ARE YOU FEELING BLUE OR IS THAT JUST THE LIGHT?

By

Justin Ullrey and Kyle Bates

This paper is submitted in partial fulfillment of the requirement for the degree of

Doctor of Optometry

Ferris State University
Michigan College of Optometry

May 2019

ARE YOU FEELING BLUE OR IS THAT JUST THE LIGHT?

By

Justin Ullrey and Kyle Bates

Has been approved

01 May 2019

APPROVED:

Mark Swan

Faculty Advisor: Dr. Mark Swan

ACCEPTED:

Faculty Course Supervisor

Ferris State University
Doctor of Optometry Senior Paper
Library Approval and Release

TESTING BLUE LIGHT BLOCKING LENSES

We, Justin Ullrey and Kyle Bates, hereby release this Paper as described above to Ferris State University with the understanding that it will be accessible to the general public. This release is required under the provisions of the Federal Privacy Act.

____
Doctoral Candidate(s)

____
Doctoral Candidate(s)

5/9/19
____
Date

ABSTRACT

Are you feeling blue or is that just the light?

Background/Purpose:

To determine the effectiveness of common ophthalmic materials, coatings and other interventions to decrease blue-light exposure to patients who use electronic displays. Many things are done today to limit the exposure to blue light, we are going to look at the products on the market today that can help to limit exposure and what the most cost effective product is to patients.

Methods:

A spectrophotometer was used to measure the irradiance of wavelengths 410-450 nm of light emitted for a Dell monitor, iPhone 7s and an iPad. The total irradiance was compared to the irradiance measured when common ophthalmic materials, coatings and other interventions were used. To approximate human exposure, spectrophotometer readings were recorded from a standard working distance that is typical of human users. Ophthalmic materials that filter irradiant light were inserted at a standard vertex distance with other lens parameters standardized. Data was analyzed by recording the irradiance for each condition in an excel spreadsheet. The percentage decrease was calculated for each of the filtering materials or other technologies. Results were plotted against each other and analyzed using stat pack software to determine significant effect and relative effectiveness.

Results:

The results showed that software designed to decrease the emittance of blue light from electronic displays reduced the irradiance of 410-450 nm light at the ocular surface by 55 to 82%. The effectiveness of reducing the irradiance of blue light using common ophthalmic filtering technologies ranged between statistically no effect to 37%. There was variability in the effectiveness of different technologies for the different sample electronic displays measured due to the spectral characteristics of the displays' light source.

Conclusion:

In conclusion, the best method to reduce the irradiance of blue light exposure when using electronic displays is by altering emittance of the source with a software program. For ophthalmic filtering technologies, there was a statistically significant difference in the lens technologies that were tested. The top reducing lens were: Blutech, Prevencia and Retina Shield. Other technologies do not appear to significantly alter the irradiance at the ocular surface. Additionally, there is a need for more research and long term studies to determine if the extra blue light received from electronic displays poses significant risk to ocular or systemic health.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER ONE

Blue Blocking Introduction

Blue light has existed since the dawn of time. So why then, in the 21st century has it become a problem? One simple reason, increased use of electronic display technology. The common use of electronic displays has increased dramatically in the past decades [3,5,6]. Many sources (scientific and product promotions) claim that blue light (or low wavelength light) from electronic displays is unhealthy [3,5], specifically for the eyes [5,6].

Blue light has been shown to effect human physiology in several ways. Blue light plays a vital role in daily sleep patterns. Specifically, blue light helps to stay awake during the day. It can increase alertness, focus ability, and attention. How? Blue light inhibits the release of melatonin in the brain, a chemical that when released, provides a deep restful sleep. When exposed to light early in the morning, the blue light inhibits the release more than double that of any other wavelength of light. So why then, is blue light such a problem? A large problem is due to extend technological display use (ie; cellphones, computers, tablets). These displays emit blue light, which many people use into the later hours of the night. This can have negative effects on sleep cycles. When devise use increases especially after 9:00pm, studies show the length and quality of sleeping alike are decreased drastically[1]. A longer, more quality night's sleep followed by a day full of alertness, attentiveness, and focus can be attained by utilizing this technology to help block unnecessary low wavelength light.

