Does Dark Mode Affect Credibility Judgements on Websites?

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ABSTRACT

Within a very short period of time after visiting a website, people judge the website's credibility based on its aesthetics. The factors responsible for this rating are highly relevant to the design, as they decide whether to stay on or leave the website. In recent years, operating systems and web browsers use increasingly dark backgrounds, which is referred as dark mode. The use of dark mode has become more and more established. Related work suggests a link between the effect of dark mode and ambient lighting, although there are very few studies examining the effect of dark mode or ambient lighting on credibility. In this paper, we conducted a lab study (N=48) to investigate the effects of dark mode and different environmental lighting on credibility judgements of websites. The participants looked at a total of 10 websites and rated their credibility after each individual page. The ambient lighting was changed in the middle of the experiment. Our results indicate that there is no significant effect of dark mode or ambient lighting on credibility. However, we found that male participants rated the sites as more credible than women. In addition, participants with a technical background assessed the credibility higher when the pages were presented in light mode and bright environment. Moreover, the participants who based their judgement on the design differed in their rating from those of the others.

KEYWORDS

Credibility, Dark Mode, Environment Lighting, Websites

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1 INTRODUCTION

Whenever information becomes relevant to decisions or actions that we do not know from our own perception, the question of its credibility arises [20]. Credibility can be understood as the willingness to accept messages from a certain object as correct based on concrete evaluation processes [42]. Frequently, 'credible information' is associated with websites [10].

Judging credibility online, Wathen and Burkell use a process-related model of credibility evaluation [41]: The user starts with the 'surface evaluation' followed by 'message evaluation' and 'content evaluation'. If the recipient perceives the credibility as 'insufficient' in one of the first two steps, the reception is terminated [41]. Consequently, how people judge the credibility of a website determines whether they stay on or leave the site, which may affect other sub-behaviours, such as making a purchase or sharing personal information [10, 28, 40, 41], which plays a decisive role for the operators behind the pages. Another assumption can be made from the model: The credibility of a website on the Internet is based on both content and visual-structural criteria [36]. This assumption is supported by the results from Lindgaard et al., who found that an initial decision to like or dislike a website is made within 50ms [23]. Furthermore, credibility judgements of websites are made after an average of 3.42 seconds based on aesthetics [35]. Hence, visual aspects of a website are crucial for the user's first impression.

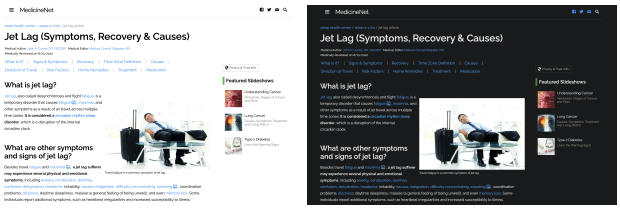


Figure 1: Snippets of a website in light and dark mode

Users themselves also specify design as the main factor in their credibility judgements[1, 10], far more frequently than information design/structure, followed by information focus [10]. The look of the design is the only visceral credibility criterion, which includes many visual elements, such as layout, typography, white space, images and colour schemes [2, 10, 44].

Alsudani and Casey found that contrast, along with balance, harmony and dominance, achieve a form of unity in design that affects judgement and attractiveness [3]. Specifically, contrast enlivens design, replacing the boring with the interesting [3, 14].

In general, the concept of contrast makes a distinction between positive and negative contrast. Positive contrast is defined as dark text on a light background, negative contrast represents light text on a dark background [5, 19]. In recent years, an upcoming trend has emerged called dark or night mode, where negative contrast is used in user interfaces [12, 37, 43]. Not only do people's preferences tend to dark mode [19], studies also showed that using negative contrast polarity in a dark environment can improve text legibility [27, 34]. Other advantages of using dark mode are saving power, which results in a longer battery life [6, 22], and offering improved usability, especially in dark environments [19]. Good usability is also a factor responsible for gaining higher credibility of a website [13], indicating, that credibility may be affected.

