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Review Article

Digital Display Preference of Electronic Gadgets for Visual Comfort: A Systematic Review

Nurulain Muhamad [1], Nurul Amira Nor Amali [2]

1. *Center of Optometry, Faculty of Health Sciences, Universiti Teknologi MARA Cawangan Selangor, 42300 Bandar Puncak Alam, Selangor, Malaysia*
2. *WHOOSH Southkey, 80150 Johor Bharu, Johor, Malaysia*

***Corresponding Author:** Email: nurulain5510@uitm.edu.my

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Abstract

Background: Digital devices such as smartphones, tablets, computers, and laptops are used for various purposes. The digital display quality has been improved, making it less tiring and more favoured among users. This study aimed to review the visual comfort of digital devices and the preferences of digital display settings that enhance the visual comfort experienced by digital device users.

Methods: A search of PubMed, EBSCO host MEDLINE Complete, Scopus database, Google Scholar, and manual citation review was conducted, covering the period between 2010 and 2022. The criteria were selected based on the PRISMA statements. The search mainly focused on finding the existing literature on digital devices that contribute to visual discomfort and digital device settings that provide better visual comfort.

Results: The database search resulted in 533 references via the application of Microsoft Excel. There were 28 studies included in the final assessment. Twelve studies accounted for digital devices that contributed to visual discomfort, while another sixteen studies for digital device settings provided better visual comfort.

Conclusion: Digital displays with high luminance contrast, positive polarity and adequate colour were preferred for better visual comfort. Meanwhile, smaller fonts were preferred for desktops and laptops, while larger fonts were favoured for smartphones. This study provides insights for digital display developers to learn and improve their display technology to fit the preferences expressed.

Keywords: Digital devices; Visual comfort; Display polarity; Color contrast; Luminance contrast; Font size

Introduction

Digital devices such as smartphones, tablets, computers, and laptops are used for various purposes. The Department of Statistics Malaysia has stated that the most assessed Information and Communications Technology (ICT) in Malaysia during 2021 is television, followed by mobile phones, radio, internet, computer, paid TV channels, and fixed-line telephone (1). Mobile phone or smartphone has been the top used among individuals. As reported by the Department of Statistics Malaysia for the year 2021, among all the ICT services and equipment, the mobile phone (98.7%), internet (96.8%), and computer (83.5%) are the top 3 being used by individuals (1). Smartphones are a familiar scene in the public nowadays, among children, teenagers and adults. The younger population is the majority who use smartphones daily and even own more than one phone (2,3). Older adults who use smartphones also commonly engage more in social media (4).

New display technology, an organic light-emitting diode (OLED), was introduced decades ago in digital devices. It has massively grown and competed with the LCD market. The strengths of the OLED display are its high contrast ratio, thinness, and fast response time for high-speed video (5). However, due to its bright and striking screen display, the OLED display can lead to visual fatigue faster than an LCD (6).

This study aimed to review the literature on visual comfort associated with digital devices and the preferences of digital display settings that enhance the visual comfort experienced by digital device users. Reviewing visual comfort can help users and digital device manufacturers achieve and provide the most preferred digital display setting.

Methods

Search strategy

A systematic literature search was conducted, covering the period between 2010 and 2022 to attain all accessible published information on digital display preferences and visual comfort following the PRISMA guidelines (7). Searches were conducted in online databases through PubMed, EBSCO host MEDLINE Complete, Scopus database, and Google Scholar. Search terms used to find relevant articles were 'smartphone', 'laptop', 'e-book', 'display contrast', 'display color', 'display polarity', 'text-background', and 'display typeface', 'visual comfort', 'visual performance', and 'subjective preference'. Journal articles that meet the requirement of the inclusion criteria were accepted. Meanwhile, journal articles that fall under the exclusion criteria were discarded. The search was narrowed to subjects free from any ocular and systemic diseases. All study designs were included. The exclusion criterion was to limit the papers published in a non-English language, commentary letters, and editorial-type of articles and articles from 2009 and below. All duplications were checked thoroughly and excluded from the search to avoid redundancy. The selected articles were scanned, and the abstracts were checked to ensure internal validity and reliability and the quality and relevance of academic literature. The research paper was carefully evaluated to carry out at a later stage. Figure 1 shows the application of PRISMA, which represents the flowchart of study selection.

