was increased. In addition, larger font sizes yielded a far higher number of accurate answers for comprehension questions.

In addition, Ali et al (2013) found no significant difference in the effect of San serif (Arial and Verdana) font styles and serif font styles (Times New Roman and Georgia) on the readability and comprehension of text in both the print and paper mediums. They conducted the experiment using 48 undergraduate students. This is in line with the finding of the current study where no significant difference was found between the effects of Times New Roman (Serif) and Calibri (San serif). On the contrary, Ralekar et al. (2018) and Derssler (2019) both found that font style has a significant effect on the readability and comprehension of texts even though they used smaller sample sizes - 14 and 24 respectively and measured text comprehension in the same way the current study did - conducting test after participants were made to read passages made of different font styles.

Furthermore, in relation to the effect of text medium on comprehension ability, Florit et al (2023) examined this phenomenon among 1st grade children and found that individually, the reading medium or text type had no significant effects. Rather, they found that the children demonstrated improved comprehension scores while reading narrative texts compared to descriptive literature on paper. In the same vein, the finding from Hermena et al. (2017) indicated that when the settings for displaying text are similar, there is no consistent variation in reading ability between the paper and digital mediums. However, after performing a meta-analysis using data from 27 published studies to examine the effectiveness of digital devices in supporting reading comprehension, Xu et al. (2017) in the quest to offer a thorough judgment on the dispute regarding the impact of digital media on reading comprehension determined that the use of computers and iPads has a beneficial impact on reading comprehension. Similarly, Tajuddin & Mohamad (2019) concluded from their quasi-experimental study to examine the impact of paper vs screen on reading comprehension and speed among undergraduate students at a public university in Sarawak that students exhibited enhanced reading comprehension while reading from electronic screens and faster when reading on paper.

Nonetheless, this study at least expected that the interaction terms of the factors would have significant effects on comprehension ability. But surprisingly, the interaction terms also were found to be insignificant.

Theoretically, the findings from this study are underpinned by the Cognitive Load Theory proposed by John Sweller in 1988. Although the Extraneous cognitive load which pertains to the cognitive burden caused by the way learning materials are presented explains that font size, style and medium have an impact on the comprehension ability of individuals, the Intrinsic and Germane aspects of the theory support the findings from the present study. The Germane aspect of the CLT suggests that the ability of individuals to comprehend text is associated to the mental resources allocated towards accumulating and automating schemata in long-term memory and the Intrinsic cognitive load relates comprehension ability to the inherent complexity of the learning material itself and can be influenced by the learner's existing understanding of the subject (Sweller, 2010). Thus, the insignificant effect of the three factors on text comprehension in this experiment could be attributed to the similar knowledge of participants in the subject areas where they were tested, and the mental efforts made by the participants to understand the text presented to them. Participants were informed about the aim of the study and what was expected of them, thus, they ensured they studied the texts well irrespective of the font style, size or medium in which the texts were presented during the experiment. In addition, the eight different texts presented to the participants covered very familiar topics including: relationship, social media, the environment, exercise, and health. Thus, students could have prior knowledge of the subjects before taking the experiment and answer the questions correctly without needing to refer to the texts provided.

4. Conclusion

The study found font size, font style and text medium to have no statistically significant effect on the ability of students to comprehend text. The result also showed that these variables do not interact to improve text comprehension ability among students.

From the results of the current study and the CLT, the study concludes that different font sizes, font styles and mediums do not affect students' ability to comprehend texts differently. The ability of students to understand texts depends more on other factors rather than the nature of the text and the medium through which it is presented. As demonstrated by germane and intrinsic cognitive load aspects of the CLT, the comprehension ability depends more on students' efforts and their previous knowledge of subject matter.

The results of the study provide numerous implications for students, instructors, publishers and educational institutions from which recommendations are made. First, the study implies that font size, style and text medium do not influence the ability of students to grab concepts but instead the magnitude of effort made to study learning materials could be of tremendous help in promoting understanding. It is thus recommended that students should commit more effort into studying their lecture materials irrespective of the characteristics of the texts or the medium in which they presented. In addition, instructors and publishers are recommended to ensure that study notes or materials are prepared in tandem with what is being taught in class. There should be consistency in lecture materials and continuation from previous levels. The CLT shows that when students have previous knowledge of subject matter, they easily understand the material. Therefore, the previous knowledge of students must be considered when preparing study materials. Specifically, the paper suggests that instructors assess the strengths and weaknesses of each cohort of students prior to the start of the program, maybe the first day of class. This will help to guide the design of study materials to reflect the knowledge of students. In addition, educational institutions and authorities must also ensure that curriculums are structured such that there is continuation in topics taught in the same subjects at subsequent levels.

