RELATIVE EFFICACY OF BLUE LIGHT BLOCKING PRODUCTS

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ABSTRACT

Background: Due to the extensive role computers, smartphones, and tablets play in the lives of most Americans, the effect of prolonged exposure to electronic devices on the human visual system is currently a topic of great importance. In particular, the effect of blue light on the human eye has sparked debate in the scientific community. Many technologies, including lenses, screen covers, and computer software, have been developed in an effort to minimize the transmission of potentially harmful short wavelength light into the user's eyes. The goal of this study was to determine which devices are the most effective in blocking the wavelengths of visible light that have been shown to be most harmful to human vision (380 nm – 460 nm) under various working conditions. *Methods*: Using the Sekonic Spectromaster C-700*,* we measured the wavelengths of light emitted from a computer screen and transmitted through eight different products that claim to minimize transmission of blue light. This was conducted using three different light sources, simulating three unique working environments: 1) no additional light source, 2) industrial fluorescent lighting, and 3) natural sunlight. *Results*: When comparing the performance of each product in its ability to block the transmission of blue light across various lighting conditions, no product performed consistently well or poorly. *Conclusions:* Since no consistent trends could be drawn from the data results, it can be concluded that despite the use of products that claim to block blue light, blue light will still enter the eye under certain lighting conditions. The next step would be to examine products that sit directly upon or within the eye, which would minimize the amount of unwanted stray light that enters the eye.

Key Words: blue light, spectral transmission, computer vision syndrome

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INTRODUCTION

With the ever-rising number of Americans who have unlimited access to computers and mobile devices, the effect of prolonged exposure to electronic devices on the human visual system is currently a topic of great importance. In particular, the effect of blue light on visual development and ocular health has sparked debate in the scientific community.

There are a multitude of hypothesized effects of blue light exposure, which range from eyestrain and Computer Vision Syndrome (Bali, 2014) to circadian rhythm disruption (Lawrenson, 2017) and retinal phototoxicity, including macular degeneration (Kim, 2016). The problem with these claims is that since the rapid influx of electronic and mobile devices has occurred so recently, there is a general lack of longitudinal data to prove the exact effects this exposure will have.

Although the exact effects of blue light exposure have not yet been determined, the general consensus is that the blue/violet wavelengths of light (380-460 nm) are the most harmful to the eyes (Youssef, 2011). This fact has created a significant demand for products that prevent blue light from reaching the eyes. Examples of such products include spectacle lenses, screen covers, computer software, and mobile apps, all of which claim to block harmful blue light (van der Lely, 2015).

The goal of this study was to determine, under various working conditions, which products are the most effective in blocking the wavelengths of visible light that have been shown to be the most harmful to human vision.

CHAPTER 2

METHODS

Using the Sekonic Spectromaster C-700, a handheld photospectrometer, the wavelengths of light emitted from a computer screen and transmitted through eight different products that claim to minimize transmission of blue light were measured and recorded. (Table 1). The products were selected solely based on availability and product variety. The authors have no financial interest in any of the brands or products used in this study.

In each trial, the primary light source remained the same: a laptop computer at 100% screen brightness, displaying a blank word processing document. The computer was placed on a desk, with the photospectrometer facing the computer screen at a distance of 50cm. Measurements were taken in three different lighting environments. The first environment included no additional light source, with the computer screen as the sole source of light in an otherwise dark room. The second environment was the same as the first, but with fluorescent room lights on, and no additional outside light sources. Finally, the third was next to a window on a bright, sunny day, with no additional lighting.

In each of these three lighting environments, measurements of the wavelengths of light transmitted into the photospectrometer were recorded, first with no blue light-blocking product (control) and then with each of the eight products in place. Measurements were taken two times each to improve reliability. Each product was positioned in relation to the photospectrometer aperture in accordance with their intended use (Table 1). For example, the Photonic Computer Filter was placed directly on the computer screen during testing, as this is the placement typically used by consumers. Likewise, each of the spectacle lens products were placed 13mm from the aperture of the photospectrometer, as this is the typical vertex distance between a spectacle lens and the eye.