Results

Overall, 28 articles were included in the final assessment after the database search, which resulted from 531 references via Mendeley. There were 7 articles removed for duplication of articles. These 28 articles were selected after an assessment based on the inclusion and exclusion criteria. The selected articles were tabulated into two tables; symptoms associated with the digital devices (Table 1) and the preferred display settings (Table 2). Twelve articles for the first table were extracted to obtain the author, year, title, associated symptoms and types of digital display devices. Another 16 articles for the second table were extracted to obtain the author, year, title, sample size, visual task, duration, device, and display settings. The highly reported associated ocular symptom due to the significant effects of digital devices was eyestrain (Table 1). Approximately 50% of digital users suffered eyestrain (6 out of 12 studies) after prolonged digital device usage (10-14). The second highly reported ocular symptom associated with digital devices was dry eyes at 41% (5 out of 12 studies) (10,12,14,15,19).

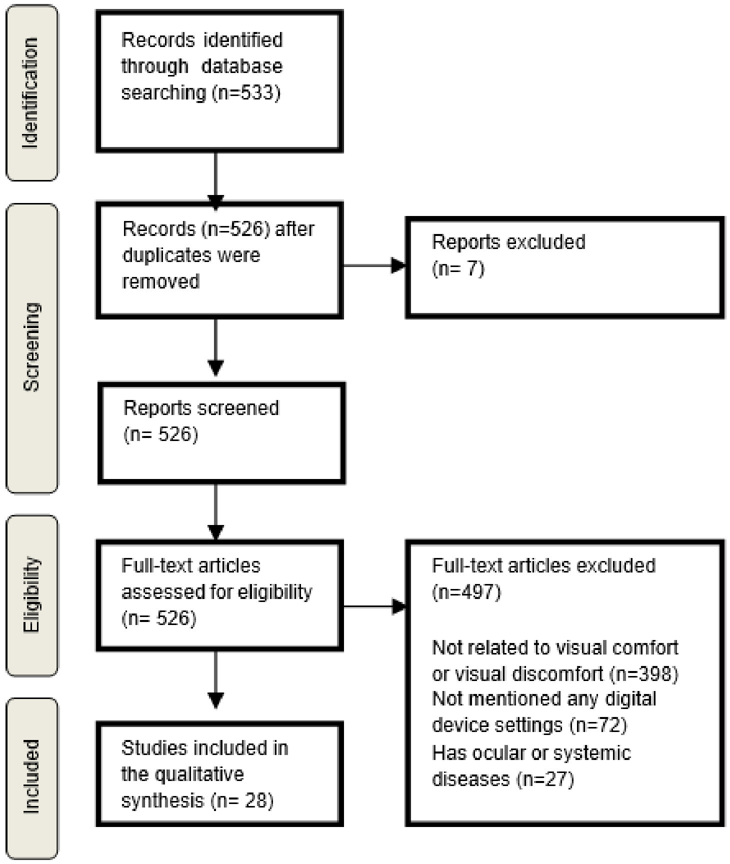

Fig. 1: PRISMA diagram of the systematic review process. PRISMA: Preferred reporting items for systematic reviews and meta-analyses

The dryness led to an increment in blink rate and decrement in tear break-up rate (14,17). This is followed by the third highly reported associated ocular symptom, blurry vision, which accounted for approximately 33% (4 out of 12 studies). Eye discomfort and tiredness were equally reported at approximately 25% as consequences of reading from digital devices (3 out of 12 studies). The second least associated ocular symptom reported was the sensation of a sore eye, at about 16% (2 out of 12 studies). The least reported ocular symptom of digital device were sleepiness, headache, redness and watery eye (8%).

The majority of the studies incorporated smartphones as the digital device (50%), where the highly used iPhones from various models (iPhone 5, iPhone 4 and iPhone 4s) (10-15). Besides the smartphone, most of the studies used tablets as the digital device, comprised of iPad and Kindles (10,16-19). Besides smartphones and tablets, computers and laptops are also being used in the study to investigate the effect of the digital device on visual comfort (19,21,22).