Another effect that blue light can have on the visual system is by causing digital eye strain, otherwise known as "computer vision syndrome". Studies show that when displays are in use, blinking is decreased to 66% less than normal[2]. High energy blue light is implicated because it scatters much easier than other visual light, making it harder to form a focused image on the retina[3]. This visual "noise" decreases contrast. The visual system attempts to combat this visual "noise" by causing the visual system to unconsciously focus more on the displays (by not blinking and straining). This can cause discomfort, headaches, dry eyes, and a myriad of other symptoms of digital eye strain. By reducing the intensity of these wavelengths, especially the lower wavelengths, technical displays can be used much more comfortably.

Many products have claimed to have the solution to these problems, mainly in the form of eyeglass lenses, or lens coatings. Some companies will even block out the blue light on their own displays to help as well. This research was conducted to compare the effectivity of these blue light blocking technologies and determine analytically if they should have a positive impact on the visual system as well as daily sleep cycles.

CHAPTER TWO

Methods of Data Collection for Blue Blocking Abilities

The sources of light used were a 19-inch Dell monitor, a iPhone 7s with retina display and an iPad with retina display. The 19-inch Dell was set to manufacturer default settings for brightness and color quality and it was opened to a blank word processing document. The 19-inch square Dell monitor is an LCD monitor, with a brightness of 250cd/m^2 with a screen coat for anti-glare and a hard coat. The iPhone 7s was set to full brightness and it was opened to a blank white screen. The iPad was opened to a blank white screen and set to full brightness.

Ophthalmic lens blanks were selected based on popular lenses available in the market today. Lenses used include: uncoated CR-39, polycarbonate with a hard coat, a Retina Shield lens, Blutech Lens, EyeZen lens, a CR-39 lens with Prevencia anti-reflective coating, a Blue Zero lens, Zeiss' Blue Protect lens, and Hoya's Recharge lens.

The Retina Shield is made of a proprietary material called Hivex and has an index of refraction of 1.56. The Blutech lens is made of mid index lens and is coated with a scratch resistant coating. The EyeZen lens has a proprietary material baked into a CR-39 lens. The Blue Zero lens was made of polycarbonate. The Blue Protect is a coating placed on top of a CR-39 lens. The Recharge is a coating applied to a standard CR-39 lens. The front base curve of each lens varied nominally, and the power of every lens was plano. In addition to these lens materials, Apple's software, night shift mode, was tested on displays that contained this feature. The night shift mode was set to the moderate setting in the middle of the extent between more warmth and less warmth.

A Sekonic C-700 spectrophotometer was used to measure irradiance. Irradiance is the amount of power received by a certain amount of surface area, mW/m^2nm.. The spectrophotometer was placed 40 cm from the electronic display to simulate the irradiance incident on the ocular surface for a typical working distance. Measurements were obtained with respect to the total irradiance of the light for the range of 410nm to 450nm in a room that had been darkened to remove ambient light. The spectrophotometer had been calibrated according to manufacturer instructions prior to making measurements.

Initial irradiance measurements were recorded from the electronic displays set to standard parameters, described earlier. Irradiance measurements were then collected under the various experimental conditions, either with the blue light reducing software, or with an ophthalmic filtering technology placed in front of the spectrophotometer.

Data for each condition was recorded on the spectrophotometer and downloaded into a database. The spectral distribution graphing function was used to determine total irradiance for the wavelengths range of 410-450 nm for each condition. The percent reduction from each display's baseline was calculated for each irradiance reducing technology and compared.

CHAPTER THREE

RESULTS OF LENS TESTING

After compiling all the measurements, it was determined that the iPad had the highest baseline irradiance of any of the three displays from wavelengths 410-450nm. The iPad emitted 3.55 mW/m^2nm. The next highest was the Dell monitor at 2.764 mW/m^2nm and the least highest irradiance was seen with the iPhone 7s with 1.404 mW/m^2nm.

The greatest reduction in irradiance for the iPad was obtained from turning on the night mode feature. When the night mode feature was turned on we saw an 81.97% reduction.

When testing the Dell monitor the best reduction was seen with the Blutech lens, providing a 25.67% reduction in irradiance. The next best was Retina Shield and Prevencia. A software reducing technology was not used with the Dell monitor.

The greatest reduction in irradiance for the iPhone 7s was seen from the night mode feature on the phone, providing a 54.46% reduction. This was followed by Blutech, Prevencia and the Hoya Recharge.

