"Is dark mode better than light mode?": Comparing Effects of Light and Dark Modes on Reading and Memory Recall

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ABSTRACT

Keywords
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INTRODUCTION

In the ever-evolving landscape of digital technology, user interface (UI) design is a vital component where the interaction between aesthetics, usability, and functionality profoundly influences the user experience. Among the myriad of design choices, one critical factor has taken center stage in recent years, sparking fierce debate and discussion in the tech community: the choice between light and dark modes for computer screens. This design debate, often taken for granted, has the potential to affect users' productivity, reading comprehension, speed, and memory retention in unique and complicated ways.

The contemporary digital age has seen a dramatic shift toward screen-centric activities, as we spend more and more time in front of computers, smartphones, and tablets. With this paradigm shift, the graphical design of the interfaces that mediate our interactions with technology has emerged as an area of profound importance. Light mode has long been the default choice for desktop displays and applications. Its popularity is deeply rooted in the history of graphical user interfaces and design principles that emerged in the early days of computing. As personal computers began to gain popularity in the 1980s, graphical user interfaces (GUIs) became an integral part of the computer experience and the fundamentals of interface design.

One of these fundamental design principles is the concept of WYSIWYG (What You See Is What You Get), which aims to make on-screen content look as much like printed material as possible. In keeping with this principle, light mode is the logical choice due to its similarity to traditional printed text on white paper. It offered high contrast and legibility, making it easier for users to read text and interact with graphical elements. Moreover, the choice of light mode as the default option was influenced by considerations of accessibility and universal design. Light mode traditionally provided a readable and inclusive interface that catered to a wide range of users. From a psychological perspective, light modes are also considered more attractive and professional. It is associated with clarity, purity, and efficiency. In productivity and office software, it conveys a sense of seriousness and authority. User familiarity with the light mode further cements its status as the default option for the majority of applications, operating systems, and websites. The preference for light mode is seen as an embodiment of design conventions that prioritize readability, accessibility, and user familiarity. However, as technology advances and our understanding of user experience deepens, the previously undisputed dominance of light mode is being scrutinized and reassessed.

In recent years, dark mode has become popular as an alternative to traditional light mode. The rise of dark mode can be attributed to a number of factors that have resonated with users and developers. One of the main benefits of dark mode is its capacity to diminish eye strain, particularly in dimly lit situations or at night. The sharp difference between a shining screen and a dull environment can cause distress for many users, leading to eye strain. Dark mode helps in alleviating this issue by employing a dim foundation and lighter content. Dark mode is said to improve focus and reduce distractions. The display's subdued colours and reduced brightness can promote concentration, making it an appealing choice for tasks that require deep focus like editing, writing, coding, etc. Lastly, by reducing the amount of blue light emitted from screens, the dark mode can be a more sleep-friendly option, which is important in a world where many users interact with screens late into the night.
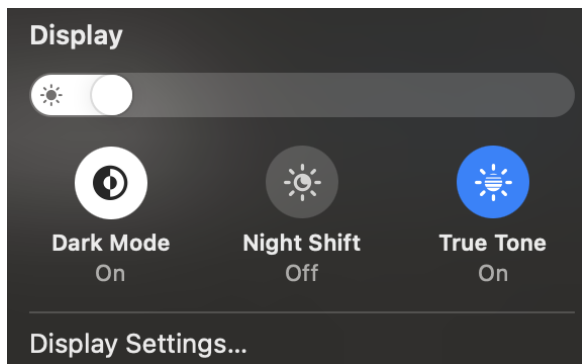
Figure 1. Screenshot of display in dark mode

The rise of dark mode as an alternative and the ongoing debate about its merits means there is a growing desire for options that cater to user preferences and different use-case scenarios. In this context, the default choice of lighting mode becomes a fascinating point of exploration as we seek to understand how and why it emerges and how its dominance influences how we perceive and interact with digital interfaces. Despite the prevalence of dark mode in today's digital environment, a comprehensive understanding of its impact on user performance, compared to a well-established light mode, remains elusive. This paper aims to fill this gap by delving deeper into the complex relationship between light mode, dark mode, and reading comprehension, speed, and memory. Specifically, we will investigate the following key questions:

1. How do light and dark modes influence reading comprehension and retention?
2. Can the selection of light or dark mode significantly affect memory recall and overall cognitive load during extended computer use?