The type of visual tasks that were mentioned, discussed and assessed (Table 2) in the preferred digital display of settings for visual comfort were reading comprehension (n=9, 56%), word search (n=2, 12%), text legibility (n=2, 12%), proofreading task (n=2, 12%), stimulus fixation (n=1, 6%) and intelligence test (n=1, 6%). The preferred display settings of digital devices for visual comfort, as reported, were high luminance contrast (n=6) (23,25,31,37-39), positive polarity (n=5) (23-26,29), larger font size (n=2) (24,32) and adequate colour contrast (n=2) (29,36).

Table 1: Summary of significant effects of digital devices on visual comfort as reported

Author, Year (Ref)	*Study*	*Associated symptoms*	*Types of Digital display devices (size/dimension)*
Golebiowski B., etal., 2020 (11)	Smartphone use and effects on tear film, blinking and binocular vision.	Eyestrain, comfort, tiredness, sleepiness (Incomplete blinks: ↑)	Smartphone: iPhone5
Jaiswal S., et al.,2019 (10)	Ocular and visual discomfort associated with smartphones, tablets, and computers: What do we do and do not know?	Headache, eyestrain, dry eyes, sore eye	Smartphone, Tablet
Antona B., et al.,2018 (15)	Symptoms associated with reading from a smartphone in conditions of light and dark	Blurry vision, difficulty in refocusing, dry eyes, eye strain, eye discomfort	Smartphones: iPhone4 (3.5", 640 x 960) Motorola Moto-G (4.5", 720 x 1280)
Long J. et al., 2017 (13)	Viewing distance and eyestrain symptoms with prolonged viewing of smartphones	Eyestrain	Smartphone: iPhone4S (3.5", 960 x 640)
Moon J.H, et al.,2016 (14)	Smartphone use is a risk factor for pediatric dry eye disease according to region and age.	Dry eye (Blink rate: ↑)	Smartphone
Kim J., et al., 2016 (12)	Association between Exposure to smartphone and adolescents	Blurry vision, redness, visual disturbance, watery eyes, dryness	Smartphone
Kim D.J., et al.,2017 (17)	Visual fatigue induced by viewing a tablet computer with a high-resolution display	Tired eye, irritated eye, sore/aching eye, watery eye, burning eye (Tear film break-up: ↓)	Tablet: iPad Air (9.7", 2048 x 1536)
Maducdoc M.M., etal., 2016 (16)	Visual consequences of electronic reader use: a pilotstudy	Eyestrain	Tablet: iPad 1 (9.7", 1024x768)
Hue J.E., et al.,2013 (18)	Reading from electronic devices versus hardcopy text	Tired eyes, eye discomfort (electronic devices only)	Tablet: Kindle vs printed text Tablet: Apple Ipad vs printed (49mmx76mm)
Phamon-vaechavan et al., 2017 (19)	A comparison between the effect of viewing test on computer screen and iPad on visual symptoms and functions	Blurry of vision, dry eye, eye pain	Computer: Dell(17") Tablet: iPad
Köpper M., et al.,2016 (22)	Reading from computer screen versus reading frompaper: Does it still make a difference?	Eyestrain	Laptop: Apple MacBook Pro (15.4", 2880x 1800) Text not in full size asa laptop (1486 x 1050)
Chu C., et al., 2011 (21)	A comparison of symptoms after viewing text on a computer screen and hardcopy	Blurry vision	Computer (Dell Optiplex GX620, 17' flat panel monitor)

↑: increases, ↓: decreases

Table 2: Summary of preferred digital display of settings for visual comfort as reported