Table 1: Product Placement in Relation to Photospectrometer

Product Name	Product Type	Placement of product
Photonic Computer Filter	Orange-tinted computer screen filter	Directly on computer screen
SleepShield	Stick-on smart phone screen filter	Directly on aperture
GUNNAR® Amber	Spectacle lens	13mm from aperture
BluBlocker™ American Eagle	Spectacle lens	13mm from aperture
BluTech® Classic	Spectacle lens	13mm from aperture
HOYA Recharge®	Spectacle lens	13mm from aperture
Essilor® EYEZEN™	Spectacle lens	13mm from aperture
F.lux®	Computer software	n/a

Table 1: Product type and placement in relation to the photospectrometer detection device for each of the products tested.

CHAPTER 3

RESULTS

Dark Room

The average spectral irradiance (mW/m^2) for each product at each wavelength interval and across the entire spectrum (380 – 460nm) as measured in a dark room is outlined in Table 2.

Table 2: Blue Light Transmission in a Dark Room

	380-390	390-400	400-410	410-420	420-430	430-440	440-450	450-460	Total
No Filter	0.00	0.00	0.00	0.00	0.05	2.80	5.15	7.00	15.00
Photonic Computer Filter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SleepShield	0.00	0.00	0.00	0.00	0.00	1.75	4.60	4.38	10.73
GUNNAR® Amber	0.00	0.00	0.00	0.00	0.00	0.00	1.40	1.78	3.18
BluBlocker™ American Eagle	0.00	0.00	0.15	0.18	0.00	0.00	0.00	0.05	0.38
BluTech® Classic	0.00	0.00	0.00	0.00	0.00	1.00	3.93	3.95	8.88
HOYA Recharge®	0.00	0.00	0.00	0.00	0.00	1.15	4.08	4.83	10.06
Essilor® EYEZEN™	0.00	0.00	0.00	0.00	0.00	1.35	4.93	5.43	11.71
F.lux®	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.28	0.49

Table 2: Spectral irradiance (mW/m^2) of light from a laptop screen after passing through blue light blocking products in a dark room.

No irradiance was detected between the wavelengths of 380 – 420nm by the control group. Between 420 – 430nm, all products performed equally and blocked transmission completely. Between 430 – 440nm, the Photonic Computer Filter, GUNNAR® Amber, BluBlocker™ American Eagle, and F.lux® each completely blocked transmission. The next most effective product was BluTech® Classic, followed by HOYA Recharge®, Essilor® EYEZEN™, and SleepShield. Only two products blocked 100% of light between 440 – 450nm, Photonic Computer Filter and BluBlocker™ American Eagle and from 450- 460nm, only the Photonic Computer Filter was able to completely block transmission. The remaining products did effectively reduce transmission compared to the control group (Figure 1).