Material	Spectral Irradiance mW/m²nm	Percent Reduction
19" Dell Monitor	2.764	N/A
CR-39	2.671	3.36%
Polycarbonate	2.821	-2.05%
Retina Shield	2.327	17.49%
Blutech	2.055	25.67%
EyeZen	2.691	2.63%
Prevencia	2.363	14.49%
Blue Zero	2.599	5.97%
Zeiss Blue Protect	2.546	7.87%
Hoya Recharge	2.537	8.23%

Table 1. Spectral Irradiance for 19" Dell Monitor

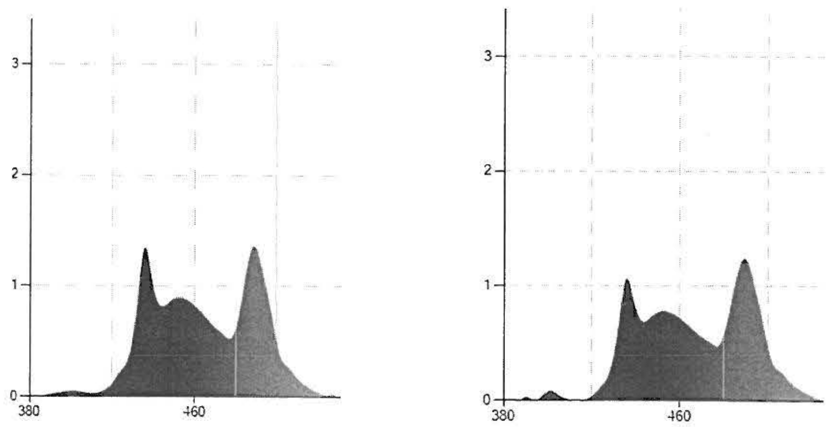
Material	Spectral Irradiance mW/m²nm	Percent Reduction
iPhone 7s	1.404	N/A
iPhone w/ night mode	0.639	54.46%
CR-39	1.324	5.69%
Polycarbonate	1.404	-0.01%
Retina Shield	1.367	2.64%

Blutech	1.120	20.26%
EyeZen	1.388	1.15%
Prevencia	1.200	14.50%
Blue Zero	1.375	2.07%
Zeiss Blue Protect	1.440	-2.56%
Hoya Recharge	1.295	7.75%

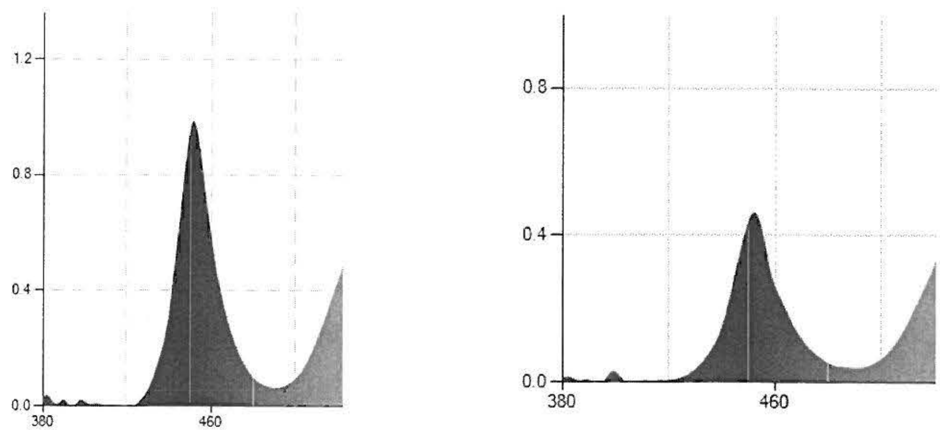
Table 2. Spectral Irradiance for iPhone 7s

Material	Spectral Irradiance mW/m^{2}nm	Percent Reduction
iPad	3.546	N/A
iPad w/ night mode	0.639	81.97%
CR-39	3.801	-7.19%
Polycarbonate	3.555	-0.26%
Retina Shield	2.421	31.71%
Blutech	2.219	37.43%
EyeZen	2.662	24.93%
Prevencia	2.356	33.56%
Blue Zero	2.589	26.98%
Zeiss Blue Protect	2.559	27.82%
Hoya Recharge	2.633	25.75%