In this work, we investigate whether dark mode affects the credibility judgements users make for websites.

2 RELATED WORK

Since dark had become even more established in recent years, there was little in the way of literature investigating the effect of a dark user interface on users' perception. Nevertheless, there were some studies showing the impact of the environmental lightning on the perception of a dark user interface and the influence of dark mode on texts. These may provide an insight into the resulting change in human perception or behaviour and show us incentives for our study and new approaches.

Erickson et al. studied effects of dark mode on head-mounted displays and found that light letters on a dark background under low lightning conditions reduces visual fatigue and increases visual acuity [7, 19]. The environmental context is also part of a study, where participants had to drive in a simulator with a map navigation device in night and day mode with bright and dark environmental lightning. It turned out, that the participants spend less time looking on the day mode display at night, but it can lead to disorientation. Furthermore, it might have advantages to use the day mode at daytime. Hence, it is more appropriate to adjust the brightness of the display to the environment [33]. That matches with people's personal preference to use dark mode in a low-light environment [19]. These findings lead us to surmise that people's behaviour may also be affected when they search for information online with screen brightness adjusted or unadjusted to the environment, which is a factor we want to examine in our study.

Furthermore, in a chat on a social media platform, messages displayed on dark background were perceived more negatively than on white background. This implies that interface colour and contrast can influence sentiment perception, especially for ambiguous textual content [25]. With this knowledge, we assume that the choice of contrast of the display has an impact on the credibility, as this is intuitively made according to one's own perception. However, it is still unclear, how a dark interfaces may influence user perceptions of web pages. For this reason, we aim to explore the effects of dark mode on credibility judgements.

3 METHODOLOGY

In this section, we describe the experiment that we conducted to investigate our research question. Participants were asked to judge the credibility of websites in context of a given task of interest under different light environment conditions. The experiment was performed as a lab study.

The protocol was approved by the Chair of Information Science of the local university, and written informed consent was obtained from each participant before the start of the laboratory study.

3.1 Materials

3.1.1 Apparatus. The used notebook was an Apple MacBook Air (M1, 2020), running at 3.2 GHZ, with 8 GB of RAM. The display had a size of 13.3-inch, a 2560-by-1600 native resolution at 227 pixels per inch and a maximal brightness of 400 nits. The brightness level was constantly at 200 nits to ensure the reliability of the experiment. A Logitech mouse was used. The software, written in JavaScript, HTML and CSS, implemented the websites. Only images of the certain websites were shown to prevent users from interacting with them. Google Chrome was set as the default browser in order to have consistency in the browser's appearance. To customise the mode, Apple's built-in dark mode was enabled or disabled depending on the implementation. As a result, the Chrome bar has also automatically adapted to the mode selection. To assure that participants were not distracted due to possible incoming notifications, Apple's "Do Not Disturb" mode had been activated.

3.1.2 Physical Environment and Lighting. We prepared an isolated room without any windows to fully eliminate daylight, which allowed us to control the overall lighting in the setup. Thus, the differences between the amount of light in the physical environment could be evaluated. We measured the different lighting conditions with a lux meter to ensure the repeatability of the test. For our experiment, we needed both a light and a dark environment. In order to create a light, authentic workplace environment, we chose a lux value of 500 lux, which is legally required as the minimum brightness in the office [9]. Contrariwise, for the dark environment we chose a value between 10 and 12 lux, which was classified as low light in a comparable experiment [17]. The desired brightness value could be easily achieved with a dimmable floor lamp.

3.1.3 Data Collection. We used the document collection in the medical domain made available by Zimmerman et al. [38], which deals with whether melatonin helps against jet lag. When seeking information via the internet, most people comb through several websites. However, the quality of the websites presented on the web search varies greatly. By using the above collection, we wanted to mimic an authentic web search.