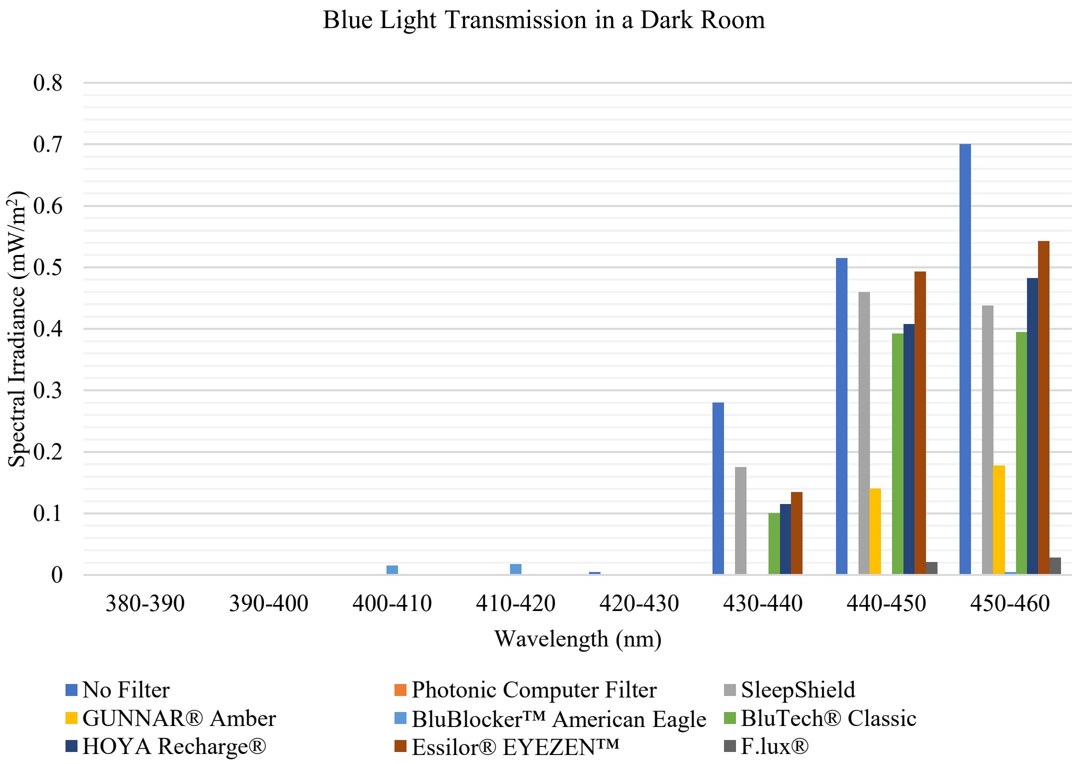

Figure 1: Spectral irradiance (mW/m^2) detected through blue light blocking products in a dark room, organized by wavelength.

The only product to filter out 100% of light across the entire spectrum (380 – 460nm) was the Photonic Computer Filter. Two other products, BluBlocker™ American

Eagle and F.lux®, significantly minimized transmission across all wavelengths, followed by GUNNAR® Amber (Figure 2). All products reduced irradiance measurements compared to the no filter group both overall (Figure 2) and for each wavelength interval (Figure 1).

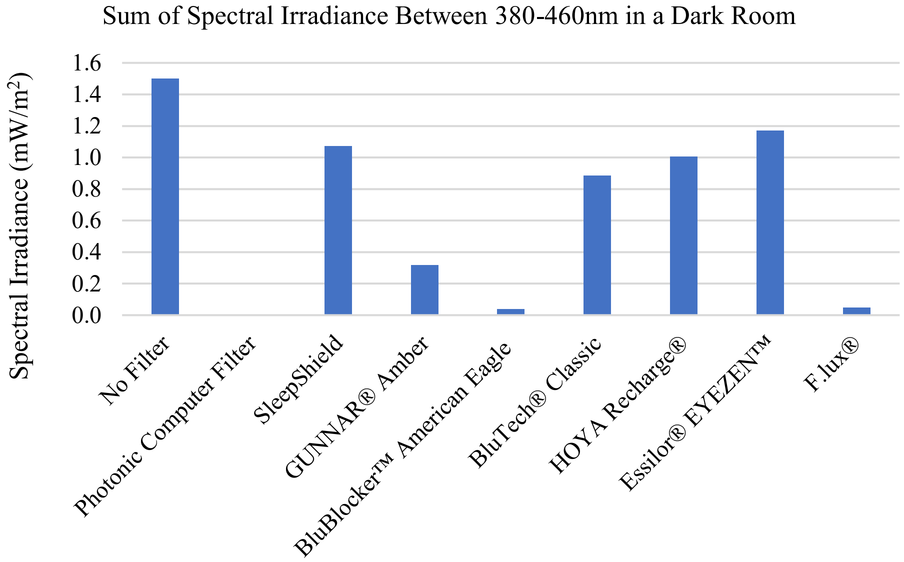

Figure 2: Sum of spectral irradiance (mW/m^2) across all wavelengths between 380-460nm for each of the blue light blocking products in a dark room.

Fluorescent Lighting

The average spectral irradiance (mW/m^2) detected utilizing each product at each wavelength interval and across the entire spectrum (380 – 460nm) as measured in fluorescent lighting is outlined in Table 3.

Between 380 – 390nm, GUNNAR® Amber, BluBlocker™ American Eagle, and the F.lux® each completely blocked transmission. HOYA Recharge® permitted equal transmission compared to the no filter group. Surprisingly, spectral irradiance was measured to be greater with all remaining products than without the use of a filter.