By addressing these questions, we aim to provide a comprehensive understanding of the light vs. dark mode debate, enabling designers and developers to make more informed choices in crafting user-friendly interfaces. This paper aims to prove/disprove the claim that dark mode has an effect on reading comprehension/speed and memory retention. This research holds the potential to unlock innovative design strategies that not only cater to users' aesthetic preferences but also enhance their overall cognitive performance, thereby advancing the field of human-computer interaction in the digital age.

Related Work

There is a multitude of research and work related to the study of the use of dark mode and its effects on readers. A relatively recent conference paper "User Interfaces in Dark Mode During Daytime – Improved Productivity or Just Cool-Looking?" discusses the rise of the actual term "dark mode" and highlights Google Trends data showing this phenomenon in the summer of 2018 (Pedersen et al 2020) [5]. Despite the differences in the terminology used

in the past and more recent years, we see that many studies have attempted to measure the different strengths and weaknesses of using dark text on a light background versus light text on a dark background.

The study of a dark vs light mode has been measured in different ways by different researchers. A list of ways that light and dark mode text can be compared include visual acuity/ readability, retention, fatigue and perceived effort, and aesthetic and personal preference rating. There are some different considerations and ongoing debates as to whether dark mode is better than light mode depending on the factors considered.

The oldest relevant discussion found was from Hall and Hanna 2004 [2], where it was found through experiment that there was a clear indicator found that light mode was better for keeping attention, but in addition, an "aesthetic rating" was also recorded in their study in which dark mode had a high rating that was unexpected by the researchers.

Piepenbrock et al. (2014) [6] also directly compared a dark mode and light mode, measuring with several tasks like proofreading and participant ratings of legibility. They found positive results for light mode at smaller text sizes, but less significant differences for larger text sizes.

Perceived effort in reading dark mode versus light mode text is discussed with Sethi and Ziat (2023)[7], where they identify and propose that dark mode is perceived as requiring less effort. They also point out that the environment around the reader (ex. a dimly lit room versus a well-lit room) affects reading differences in light mode versus dark mode as well.

Finally, a moderate middle ground is discussed with Kim et al. 2019 [3], where different 'optimal' uses are discussed for dark mode and light mode depending on the situation, and suggests that dark mode is better for tasks that need to be sustained, but low levels of attention and light modes are better for shorter focused efforts

In addition to the fact that different characteristics are measured between different studies, the results of these studies still leave in contention which is the 'best' display type to use. As an insertion to this ongoing discussion, we hope to provide some increased clarity on how exactly dark mode may or may not be beneficial to readers of the text.

METHOD

Participants

The study will be performed with twenty participants who will be volunteering without any incentive for their participation. Each participant will be required to have prior experience with a computer or laptop and be able to interpret a small passage in English. This study will focus

on understanding the impact dark and light modes have on reading speed and memory retention; thus, for initial survey purposes, ten participants would be predominant dark mode users, whereas the remaining ten participants would be predominant light mode users. The study would target participants between the ages of 18 and 40, as this would represent a portion of the population of adults who spend a large portion of their day in front of a screen. Other demographic information about the participants would not be relevant for this study, as the focus is not on a particular gender or race.

Measurements

This user study will use both qualitative and quantitative measurements as experience, accuracy, understanding, and time will be measured. Each participant will be asked about their preference between dark and light modes and why they chose the particular mode. While testing for memorization, participants will be measured on the accuracy and speed of their memory of the text presented during a given time. For the reading comprehension portion of the study, participants will be timed while reading a small passage and will be tested on their accuracy and understanding based on their answers to questions about the passage. Once the tasks are completed, participants will be asked if there are any changes in preference for dark or light mode and how they felt while completing the tasks.