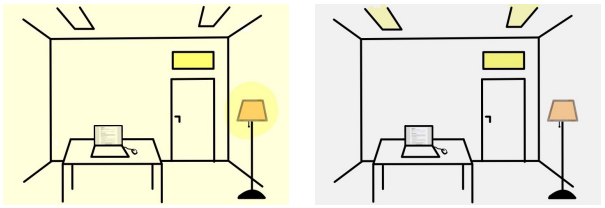
Since we could not show the participants all the websites in the collection due to time and fatigue, we conducted a preliminary study aimed at finding the websites where the subjects were most unsure about their credibility judgements. By eliminating the extremes, we got the pages that people are most unsure about, so dark mode had a chance to affect credibility judgements. The preliminary study included all the websites in the collection, each of which was rated on a 7-point Likert Scale according to its credibility and the certainty of this assessment. From this, we obtained 10 suitable websites for our study.

3.2 Participants

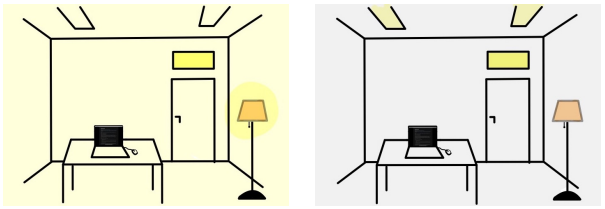
A total of N = 48 participants were recruited via e-mail lists and personal interaction at University of Regensburg, ranging in age from 18 to 30 years (M = 22.56, SD = 2.641). 19 participants identified as male, 29 as female and none as diverse. All participants were either undergraduate (n = 28), graduate students (n = 6) or other students (n = 14), from first to eleventh semester (M = 4.71, SD = 2.783). 20 participants are studying computer science-related courses (media informatics, information science, business informatics), 24 are from other faculties, such as human science and languages, economics or education science.

The participants were asked to rate their English proficiency on a 7-point Likert scale from "Very bad" to "Very good" (M = 5.21, SD = 0.898) to role out the possibility of language barriers.

Half of the participants in the study (n = 24) had a visual impairment such as myopia (n = 23) and/or red green deficiency (n = 2) and four participant reported having a diagnosed dyslexia.



(a) Group 1&2: light mode; changing order of environments



(b) Group 3&4: dark mode; changing order of environments

Figure 2: Experiment Design

On a 7-point Likert scale, 12 participants stated that they never use dark mode, whereas 5 always use it (M = 3.75, SD = 2.047).

Due to making mistakes in execution, 4 persons were excluded as they judged all websites within the first environment.

3.3 Design

This experiment had two independent variables in a 2 x 2 arrangement (4 combinations, see Figure 2):

- mode: light and dark
- environment: bright and dark

The dependent variables were:

- credibility judgement on a 7-point Likert Scale
- level of confidence of the judgement on a 7-point Likert Scale

The experiment had a mixed group design: Regarding the mode, between group design was chosen so that the participants would not realise that the study examines the effect of dark and light mode. This knowledge or assumption could influence the judgements, depending on whether one likes to use dark mode or not. Thus, carry over effects were eliminated.

Regarding the ambient lighting, within group design was chosen to take individual differences into account. The lighting is only changed once, resulting in two blocks, as the eyes had to get used to the light and the study would be unnecessarily lengthened otherwise. Since the order of light and dark surroundings should be balanced, this resulted in four groups (see Figure 2). The problem of the order was taken into account by using a balanced latin square design. Each participant completed a set of 10 pages. Given, that there were 44 participants and 10 different websites, this made a total of 44 x 10 = 440 judgements overall.

3.4 Procedure

Before the participants entered the room, the apparatus was fully prepared and the ambient lighting was adjusted.

Upon entering, they were greeted and instructed to sit on the designated chair positioned in front of the computer display at a distance of about 0.4 m. Then, after a brief general introduction of the experiment content, the participants were asked to give their informed consent. The program started with a short introduction to a scenario, the task of interest, dealing with the topic of whether melatonin can help against jet lag. Next, the previous knowledge on this topic was queried on a Likert scale. Finally, the first website was shown. The participants could deal with the website without a time limit. After pressing the space key, the participants could submit their judgements on a Likert scale, first, how credible they find the website and second, how confident they are in their judgement. This process was repeated for another four websites, thus there are five websites per environment.