This study, like any other one, has some limitations. The study used a sample size of 24 which is small and thus could have influenced the results obtained. It was observed that the equal variance assumption was violated even after performing Box-Cox transformation. This could be due to the small sample size since sample size is known to influence heteroscedasticity. Future studies are recommended to explore this topic further with a larger sample size to obtain a more informative result. Second, the study used texts that were created from topics that are familiar to participants. This could be one of the reasons why statistically insignificant results were obtained. Further research could be conducted by using complex and familiar topics to examine the topic in different familiarity contexts. This would help explain if the subject area familiarity influences how font size, style, and medium affect text comprehension. Also, future studies can

assess comprehension using both multiple choice questions and open-ended questions to obtain a broader evaluation of text comprehension.

Appendix

Table 3.1. Anova Table.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	386282057	55183151	0.85	0.5632
Error	16	1037833577	64864599		
Corrected Total	23	1424115633			

Table 3.2. Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	14508	1643.98650	8.82	<.0001
F.style (A)	1	1609.54167	1643.98650	0.98	0.3421
F.size (B)	1	5.04167	1643.98650	0.00	0.9976
Medium (C)	1	145.47500	1643.98650	0.09	0.9306
F.styel*F.size (AB)	1	2512.12500	1643.98650	1.53	0.1460
F.style*medium (AC)	1	-953.54167	1643.98650	-0.58	0.5700
F.size*medium (BC)	1	-2026.07500	1643.98650	-1.23	0.2356
F.style*F.size*medium (ABC)	1	1469.10833	1643.98650	0.89	0.3848

Table 3.3. Factor Effects

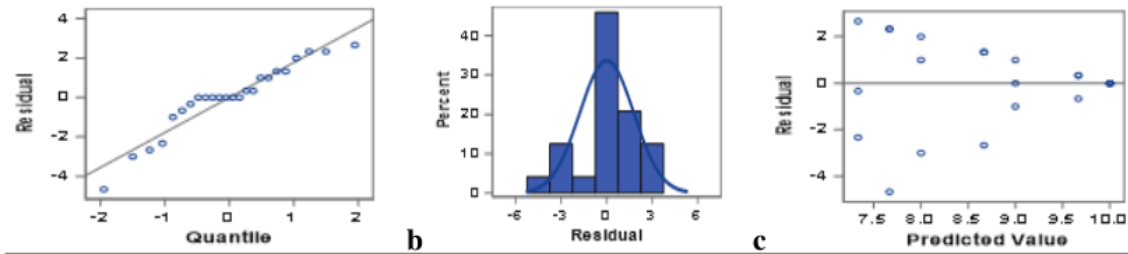| Obs	_NAME_	COL1	effect	neff
1	F.size*medium (BC)	-2026.07	-4052.15	-1.36449
2	F.style*medium (AC)	-953.54	-1907.08	-0.75829
3	F.size (A)	5.04	10.08	-0.35293
4	Medium (C)	145.48	290.95	0.00000
5	F.style*F.size*medium (ABC)	1469.11	2938.22	0.35293
6	F.style (A)	1609.54	3219.08	0.75829
7	F.styel*F.size (AB)	2512.13	5024.25	1.36449

