Introduction

Visible and invisible light rays, including blue light, are produced from a variety of sources including interior lighting, sunlight, and devices such as smart phones and computers (Heiting, 2017, p.1). While the cornea and lens of the human eye are very good at blocking Ultra Violet (UV) light rays from reaching the retina, almost all blue light is able to reach this light sensitive area of the eye (Heiting, 2017, p. 3). Research has suggested that humans are particularly susceptible to the effects of blue light, which can be both harmful and beneficial depending on setting, amount, and time of day.

Blue light has some benefits and is essential for maintaining circadian rhythm, boosting mood, alertness, mood, and cognitive function. Conversely, too much blue light exposure in the evening can disrupt sleep (Heiting, 2017, p. 4-5). Excessive blue light reaching the retina can cause macular degeneration and lead to irreversible vision loss (Heiting, 2017, p. 4).

The significance of the effects of blue light on the brain and body to LIS professionals is readily apparent. The shift to digital media not only gives users the option to use blue light emitting devices in order to complete their learning tasks; often, students, scholars, and members of the public are *required* to use digital devices to complete their day to day tasks at school, at work, and at home. For library professionals, this could mean working with a patron base that is more sleep deprived, and less healthy.

The reason I chose to explore this topic is that I have heard negative effects of blue light mentioned briefly a couple times throughout my academic career, and it seems to me that this is a topic worth delving into because of the significant amount of time people spend staring at screens. Understanding the risks and benefits of blue light is important to me because I care about my own health and want to be as educated as possible about the health effects of activities I engage in. Too, as I embark on my journey into the LIS field, I want to have as much beneficial knowledge as possible in order to help educate community members so they can live healthier and more productive lives.

Methods and Organization

In order to construct this analysis, a review of scholarly research was conducted around the effects of blue light on the body and brain. In order to find these sources, multiple databases were searched including PsycInfo, ProQuest Social Science Premium, Scopus, ACM Digital Library, ERIC, Jstor, Business Source Premier, Library Literature & Information Science, and Environment Complete. Search terms included "Blue light", "Blue light" AND "Effects on brain", "Blue light" (title field), and "Blue light" AND "Literature review".

Blue light as it affects the human body is a relatively recent area of research; for this reason, no technical standards were available for this discussion. In lieu of standards, a study that produced guidelines for the optimization of spectral transmittance profiles of blue light blockers in order to develop a compensation algorithm to minimize color distortion while safely filtering blue light will be reviewed. Following the exploration of this research will be a discussion of the implications of blue light exposure for students, LIS professionals, and the public. Some recommendations for working through this issue will also be presented.

Background

Rays of light that are shorter contain more energy, while longer light rays contain less energy (Heiting, 2017, p.2). Varying wavelengths of light correspond with different colors (Holzman, 2010, p. A23); blue light has shorter rays than those on the other (red) end of the spectrum (Heiting, 2017, p.2). About one third of all visible light is blue light or High-energy visible (HEV). Melanopsin-containing retinal ganglion cells (mRGCs) or intrinsically photosensitive retinal ganglion cells (ipRGCs) are photoreceptors in the eyes which transmit signals to the suprachiasmatic nucleus (SCN). The SCN is the master “clock” for the brain (Holzman, 2010, p. A25). Research has suggested that the mRGCs “are uniquely sensitive to blue light” (Holzman, 2010, p. A26); additionally, light related vision disorders are related to mRGCs. These cells have their own photopigment that is affected by light and negative health outcomes result if the response of these cells is too high. Response in mRGCs also inhibits melatonin production (Kuang-Tsu Shih, Jen-Shuo Liu, Frank Shyu, Su-Ling Yeh & Chen, 2016). While 40% of mRGCs axons (nerve fibers) project to the SCN, others have been found to project to areas of the brain involved in activity levels, sleep and hormone regulation (Holzman, 2010, p. A23). Additionally, mRGCs are especially sensitive during late hours of the evening (Holzman, 2010, p. A26). This research points to the vast potential of the human brain and body to be affected by blue light exposure.

There is not currently a consensus on the threshold for safe blue light exposure, but the amount of “screentime” the average person is exposed to is a concern for many vision professionals (Heiting, 2017, p. 4). Short wavelength blue light scatters easily, reducing contrast; this can mean eye strain for users who stare at computer or other device screen for long periods of time (Heiting, 2017, p.3). Unfortunately, this includes a large proportion of people. Average time per day spent on smartphones is increasing and jumped from 98 minutes in 2011 to 195 minutes in 2013 . In addition to increased smartphone use, a US survey indicated that 39% of adults use their smartphones within one hour before going to sleep (Heo et al., 2017, p.61). This illustrates that awareness of the effects of blue light is lacking within the general population.

Harmful Effects of Blue Light

The short wavelength of blue light means that the front of the retina focuses on it rather than the center. As a result, long exposure to blue light causes nearsightedness and visual fatigue, and may lead to cataracts (Zhao, Zhou,Tan, & Li, 2018, p.2). The direct physical effects of blue light exposure present a substantial risk to the function of one of our most relied upon senses. Beyond these direct physical effects, blue light can disrupt sleeping ability, which itself causes significant issues.

Light with visible wavelengths has the ability to reset the human circadian rhythm, and blue light is most effective in doing this. Research suggests that an off balance circadian rhythm can be a factor in many health conditions including diabetes, obesity, depression, a variety of tumoral diseases (Holzman, 2010, p. A23), fatigue, sleep disorders, and depression causing mood disorders (Touitou et al., 2016, p. 468). Increased morbidity and mortality relating to multiple health conditions including cancer and cardiovascular disorders have been found among shift workers. The World Health Organization stated in 2007 that shift work is a risk factor for breast cancer (Holzman, 2010, p. A23).