After the first five judgements were made, the ambient lighting was changed and a short five-minute pause started to allow the eyes to adjust [16]. To bridge the gap, the first questionnaire was asked, which consisted of demographic questions, since these were not strenuous and did not tire the participants. This questionnaire was filled out by the experimenter leaders because the participants should not look at a display during this adjustment time so that their eyes did not adapt to an unintentional brightness. This was followed by the next five websites, which were again rated according to their credibility and certainty of judgement.

Finally, participants completed the last questionnaire, which included technical questions such as their internet usage, the content of the study and their use of dark mode, by themselves.

4 RESULTS

The data was analysed using the statistical software R [8]. We used an alpha level of 0.05 for all statistical tests.

A two-way ANOVA was performed to compare the effect of dark and light mode and dark and bright environment lighting on credibility judgements. The ANOVA revealed that there was not a statistically significant interaction between the effects of mode and environment lighting ($F(1,42) = 2.770$, $p = 0.103$). In addition, neither mode ($F(1,42) = 0.399$, $p = 0.531$) nor environment ($F(1,42) = 0.007$, $p = 0.935$) alone showed a significant effect on credibility.

Descriptively, the means of the conditions assumed the following values:

Mode	Environment	Mean	Standard Deviation
light	bright	4.109	1.188
	dark	4.373	0.933
dark	bright	4.536	0.863
	dark	4.245	0.823

However, another two-way ANOVA showed that there was a statistically significant interaction between the effects of environment and gender, when using mode and gender as between, environment as within variables ($F(1,40) = 4.487$, $p = 0.040$). A post-hoc test did not provide any significant results, but from ANOVA we knew that gender had an effect on credibility. In order to investigate this effect in more detail, a t-test was carried out with the null hypothesis, which stated the means of the judgements of the respective gender were the same. Therefore, we performed a Welch's t-test with a 95% confidence interval (CI) to decide whether it could be rejected.. Inspection of Q-Q Plots revealed that credibility judgement was normally distributed for both groups and that there was homogeneity of variance. It was found that the credibility judgement of the

males (M = 4.547) were significantly higher (t(85) = 2.059, p = 0.043) than of the females (M = 4.140) with a difference of 0.407.

A three-way ANOVA was conducted to compare the effect of the mode, environment and study background. There was a significant effect on credibility judgement for the three variables (F(1,40) = 6.178, p = 0.017). Post-hoc comparisons using the Bonferroni Correction test indicated that the mean score of judgements in light mode in a bright environment by technical students (M = 4.525, SD = 0.628) was significantly higher than for the same setting by non-technical students (M = 4.142, SD = 0.865), with p = 0.043.

To compare the effect of the mode, environment and criteria of the judgement on credibility, another ANOVA was carried out. We differentiated between the participants who indicated in the questionnaire the design of the website as a factor that they used for their assessment. The ANOVA revealed that there was a statistically significant interaction between the effects of mode and aesthetics (F(1, 40) = 4.506, p = 0.040) and environment and aesthetics (F(1, 40) = 6.386, p = 0.016) on credibility. Post-hoc tests showed that no groups differed significantly from each other.

5 DISCUSSION

In this section, we discuss the results related to our research question and what the results mean for website design and website operators.

Mode & Environment: We expected to find differences in the credibility judgements based on which mode and environment lighting was chosen, aligning from ideas in the literature. However, our results showed no effect of mode or/and ambient lighting on the credibility ratings. Contrary to our expectations, we found out by means of descriptive statistics that the inappropriate use of the mode (e.g. dark mode in a bright environment) produces higher credibility values (M = 4.455) than the adjusted use (e.g. dark mode in the dark environment) (M = 4.177). However, it must also be mentioned that the differences were not significant. These results did not directly support previous literature that found the benefits of using dark mode on human perception [4, 7, 19, 33] and personal preferences of users to use dark mode with low light environments [19]. That dark websites received more credibility even contradicts previous knowledge, that information on a dark background would be perceived more negatively [25].