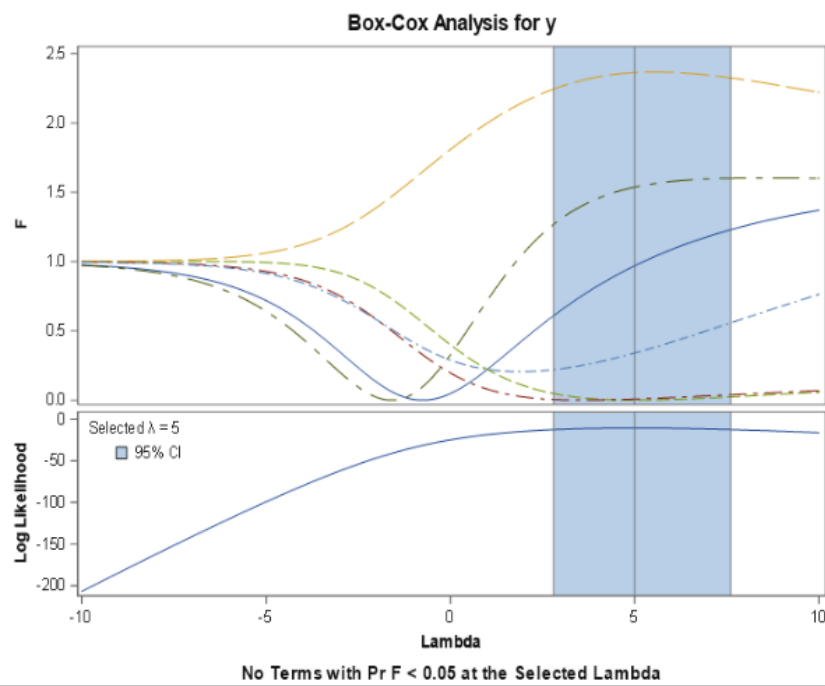Fig. 3.1. (a) Q-Q Plot; (b) Histogram; (c) Residual vs predicted plot
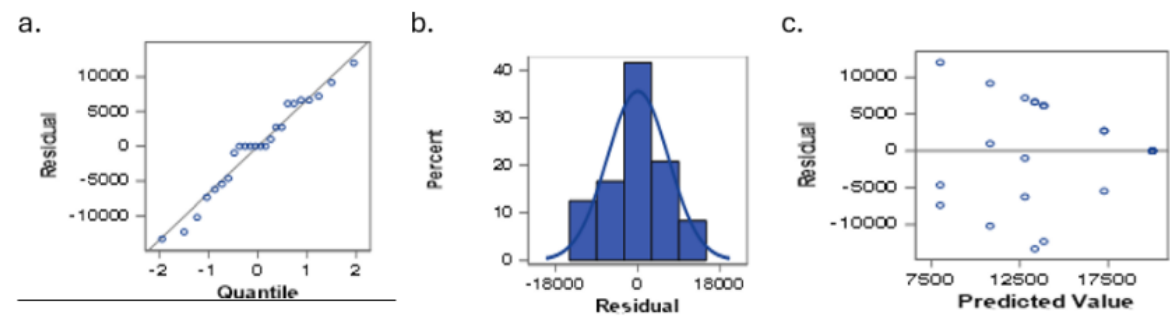
Fig.3.2 Box-Cox transformation of y

Fig. 3.3. (a) Q-Q Plot; (b) Histogram; (c) Residual vs predicted plot , after Box-Cox Transformation
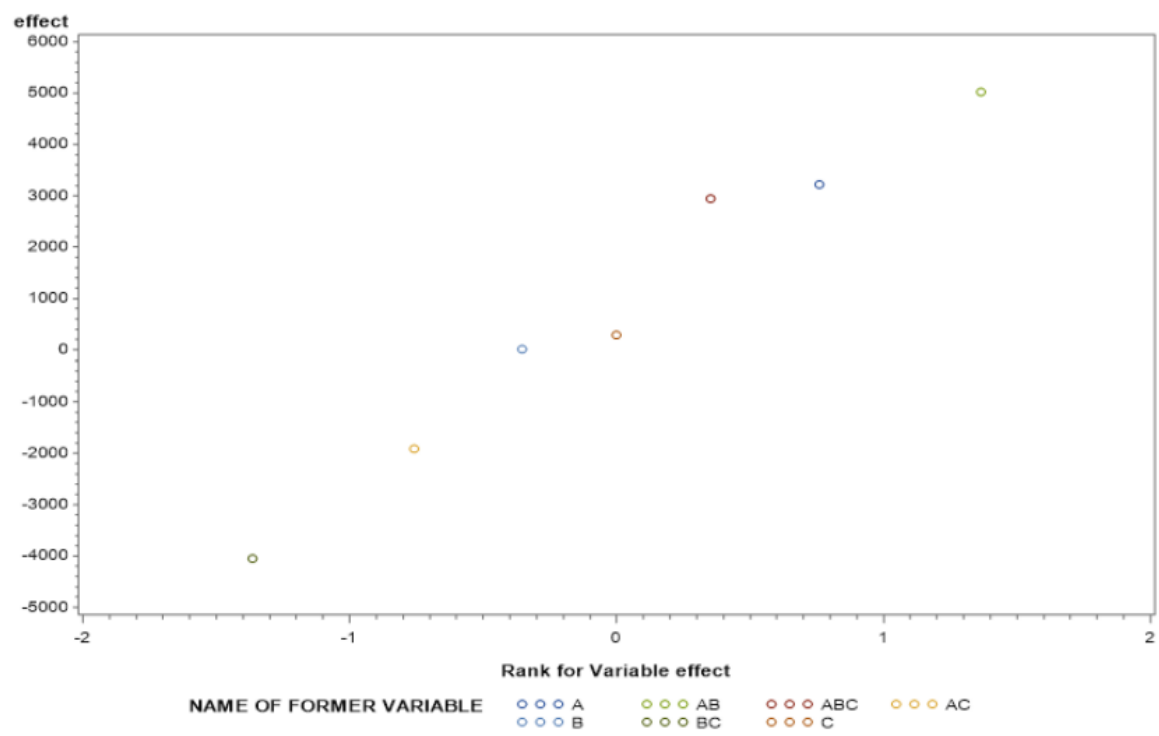
Fig 3.4. Percentage Probability Plot

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