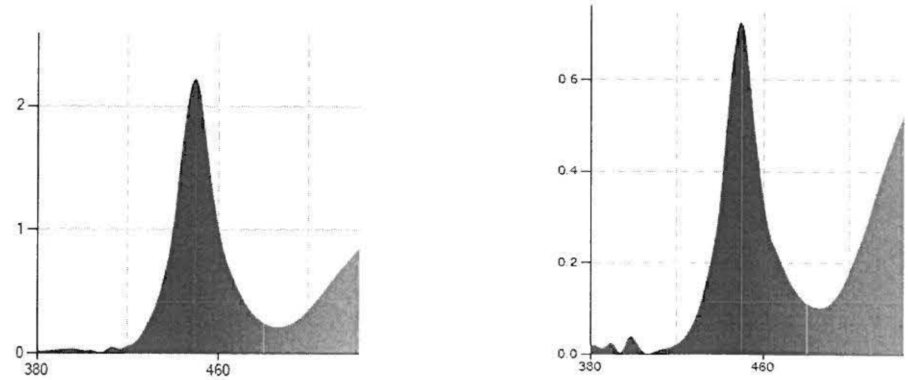
Table 3. Spectral Irradiance for iPad



Graph 1. Spectral distribution between the Dell Monitor (left) and the Dell Monitor with the Blutech lens (right)



Graph 2. Spectral distribution between the iPhone 7s (left) and the iPhone 7s with night mode (right)



Graph 3. Spectral distribution between the iPad (left) and the iPad with night mode (right)

CHAPTER 4

DISCUSSION OF BLUE LIGHT BLOCKING LENSES

The results of the data show that while ophthalmic lens filtering technology worked in reducing the irradiance produced by electronic displays, in most situations it is best to reduce the blue light at the source. In both situations where software was tested it was found that the software performed significantly better than ophthalmic filtering at reducing the irradiance at the ocular surface.

The best ophthalmic filtering technologies were Blutech, followed by Prevencia and Retina Shield from the light tested from the iPad. In the data collected, it was determined that there was statistically significant decrease seen in night mode, retina shield, Blutech, EyeZen, Prevencia, Blue Zero, Zeiss Blue Protect and Hoya Recharge. It was interesting to see that the CR-39 and Polycarbonate lenses may increase the amount of irradiance, it was determined that this may be due to focusing the light slightly as well as the hard coat that was applied to the polycarbonate lens. Blutech, Retina Shield and Prevencia also showed a statistically significant reduction in the irradiance captured by the spectrophotometer when measuring the blue light emitted from the Dell Monitor. The Hoya Recharge and Zeiss Blue Protect were borderline in showing a reduction that was statistically significant. The only products that showed statistical significance when tested with the iPhone were the night shift mode and Blutech lens.

Comparison of the ophthalmic filters showed the best ophthalmic filter for reducing the irradiance in all situations was the Blutech lens. The Blutech lens produced anywhere from a 20.26% reduction to a 37.43% reduction in the blue light irradiated. The next best across the different displays proved to be a high grade anti-reflective coating in the form of Crizal's Prevencia. The Prevencia coating produced a 14.49% reduction to a 33.56% reduction. It should also be noted that both of these products have a cosmetically noticeable appearance.

When breaking down the data it was interesting to note that Polycarbonate in all the testing models showed an increase in the irradiance of the displays. This is most likely due to the hard coat applied to the lens. However, the amount increased does not appear to be statistically significant in any of the observed situations.

It is important to note that all the testing was performed at 40 cm. However, according to the inverse square law, if we were to decrease the working distance to 20 cm, the irradiance would be four times greater. This information becomes very valuable when discussion the effects of blue light from displays for patients who are a 2.00 D myope versus a 4.00 D myope and even an 8.00 D myope. As the patients progressively hold objects closer to their faces when they are uncorrected the amount of blue light that is striking their retinas is increasing as well. The significance of values recorded in this research may change if a user increases or decreases their working distance.