Table 3: Blue Light Transmission in Fluorescent Lighting

	380-390	**390-400**	**400-410**	**410-420**	**420-430**	**430-440**	**440-450**	**450-460**	**Total**
No Filter	0.20	1.70	0.00	0.00	0.45	10.78	7.54	8.20	28.87
Photonic Computer Filter	0.55	2.31	0.00	0.00	0.00	9.64	13.23	8.65	34.38
SleepShield	0.48	2.60	0.85	0.00	0.00	6.75	8.65	4.20	23.53
GUNNAR® Amber	0.00	1.38	0.18	0.00	0.00	9.30	8.82	5.89	25.57
BluBlocker™ American Eagle	0.00	2.35	0.45	0.00	0.00	9.68	13.63	9.25	35.36
BluTech® Classic	0.25	1.90	0.20	0.00	0.00	10.22	14.31	9.50	36.38
HOYA Recharge®	0.20	1.55	0.20	0.00	0.00	8.19	10.93	7.10	28.17
Essilor® EYEZEN™	0.50	1.16	0.00	0.00	0.00	8.50	10.43	3.30	23.89
F.lux®	0	1.60	0	0	0	9.95	10.55	3.65	25.75

Table 3: Spectral irradiance (mW/m^2) after passing through blue light blocking products in fluorescent lighting.

From 390 – 400nm, Essilor® EYEZEN™ was most effective at reducing transmission, followed by GUNNAR® Amber, HOYA Recharge®, and the F.lux. The remaining products produced spectral irradiance greater than that of the no filter group. Between 400 – 410nm, no spectral irradiance was detected with the no filter group, Photonic Computer Filter, Essilor® EYEZEN™, and F.lux® products. All other products did produce irradiance measurements. No light was detected by any testing group between 410 – 420nm, and all products completely blocked transmission from 420-430nm. All products were effectively reduced transmission compared to measurements collected without a filter between 430 – 440nm. Surprisingly, all tested products produced values greater than the control group between 440 – 450nm. Five products produced were effective at reducing transmission between 450-460nm, including Essilor® EYEZEN™, F.lux®, SleepShield, GUNNAR® Amber, and HOYA Recharge®, in order of greatest to least effect. The remaining three products produced higher spectral irradiance values than the no filter group (Figure 3).