Gender: We had found through Welch's t-test that gender had an impact on the level of credibility judgement, with men rating it higher than women. This aspect was confirmed in previous work, in which gender influences viewing behaviour on webpages [15, 29–31]. Pan et al. found out using eye-tracking, that males exhibited significantly longer mean fixation durations than females [31].

In our study, we also had found a difference between gender and environment, which could also be substantiated by literature. Hence, women are more likely to perceive lighting as an important factor in their everyday lives [21]. Liu et al. had investigated how the lighting in the room affects the perception of different genders. Males showed less trustworthiness in a trust game in a dark environment than in a lighter environment, while there was no discernible difference in females [24]. This shows that ambient lighting and gender could affect credibility judgements and that both factors could influence the perception of a website.

Study Background: The study background also had a significant effect on credibility. Using a three-way ANOVA and Bonferroni correction, we found that technical students found websites viewed in light mode in a bright environment more credible than non-technical students. A study by Wei and Zhang [26] found that people's Internet knowledge significantly influences their intention to continue using the Internet by influencing their cognitive and affective cognition. From this, one could deduce that students from technical courses have more knowledge and experience in using digital devices and the internet due to their background, which could make them more discerning in their evaluations of online content. However, more literature is missing on this topic.

Evaluation criteria: The participants who named aesthetics as an evaluation criterion judged the pages significantly differently than those who did not explicitly pay attention to the design. However, it could not be determined which rating was higher. That website design affects credibility was supported by previous research which had shown that aesthetic design factors influence perceived credibility [3, 10]. The fact that 41% of participants explicitly cited design as an evaluation criterion is consistent with the results of Fogg's study mentioned in the introduction, in which 43.1% of participants cited "design look" as a comment on their credibility rating. From this, it can be deduced that the quality of the design can largely differ from the quality of the information presented. Some individuals may be more attuned to the visual aspects than others, who did not explicitly pay attention to design. Although the design was crucial for the judgement and hence affects how we negotiate further [10, 11, 40, 41], this aspect does not go as far as suspected that the contrast significantly influences the credibility.

Limitations: It is important to recognize that this work has limitations. Firstly, only young people between the ages of 18 and 30 participated in the study. Especially for people above this age range, the use of dark mode can potentially produce a different effect as fewer of them use the Internet. Specifically, the distribution of Internet users worldwide consists of 22.8% 18 to 24 year old and 33.8% 25 to 34 year old people [32], thus the young generation makes up the largest part. In addition, younger people use the Internet for a longer period of time [18], which can also have an impact on how Internet pages are perceived.

Furthermore, the generalisability of the study is limited by the choice of topic. Since melatonin is a drug and thus associated with the medical domain, which in turn is associated with the colour white [39], for the sterile, white pages may be considered more credible for this chosen topic. In contrast, if the topic were related to programming, the opposite effect could potentially be produced and pages presented in dark mode could gain overall more credibility.

6 CONCLUSION & FUTURE WORK

In this paper, we described a lab study investigating whether light respectively dark mode affects how people judge the credibility of websites. We included the ambient lighting and thus also considered the adaptation of the environment to the selected display mode.

Our study did not find any significant differences in credibility judgements, suggesting that the use of dark mode may not have an impact on the credibility of the presented website - even if the

mode is not adapted to the environment. Further research may be necessary to confirm this conclusion.

Males, participants with a technical study background and participants who use aesthetics as a judgement criterion assessed credibility of the websites significantly higher.

Future work could further examine gender differences, specifically what factors the genders use to judge a website's credibility. As well, a distinction could be made between the educational backgrounds of the participants and thus discover specific factors as to why people with an affinity for technology give different ratings. Furthermore, age groups could be distinguished, even in young ages. However, with these differences, it is important to have a large sample size in order to still obtain a representative image when there are several smaller groups formed.

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