Apparatus

There will be a couple of key apparatuses used, all of which must be sterilized between each usage periodically, and re-set to ensure data collection is as unbiased as possible. The first is a computer which has been pre-set to the light mode versus dark mode comparison program for the study. Second, is a timing device, a stopwatch, that is separate from the computer being used to conduct the study on the participants. Thirdly, there will be questionnaires done via electronic form submission for the participants after each experimental set. They will fill it out and submit it promptly upon completion of the light versus dark mode program. Therefore, there will be both quantitative data collected and qualitative data, with biases accounted for concerning each participant. Lastly, there will be memorization material such as the names, characters or objects to compare the participants' performance in light mode versus dark mode. All in all, the software and hardware components will be pre-set by the experimenter and administered accordingly and equally for every participant to minimize bias or errors.
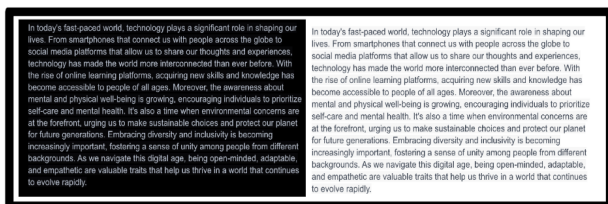
Figure 2. Screenshot of passage in dark and light mode

The second and third apparatuses are of critical importance and have past precedence of being used successfully in studies to record the time taken by participants to complete various tasks, a reliable timing device will be utilized. This approach is in line with previous studies that measured reading speed and comprehension Cheon et al.[1] in 2012. There is also the aspect of structured questionnaires which will be administered to participants to gather data on their preferences regarding dark and light modes. The questions will explore the reasons behind their choices and their subjective experiences with each mode. This instrument is inspired by prior research examining user preferences in interface design and reading mode. Lastly, memorization material is commonly used for cognitive computer-related tests to assess memory retention such as what Larson[4] did in 1998.

Procedure

The purpose of the experiment will be explained to the participants, and their preferences regarding light and dark modes, as well as the reasons for their choices, will be recorded. Each participant will be seated in front of a computer or laptop and will be familiarized with the task until they are prepared to proceed.

Einstein 42 Oprah 18 DaVinci 7 Curie 5 Luther 11

Figure 3. Screenshot of a memorization task

The first ten participants will perform the memorization method first in dark mode, while the remaining ten participants will perform in light mode. They will receive clear instructions that the time taken for them to memorize and the accuracy of their memorization will be recorded for the experiment's purpose. The task assigned to them in the first level involves memorizing names and small numbers, while random characters will be the focus of the second level. The amount of time required for participants to memorize the information until they are ready will be documented. Following the completion of each level, the participants will input what they have memorized, and the number of correct answers will be recorded.

Following the memorization method, the participants will be directed to perform the speed reading method. Explanations regarding the time taken for their readings and the accuracy of their answers in questionnaires that will be recorded will be given to the participants. The time required for the participants to comprehensively read and grasp the information will be recorded for both the first and second levels, with the first level expected to be comparatively easier than the second level. It is important to note that the passages in both levels will be designed for easy comprehension within the participants'

knowledge. After the completion of each level, a questionnaire will be distributed to the participants, based on the passage they have read, and the number of correct answers will be recorded.

Upon the completion of these procedures, the first ten participants will then follow the same procedures in light mode while the other ten participants will perform in dark mode. The time taken to complete the assigned task and the number of correct answers obtained for both memorization and speed reading methods in light mode will be recorded.

Design

This user study employed a 2 x 2 x 2 within-subjects design and the independent variables and levels will be as follows:

Method: Memorization, Speed Reading
Level of difficulty: 1, 2
Mode: Light mode, Dark mode

There will be two dependent variables: the task completion time, which measures the time taken for each participant to complete the assigned tasks for both memorization and speed reading, and the number of correct answers. Memorization relates to the accuracy of the responses matching the provided sentences that need to be memorized, while the speed reading task, is the number of accurate responses obtained from the questionnaire at the end of the task.

Each participant will be tested on both memorization and speed reading at two levels of difficulty in both light mode and dark mode. Considering that each of the 20 participants will be tested, there will be 20 participants x 2 methods x 2 levels x 2 modes = 160 trials.

RESULTS AND DISCUSSION

CONCLUSION

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