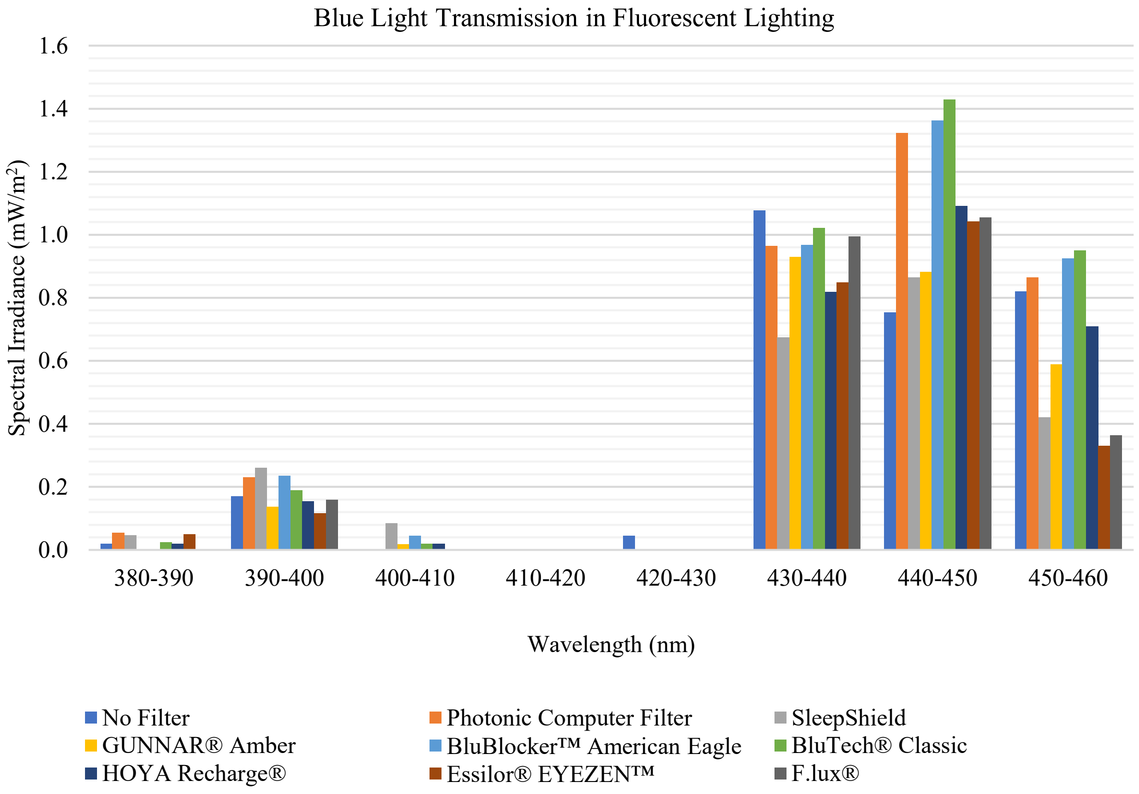

Figure 3: Spectral irradiance (mW/m^2) detected through blue light blocking products in fluorescent lighting, organized by wavelength.

Across the entire blue-light spectrum (380 – 460nm), five of the eight products effectively reduced transmission compared to the no filter group. Of these products, SleepShield was the most effective, followed by Essilor® EYEZEN™, GUNNAR® Amber, F.lux®, and HOYA Recharge® (Figure 4).

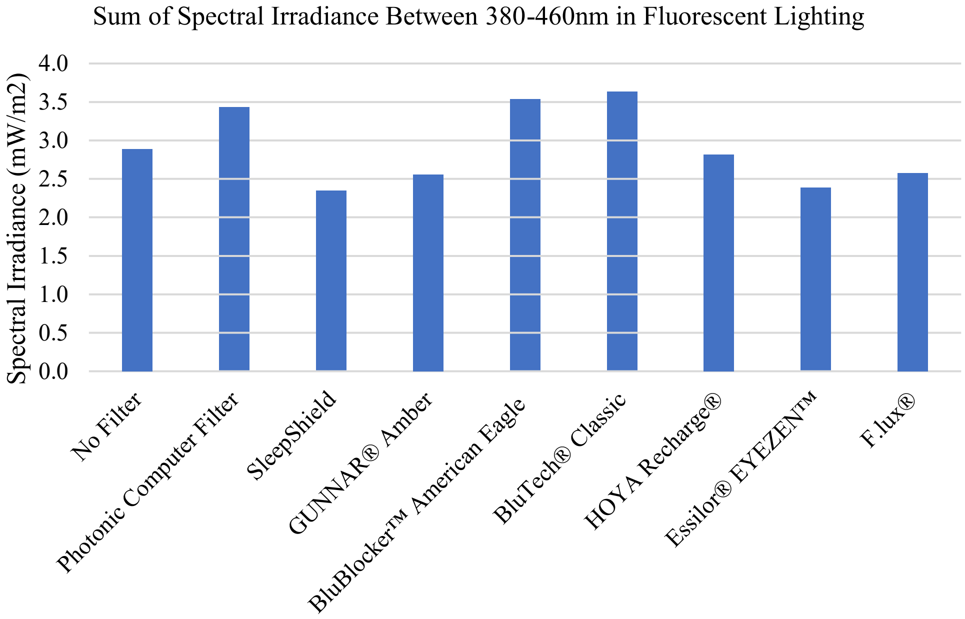

Figure 4: Sum of spectral irradiance (mW/m^2) across all wavelengths between 380-460nm for each blue light blocking product in fluorescent lighting.

Sunlight

The average spectral irradiance (W/m^2) detected utilizing each product at each wavelength interval and across the entire spectrum (380 – 460nm) as measured in sunlight is outlined in Table 4.

Between 390 – 400nm, all products reduced transmission, with HOYA Recharge® producing the lowest transmission values and GUNNAR® Amber yielding the highest. HOYA Recharge® was again most effective from 400 – 410nm, followed by BluTech® Classic and BluBlocker™ American Eagle, Photonic Computer Filter and SleepShield, and F.lux®. Essilor® EYEZEN™ had no effect on spectral irradiance, and GUNNAR® Amber produced greater transmission than detected without a filter.