Author, Year	Study	Sample size (n)	Visual task	Duration	Device	Preferred digital display settings
Xie X.J., et al., 2021 (23)	Study on the effects of display color mode and luminance contrast on visual fatigue	Young adult (n=60)	Searching words, Reading comprehension	60 min	Computer: Benq (27", 3480 x 2160)	• Positive polarity • High luminance contrast
Huang H.P., et al., 2021 (25)	Visual comfort of tabletdevices under a wide range of ambient light levels	Young adult (n=24)	Reading	N/A	Tablet: iPad Air 2 (9.7", 2048 x 1536)	• Positive polarity • High contrast text-b/g
Dobres J., et al., 2017 (24)	Effects of ambient illumination, contrast polarity, and letter size on text legibility under glance-like reading	Adult (n=34)	Forced choice lexical decision task	N/A	Computer: Dell (17", 1280 x 1024)	• Positive polarity • Letter size: Larger in negative polarity
Piepenbrock C., et al., 2014 (26)	Positive display polarity is advantageous for both younger and older adults.	Elderly (n=85) Young adult (n=84)	Proofreading task	75 min whole session. 50 sec each text, 28 texts with a break within 2 text	Computer: Apple iMac (24", 1920 x 1200)	• Positive polarity
Shih Y.N., et al., 2013 (29)	The influence of computer screen polarity and color on accuracy if workers' reading of graphics	Adult (n=504)	Question bank for graphic intelligence test	Pre-test: 15min Whole: 20min	Computer	• Positive polarity • Adequate color contrast
Tian P.Y., et al., 2022 (36)	Effects of paradigm color and screen brightness onvisual fatigue in light environment of night based on eye tracker and EEG acquisition equipment	Young adult (n=15)	Stimulus fixation	Whole: 120 min, 12 rounds of the experiment	Computer: Asus (27", 3840 x 2160)	• Low luminance • Preferred color: green, blue, black,

Morrice E., et al., 2021 (31)	Assessing optimal color and illumination to facilitate reading	Undergraduate student (n=15) Young adult (n=15)	Reading comprehension	Based on reading speed	Tablet: iPad Air (9.7", 2048 x 1536)	• High luminance and colour temperature
Huang H.P., et al., 2019 (28)	Effects of text-background lightness combination on visual comfort for reading on tablet display under different surrounds	Young adult (n=20)	Reading	Whole experiment: 80 min	Tablet: iPad Air 2 (9.7", 2048 x 1536, highest luminance 403 cd/m2)	• Darker text against a lighter background is preferable.
Dobres J. et al., 2018 (32)	The effects of visual crowding, text size, and positional uncertainty on text legibility at a glance	Adult and elderly (n=30)	Forced choice lexical decision task	1 hour for 5 conditions with a short 30s break	Laptop: Acer (27", 2560 x 1200)	• Large font size
Huang S.M., 2019 (34)	Effects of font size and font style of Traditional Chinese characters on readability on smartphones	Undergraduate students (n=162)	Reading comprehension	<10 min	Smartphone: ZenFone 2 Laser (5.5", 720 x 1280)	• A small font size is preferable due to the variable viewing distance
AliA.Z. M., et al., 2013 (35)	Reading on the computer screen: Does font type has effects on web text readability.	(n= 48)	Reading comprehension	Depending on 140 words for each reading block	Computer (21", 1280 x 1024)	• Font type: San Serif (Verdana and Georgia)
Lee D.S., et al., 2011 (33)	Effect of light source, ambient illumination, character size and interlinespacing on visual performance and visual fatigue with electronic paper displays	Young adult (n=60)	Letter-search task	90 min to complete	E-book: Kolin (640 x 480) Ebook: Sony (800 x 600)	• Larger font/character

Köpper M., et al., 2016 (22)	Reading from computer screen versus reading from paper: does it still make a difference?	Young adult (n=186)	Proofreading task	45 min for reading time. 60 min for the entire procedure.	Laptop: Apple MacBook Pro (15.4", 2880x 1800). Text not in full size as a laptop (1486 x 1050)	• Low luminance
Na N. & Suk H.J., 2014 (37)	Adaptive luminance contrast for enhancing reading performance and visual comfort on smartphone display	Young adult (n=50)	Reading	10 pages x 7 selected stimuli	Smartphone: Samsung Galaxy S3 (4.8")	• High luminance contrast
Na N. & Suk H.J., 2015 (38)	Adaptive display luminance for viewing smartphones under low illumination	Young adult (n=50)	Reading	5min	Smartphone: Samsung Galaxy S3 (4.8")	• High luminance contrast
Na N., et al., 2016 (39)	Adaptive luminance difference between text and background for comfortable reading on a smartphone	Young adult (n=50)	Reading	10 pages x 7 selected stimuli	Smartphone: Samsung Galaxy S3 (4.8")	• High luminance contrast

Discussion

Effects of digital devices on visual comfort

The American Optometric Association has reported that digital eye strain refers to eye and vision-related problems due to prolonged screen time. A person exposed to 2 h or more screen time has a higher risk of developing Computer Vision Syndrome (CVS) (8). In conjunction with the COVID-19 pandemic, a significant increment in digital device use from 4 h to more than 5 h was shown during the lockdown period among children and adults (8,9). Different types of digital devices, such as smartphones, tablets, and laptops, lead to different experiences in visual comfort.