An important factor in discussing the appropriate lenses or programs for a patient it is vital to discuss the appearance. The best reduction came from the night mode on the iPhone and iPad, however, the night shift mode causes distortion to the image, giving it a very yellow appearance. The next best was the Blutech, the Blutech lens has a very yellow-olive appearance to it. The lens is very noticeable cosmetically, however, the effect noticed by the user is not as dramatic. The anti-reflective coating, Prevencia causes the lens to have a purple reflection on the front surface. This was also noticeable on the Hoya and Zeiss product as well. When looking at proper products to recommend to patients it is vital to consider the appearance of the lens because this can be a very important feature for patients.

Many factors are in play in the issue of blue light causing ocular health side effects and while at this point there are many claims about the outcomes of prolonged use, there is insufficient research to substantiate the claims. It has been noted that in many cases the irradiance of blue light form LED computer screens is less than what is produced in natural outdoor lighting conditions[4]. While there is data to show that the blue blocking lenses do block a significant amount of the blue light that they say they do, there needs to be more research to determine what exposure levels are significant so that the effectiveness of the irradiance reducing technology can be used to determine if the risk of harm is actually being achieved.

References

1. Tosini, Gianluca, et al. "Effects of blue light on the circadian system and eye physiology." ncbi.gov, Jan. 2016.
2. Sindt, C. (2015, September). Computer Vision Syndrome. In *University of Iowa Hospital and Clinics*. Retrieved from https://uihc.org/health-topics/computer-vision-syndrome
3. Heiting OD, Gary. "Blue Light: It's Both Bad And Good For You." All About Vision, Nov. 2017, www.allaboutvision.com/cvs/blue-light.htm.
4. Bush, Sara. "Screen Time in the Pediatric Population: A Review of Its Effetcs on Refractive Error, Attention and Learning and Ocular Health." Sept. 2018.
5. "Blue Light and Your Eyes." Prevent Blindness, www.preventblindness.org/blue-light-and-your-eyes.
6. "Computer Vision Syndrome." aao.org, www.aoa.org/patients-and-public/caring-for-your-vision/protecting-your-vision/computer-vision-syndrome
7. Rohan, Alicia. "Debunking digital eyestrain and blue light myths." uab.edu, 25 Apr. 2016, www.uab.edu/news/youcanuse/item/7258-debunking-digital-eyestrain-and-blue-light-myths www.aao.org/eye-health/tips-prevention/should-you-be-worried-about-blue-light
8. "Blue light has a dark side." Harvard Health, May 2012, www.health.harvard.edu/staying-healthy/blue-light-has-a-dark-side

PRODUCT INFORMATION

*All lens products were donated by Walman Optical for the sake of this project. There was no financial compensation for this study. The conclusions drawn in this study are strictly based on objective data.

1. Dell Monitor: https://www.dell.com/en-us/work/shop/dell-19-monitor-e1916h/apd/210-agnd/monitors-monitor-accessories
2. iPhone 7s: https://www.apple.com/shop/buy-iPhone/iPhone-7
3. iPad: https://www.apple.com/iPad-pro/?afid=p238%7Cs9aEBTe3D-dc_mtid_2092592t39165_pcrid_307875917003&cid=wwa-us-kwgo-iPad-slid---iPad-e
4. Night Mode: https://support.apple.com/en-us/HT207570
5. CR-39: https://www.eyeglasses.com/prescription-lenses/plastic/
6. Polycarbonate: https://www.allaboutvision.com/parents/polycarb.htm
7. BluTech: https://blutechlenses.com/learn/
8. EyeZen: https://www.essilorusa.com/products/eyezen-computer-glasses?gclid=CjwKCAiAv9riBRANEiwA9Dqv1Tl9AO_cRDEZucpUCUHhJR57aSyDxatEI058hQzRkPJyMaKm2zhyvBoC8O4QAvD_BwE
9. Bluezero: https://www.shamirlens.com/products/materials-products?tab=120
10. Retina Shield: called Cherry Optical for details
11. Crizal Prevencia: https://www.essilorusa.com/products/crizal?gclid=CjwKCAiAv9riBRANEiwA9Dqv

1Vtdh_xvP89I1OPWG0pd4Ncf7f9ykm6DOElEA8jgTLSzuidelJoCuhoC3bMQAvD_BwE

12. Zeiss Blue Protect: https://www.zeiss.com/vision-care/us/for-eye-care-professionals/products/coatings/duravision-blueprotect-uv.html

13. Hoya Recharge: http://www.hoya.ca/Home/Recharge