Table 4: Blue Light Transmission in Sunlight

	380-390	390-400	400-410	410-420	420-430	430-440	440-450	450-460	Total
No Filter	0.64	1.03	1.43	1.68	1.79	1.95	2.23	2.50	13.25
Photonic Computer Filter	0.54	0.80	1.28	1.55	1.73	1.99	2.34	2.68	12.91
SleepShield	0.53	0.78	1.28	1.55	1.71	1.98	2.34	2.63	12.80
GUNNAR® Amber	0.71	0.91	1.53	1.85	1.98	2.25	2.63	2.87	14.73
BluBlocker™ American Eagle	0.55	0.75	1.20	1.53	1.66	1.93	2.31	2.56	12.49
BluTech® Classic	0.58	0.81	1.20	1.51	1.70	2.01	2.38	2.63	12.82
HOYA Recharge®	0.57	0.69	1.17	1.49	1.74	2.05	2.39	2.67	12.77
Essilor® EYEZEN™	0.61	0.88	1.43	1.73	1.86	2.11	2.48	2.77	13.87
F.lux®	0.60	0.82	1.30	1.63	1.72	1.90	2.15	2.37	12.49

Table 4: Spectral irradiance (W/m^2) after passing through blue light blocking products in sunlight.

Once again, HOYA Recharge® was most effective from 410 – 420nm. All others were effective to a lesser extent, aside from Essilor® EYEZEN™ and GUNNAR® Amber, which yielded increased transmission values. Between 420 – 430 nm, only BluBlocker™ American Eagle and BluTech® Classic reduced transmission. BluTech® Classic was again shown to be effective from 430 – 440nm, along with F.lux®. F.lux® was the only product to decrease spectral irradiance between 440 – 460nm (Figure 5).

Across the entire spectrum, six of the eight products tested produced values that were lower than the no filter group. These products, in order of effectivity, were BluBlocker™ American Eagle, F.lux®, HOYA Recharge®, BluTech® Classic and SleepShield, and Photonic Computer Filter. Essilor® EYEZEN™ and GUNNAR® Amber both produced values greater than that of the filter group (Figure 6).

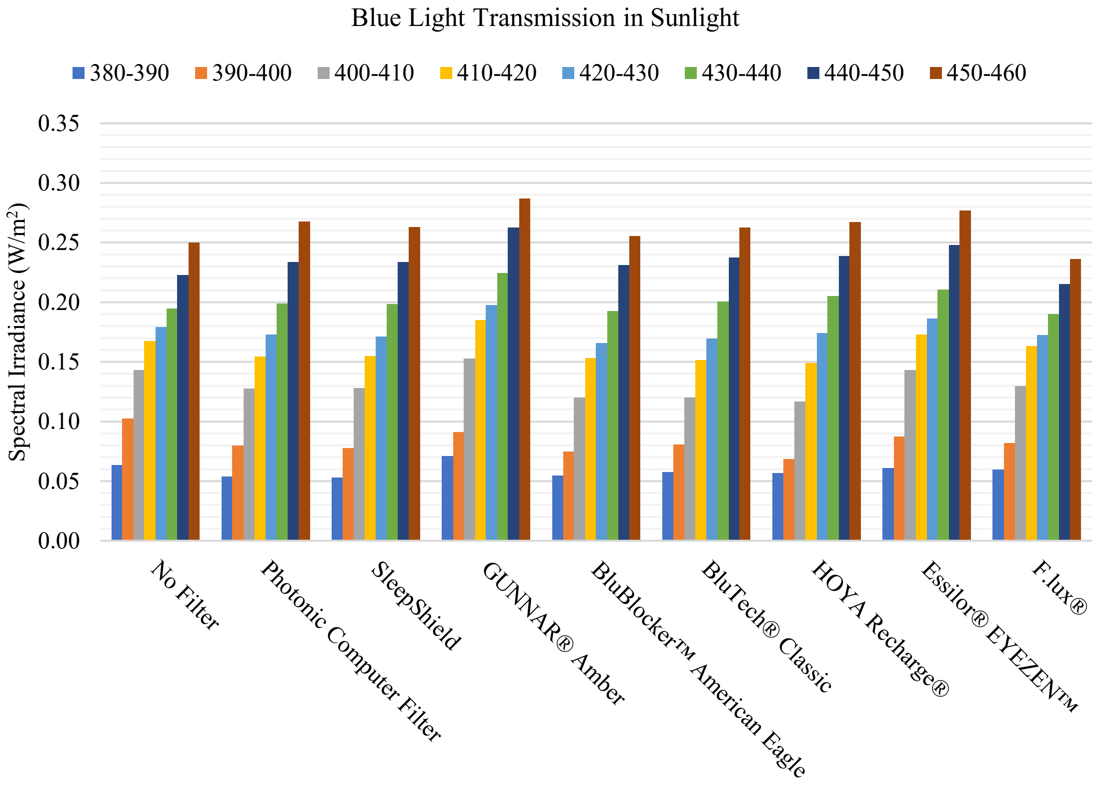

Figure 5: Spectral irradiance (W/m^2) detected through blue light blocking products in sunlight, organized by wavelength.