Smartphone

A systematic review by Jaiswal et al. found 4 articles concluded that smartphone use significantly increases the symptoms of ocular and visual discomfort, such as visual fatigue, blurry vision, asthenopia, tired eyes, and eye strain (10). The symptoms increased with prolonged smartphone use (11-13). A study also found that prolonged smartphone use increases the tendency of several ocular symptoms and has suggested that smartphones affect distance visual acuity when used close to the eyes (12).

Smartphone use within 60 min induces eyestrain symptoms among young adults, such as tired eyes, irritated eyes, eyestrain, and blurry vision (11,13). The symptoms significantly increase when the viewing distance decreases, especially at the end of the 60 min. The viewing distance during the first 10 min of the experiment, the second 10-minute interval, and the fifth 10-minute interval were more significant than the viewing distance during the last 10 min of the task. The subjects tend to hold their smartphone closer at the end of the reading period (13). Thus, viewing distance that becomes shorter after prolonged use of a smartphone is one of the reasons for increased symptoms of visual discomfort.

Besides eye strain, asthenopia, and blurry vision, dry eye is a common symptom of prolonged smartphone use. A study on Korean children found that children who have dry eyes have the most screen time compared to the control group, which is 0.62 ± 0.68 h in the control group and 3.18 ± 0.97 h in the Dry Eye Disease (DED) group (P<0.001). The signs of dry eye were assessed before and after 4 weeks of smartphone use cessation, which showed significant changes in punctate epithelial erosion and TBUT (14). The signs of dry eye reduction after stopping smartphone usage indicate that the use of smartphones, especially for a continuous period, is the factor towards the dry eye and discomfort of eyes. The mechanism of dry eye development after prolonged screen time is incomplete blinking. After 10 to 60 min of reading a novel using a smartphone, the incomplete blinking significantly increases compared to the first 10 min (11). This study also supported the worsening symptoms after prolonged screen time (11).

Consequently, sleepy and tired eyes were one of the significant symptoms shown after 60 min of continuous reading with a smartphone. This was all due to the frequent incomplete blinking after prolonged screentime. A study was also done by presenting text on smartphones using the WhatsApp application, commonly used among participants (15). The symptom scores were higher in smartphones compared to paper. The symptoms comprised blurry vision while reading, blurry vision after reading, difficulty refocusing, burning eyes, dry eyes, eyestrain, tired eyes, sensitivity to bright lights, and eye discomfort (15).

Tablet

The use of tablet devices has been reported to induce eye strain and irritation (16). This study compared iPad and printed (controlled) groups when reading for an hour. During an hour of iPad reading, eye strain and irritation were induced. However, the other ocular symptoms (burning, dryness, eye pain, and tired eyes) were raised only after an hour of reading with the iPad and the printed text (16).

The symptoms of tired eyes, irritated eyes, sore/aching eyes, watery eyes, and hot/burning eyes show significant increments in the score after an hour of screen time (17). This study has tried to reduce asthenopia by improving retina display using a high pixel density technology (state-of-the-art). Unfortunately, the high pixel density technology does not prevent asthenopia from happening (17). Tablet screen time for 12 min was insufficient to raise the subjects' symptoms of blurry vision, visual fatigue, and discomfort (18). Even though the amplitude of accommodation (AA) significantly reduced after near-work activities using a tablet, it still does not support that reduced AA affects visual comfort because the study shows no symptoms with tablet usage for 12 min.

However, in a recent study, iPad significantly led to a higher pain score (eyestrain, headache, and tired eyes) and blurred vision scores compared to a computer after 20 min of reading (19). Changes in AA were also significantly reduced after reading with a tablet. Thus, reduced AA after prolonged tablet use affects one's visual comfort.