One study showed that 6.5 hours of blue light exposure suppresses melatonin production for twice as long as green light (Holzman, 2010, p. A26). A double blind study of subjects using blue light producing smartphones and subjects using color enhanced blue light blocking smartphones revealed use of blue light emitting devices in the evening to postpone melatonin onset and increase accuracy errors (Heo et al, 2017). These facts give way to concerns about public health. Digital devices are not only altering the way we communicate and relate with one another, their widespread use in absence of awareness about their direct and indirect effects on the body and brain could be dangerous for individuals and the future of society.

Blue Light and Age

A body of research suggests that adolescents may be particularly vulnerable to the effects of blue light. A study of preschoolers revealed that evening screen time led to less sleep, and as a consequence, decreased theory of mind (the ability to understand the feelings and rationale of others) (Nathanson & Fries, 2014, p. 252).

A 2014 study utilizing fMRI technology demonstrated that the effects of blue light on the brain reduce with age. Younger participants experienced reactions in several parts of the brain, while older participants experienced a reaction in a reduced set of areas; all the areas activated in older participants were also activated in younger participants (Daneault et al., 2014, p. 90). Another study comparing moderate light exposure in nine year old children to their parents showed that twice the percentage of melatonin inhibition in the children (Touitou et al., 2016, p. 471). A reported 15%-50% of children and adolescents of western countries have sleep disorders (depending on location, age, and culture) (Touitou et al., 2016, p. 473).

Benefits of Blue Light

Research suggests that bright white light can reduce depression and have a positive effect on mental health; blue light is especially effective in this way (Holzman, 2010, p. A23). Blue light goggles and other devices have been used to treat sleep disorders, seasonal affective disorder, and premenstrual syndrome. Additionally, individuals under the stimulation of blue light had fewer lapses in attention and better auditory reaction times (Holzman, 2010, p. A26). One study exposed study participants to either blue or amber light for 30 min prior to the subjects performing memory tasks while being monitored by fMRI machines. The subjects who had been exposed to the blue light had faster response times and increased activation in the dorsolateral prefrontal cortex and ventrolateral prefrontal cortex (VLPFC). VLPFC activation was also positively correlated with faster response times (Alkozei et al., 2016).

Mechanisms for Reducing Harmful Effects

While blue light is everywhere, screens present a substantial risk to human health because of the amount of time we spend looking at them. Fortunately, blue light filters work successfully to mitigate the effects of blue light. Smartphone apps are available to filter blue light, and some devices have this option built in. Yellow tinted lenses can increase contrast thereby reducing eye strain for device users (Heiting, 2017, p. 4). Tempered glass and can also help with reducing the amount of blue light users are exposed to (Heiting, 2017, p. 5). The study in which the double-blind experiment using smartphones with and without blue light utilized blue intensity modulation technology produced by Samsung (Heo et al., 2017, p. 62). These technologies combined with an increasing awareness around the effects of blue light are promising and point to a future where technological developments take into account and adjust for the effects of blue light on the human body.

Blocking Blue Light While Maintaining Color Integrity (Standards)

The harmful effects of blue light exposure can be mitigated by using a blue light filter either on the display itself or with blue light glasses or goggles; this presents a problem, however, in the way of color distortion. Standard blue light blockers cause the image to present with more red and yellow hues (Kuang-Tsu Shih et al., 2016).

In an effort to facilitate production of images lacking blue light frequencies while preserving color integrity, Kuang-Tsu Shih and colleagues constructed a theoretical guideline for blocking the most harmful frequency of blue light while maximizing the color spectrum. Since color perception is a subjective psychological phenomenon, it is possible to induce the same subjective perception of color with multiple color spectral power distributions. This process is called metamerism, and when two spectral power distributions induce perception of the same color, they are called a metameric match. Kuang-Tsu Shi and colleagues set out to create a metameric match of colors produced with blue light, while blocking the most harmful blue light frequency. To achieve this, a color compensation algorithm was developed to be combined with a selective frequency light blocker. The basis of the algorithm is that if a color falls within the spectrum of non-harmful frequency, its value is retained. If its frequency is that of harmful blue light, its light producing properties are suppressed while the qualities inducing perception of its visible appearance are matched. In this way, color distortion caused by blocking of blue light are compensated for. Images produced using this algorithm were difficult to distinguish from original images (Kuang-Tsu Shih et al., 2016). This undertaking demonstrates that although blue light can cause harmful health effects, innovation combined with technology can produce ways of reducing harm while maintaining the enjoyable experience of viewing images that lack visual distortion.

Summary and Conclusions

The topic of blue light is a complex one. Depending on time, duration, and intensity, exposure can lead to improvement or worsening of the function of many systems in the body. Children and adolescents are especially vulnerable to the effects of blue light. This is an important time in the implementation of upgraded technologies that may help mitigate the harmful effects of blue light exposure. The LIS community is in transition with the rest of society to a time of increased reliance on digital devices. For librarians and other LIS professionals, knowledge of the effects of blue light is important in order to offer the most helpful service and education to patrons and community members, as well as to maintain the highest level of personal health and professional success.

Recommendations

This author recommends that LIS professionals keep themselves up to date on blue light technologies and how they can pose both harms and benefits depending on the application. Implementing blue light controlling technologies in libraries will to keep libraries a safe and functional space for patrons and staff. Blue light filters on library desktops are helpful for reducing negative impact, especially for libraries that are open later at night. Blue light filters on devices are an easy way to protect against the harmful effects of blue light and should be used during the evening hours especially for children and adolescents.

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