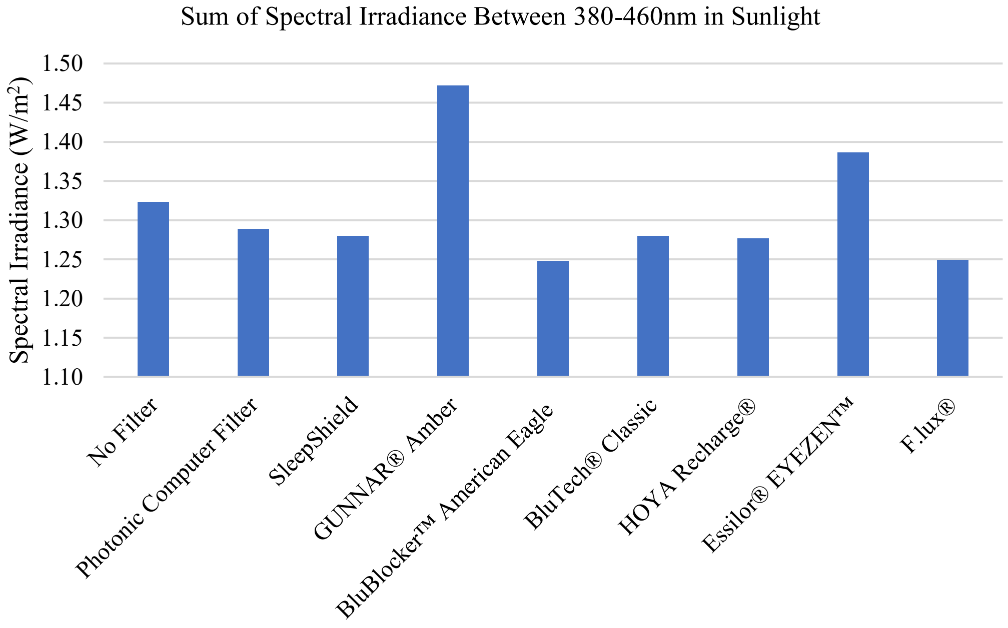

Figure 6: Sum of spectral irradiance (mW/m^2) across all wavelengths between 380-460nm for each blue light blocking product in sunlight.

CHAPTER 4

DISCUSSION

In analyzing the data, few if any consistent trends can be drawn. In fact, if the eight products in question were grouped into the “best four” and “worst four” products in terms of transmission of light in the 380-460nm range, only one product, the F.lux® app, remained in the “best four” throughout each of the three lighting conditions. None of the seven other products remained in the same grouping of “best four” or “worst four” throughout testing. This variability suggests the lighting condition itself may have a greater impact on blue light exposure than which products are being used.

While these data were being collected, the goal was to set up the products in a way that most closely mimicked the relationship of the product with the human eye. For example, when testing a spectacle lens, it was held 13mm from the aperture of the photospectrometer, which is the typical vertex distance between the human eye and a spectacle lens. When testing a screen cover, it was placed directly on the computer screen. By testing these products in this way, with the aperture of the photospectrometer representing the eye’s pupil, the products interacted with light incident on the photospectrometer the same way they would with the human eye. Because of this, some light from the room (fluorescent light or sunlight) was allowed to enter the instrument from the sides, as well as through ghost reflections off the back surface of the spectacle lenses. While some may argue that this does not give the true reading of light allowed to pass through a given product itself, we felt this was appropriate because light is also allowed to enter the human eye from angles reflected and/or not blocked by these products.

CHAPTER 5

CONCLUSION

Given the fact that no single product performed consistently well or poorly, it can be concluded that the light source itself, and not the products designed to block the blue light, plays a larger role in the amount of potentially harmful blue light allowed to enter the human eye. While more testing is needed, the logical next step in reducing the amount of blue light that enters the eyes is to place a product directly on or in the eyes. Therefore, blue-blocking contact lenses and intraocular lenses may be the solution to the blue light crisis.

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