Laptop/Computer

The previous study found that up to 90% of users experienced visual symptoms after prolonged use of laptops and computers, including eyestrain, headache, ocular discomfort, dry eye, diplopia, and blurry vision. Similar symptoms are also known as Computer Vision Syndrome (CVS). CVS can be caused by two major factors, which are 1) inappropriate oculomotor responses and 2) dry eye (20). A study found a significant difference when comparing the symptoms of blurry vision between computer and hardcopy after 20 min of continuous reading (21). Blurry vision while viewing the task has a higher score in computer use than the hardcopy. The other symptoms, including difficulty refocusing, irritated eyes, dry eyes, eyestrain, headache, tired eyes, sensitivity to light, and discomfort, also contributed to a higher computer use score than hardcopy. However, each symptom score has yet to achieve a significant level compared to the hardcopy (21). This study was done for 20 min with a reading task that might not fully contribute to CVS. The results of each symptom are also similar when compared between computer and paper, except for blurry vision while viewing.

Another similar study with 20 min reading period on a computer and iPad found that the two groups have significant differences: pain and blurred vision scores (19). However, the difference was higher for iPad than computers. Meanwhile, the dry eye score shows no significant difference between those two devices. A 20-minute reading period was insufficient to induce dry eye symptoms. Comparing computers and tablets shows computers have less contribution to the visual symptoms while the tablet was vice versa.

Another study compared laptops and paper where the participants needed to proofread for 21 and 63 min for each display text (22). In this study, since the task duration is longer than in the previous article that has been discussed, it was expected to have a higher score of ocular symptoms. It was found that eyestrain scores were significantly higher in periods of 21 min and 63 min (22). However, headache and musculoskeletal strain show no significant difference between screen and paper (22). Thus, prolonged screen time might increase symptoms, but the difference between laptop screens and paper was insignificant. In addition, the study has found no significant differences between reading speed and proofreading performance on computer screens and paper (22).

Display polarity

Electronic devices with negative polarity (NP) induce a higher blink rate (BR) and pupil accommodation (PA) compared to positive polarity (PP), which instinctively results in lesser visual fatigue in NP (23). However, subjectively, the visual fatigue score (VFS) was significantly higher and subjective preference (SP) was lower in NP compared to PP (23). The results contradict each other, where the objective aspects show that NP is better than PP, whereas subjective aspects show that PP is better than NP.

The "positive polarity advantage" has been discussed in several studies, which found that PP text was easier to perceive compared to NP (24-27). The PP has a lower threshold than NP under bright and dark lighting, where a lower stimulus display time threshold indicates superior legibility. This "positive polarity advantage" results from pupil constriction due to bright illuminations (24). The visual comfort scale was larger in NP for illumination under 1,500 lx. Meanwhile, PP was higher for lighting above 3,000 lx. However, PP has an increasing trend of visual comfort with a lighter background in all the illuminance from dark to 15,000 lx (25).

Due to the "positive polarity advantage", PP has been chosen as the most preferred polarity. A study found that a "positive polarity advantage" exists for both younger and older adults because both populations significantly affect visual acuity and proofreading performance regardless of polarity (26).

Preferred digital display settings for visual comfort

Color Contrast

The text-background choices were essential to ensure the most comfortable experience of the digital devices. Studies have shown that higher color contrast gives more comfort in a dark environment: black text with a light grey and a medium grey background (25,28). A lighter background color provides the most comfortable experience when infusing positive polarity aspects. In terms of primary color and polarity, a study found that blue PP has the highest accuracy in graphic comprehension (29). This is then followed by blue NP, green PP, green NP, red PP, and red NP (29). Thus, different primary colors for the screen background have highly influenced graphic comprehension. It was crucial to understanding that screen polarity and color changes technically affect human performance because they contribute to a particular occupational form. This was based on a theory that occupational performance changes with occupational structure (30).

Younger and older adults with 20/80 conditions read faster in higher lux and lower color temperatures (31). This study introduced three assistive technology devices, the LuxIQ, the Apple iPad, and the Playbulb smart bulb, that can allow lighting and color output changes based on the user's preferences. All the devices benefited older adults regarding reading speed, while younger adults with 20/80 VA significantly improved their reading speed with LuxIQ and Playbulb (31). A more extensive prospect is awaiting digital device developers who want to incorporate assistive technology into their devices for better user visual comfort.

Font Type and Size

A study using a laptop display found that a 4mm font size performs significantly better than a 3mm font size in terms of display time threshold among adults and older people (32). This is similar to an article where a different device, an e-book, was studied, and the author found that the largest font size of 3mm has a higher searching speed than the 2mm font size (33). Thus, larger text sizes have higher reading and searching speeds than smaller text. Even though the inter-line leading is wider at 3mm, this study found that the condition still has a higher display time threshold than a 4mm font size with a narrow leader (32). inter-line leading does not significantly affect reading performance (32). Besides that, a larger font size improved performance with laptops and computers.

Meanwhile, a study that used smartphones as text displays found that the subject spent lesser time reading the smaller font (10 pt) compared to the largest character (14 pt) (34). The different devices display is a factor that provides different results. Smartphones have a smaller display which requires scrolling, and the scrolling affects the time required for the subjects to finish the text. Theoretically, a larger font size requires more scrolling than a smaller one. Besides that, smartphones also do not have a fixed viewing distance like laptops, as subjects can hold the smartphone closer, thus making the effect of font size unreliable in this study (34). Therefore, a smaller font size (12pt) performs better with smartphones.

The types of computer fonts such as Georgia (serif font) and Verdana (san serif font) were studied and the author found that there is no significant difference in the readability score among these two font types on the computer screen (35). The same goes for the former font for printed categories with Times New Roman (serif font) and Arial (san serif font) when used on a computer screen (35). However, the subjects preferred Verdana better than Georgia for the computer font. Thus, Verdana was preferred, followed by Georgia, Arial, and Times New Roman.

Luminance Contrast

The digital display's brightness (luminance) difference also affects visual comfort, which is commonly associated with visual fatigue. High luminance induces higher visual fatigue, especially at night (scenes with low environmental lighting) (36). Paradigm color was infused into this study to compare which color performs better or worse, either black, green, blue, or red. The color red has the worst performance in all luminance levels because visual fatigue scored high in all red paradigms with a low subjective preference (36). Even though higher luminance induces more visual fatigue, certain paradigm colors, such as blue and black, have lower visual fatigue scores with a higher subjective preference.

The higher luminance contrast shows the highest blink rate (BR) and fastest pupil accommodation (PA), which tentatively results in the lowest visual fatigue when using electronic devices at night. The opposite happens on low luminance contrast (23). Thus, the high luminance contrast is suggested to protect the eye when using electronic devices under low screen luminance and low ambient illumination at night. Besides, from a subjective perspective, the luminance contrast of 0.868, 0.855, and 0.725 show lower visual fatigue scores (VFS) and higher subjective preferences (SP), followed by a luminance contrast of 0.969 and 0.935 when using electronic devices in a dim room, it is suggested to use a higher luminance contrast to reduce visual fatigue (23). However, the consistency between subjective and objective indicators was not found.

This review's limitation is that most of the articles were from somewhere other than the latest year. Thus, the devices used in the experiment differed from the newest version of devices used in 2020. This study helps digital display developers understand and improve their display technology to fit in based on the preferences that have been discussed. Thus, digital display users can optimize their performance with the latest technology while avoiding further visual discomfort.

Conclusion

This systematic review found that smartphones, tablets, laptops, and computers significantly affect visual comfort after prolonged screen time. Besides, device display settings have been one of the factors contributing to visual discomfort. The preferred digital display settings are positive polarity, high color contrast, high luminance, and high luminance contrast. Meanwhile, the font size needed to be smaller for desktops and laptops, while larger fonts were preferred for smartphones. Thus, it will benefit the digital device developers and the users if the display settings are created based on the best preferences discussed in this review. This review's limitation is that most articles were from somewhere other than the latest year. Thus, the devices used in the experiment were not the newest version of devices used in the era of 2020. This study helps digital display developers understand and improve their display technology to fit in based on the preferences that have been discussed. Thus, digital display users can optimize their performance with the latest technology while avoiding further visual discomfort.

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Journalism Ethics considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Conflict of interest

The authors declare that there is no conflict of interest.

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