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THE EFFECTIVENESS OF BLUE LIGHT BLOCKING GLASSES ON REDUCING THE SEVERITY OF SHIFT WORK SLEEP DISORDER

Science Extension Major Work

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Abstract

To investigate if blue light blocking glasses reduce a significant amount of blue light (450-490nm), and hence if they are a viable non-pharmacological treatment for Shift work sleep disorder, a study was conducted based on the effectiveness of blue light blocking glasses. Multiple glasses and distance from light source to glasses lens were tested to find the remaining light after the blue light blocking glasses had been applied. The initial data set was cut down from 40,000 pieces of data to 168 by identifying and calculating only relevant results that largely effected the circadian rhythm, such as only including the range of blue light due to the intrinsically photosensitive retinal ganglion cells have a photopigment of melanopsin, which is mostly reactive to blue light. The results found that the glasses produced minimally statistically significant changes in light levels as well as showed the inconsistencies in the manufacturing of blue light blocking glasses. Ultimately, these small changes in light levels (8% change was maximum) were not enough to alter a circadian cycle enough to treat Shift work sleep disorder.

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Literature Review

Sleep disorders involving disrupted circadian rhythms have a limited range of effective pharmacological and nonpharmacological treatments (Neil-Sztramko, S. E., Pahwa, M., Demers, P. A., & Gotay, C. C., 2014). Shift Work Sleep Disorder/Shift Work Disorder (SWSD/SWD) affects shift workers who work a range of types of shifts from morning to overnight shifts. It can often engage a variety of dysfunctional transformations to the standard circadian rhythm as the brain attempts to realign the suprachiasmatic nucleus due to constant change in light hitting photoreceptors.

While no cures for the disorder exist, certain treatments attempt to reduce the symptoms and control the rhythm (Thorpy M. J. ,2010) Some pharmacological treatments for SWSD include melatonin supplements, soporific drugs, and wake-promoting agents. These often only work short-term and create a dependency for symptomatic relief. This can progressively damage the long-term effects of the disorder through addiction and constant addition of drugs to fight the unwanted and uncomfortable side effects. Nonpharmacological treatments are hence often prioritised by health care professionals, such as bright light therapy (BLT) and changes to sleep and work routines. Unfortunately, these such treatments are not always feasible as some workers are required to work their set 'unnatural' shifts and cannot change their schedules. Similarly, BLT can be effective, but is can also be uncontrolled when self-conducted, reducing its effectiveness. Patients can alternatively attend a clinic for their BLT, but this can be expensive. In addition, BLT can present side effects such as headaches, nausea, and eye strain (Rizza, S., Luzi, A., Mavilio, M. et al., 2022)

Limited research has been done analysing blue light blocking glasses (BLBG) and their effectiveness as a treatment for SWSD. Some research has been done into their effectiveness in treating other sleeping disorders such as insomnia and delayed sleep phase disorder, and while some investigations proved their effectiveness, others had positive results that were not statistically significant. A viable treatment for SWSD could be the scheduled use of blue light blocking glasses as people who suffer from it often work in places that utilize a lot of blue light (device screens, LED lights, etc). As the patient approaches the end of their shift (soon needing to go to sleep), use of BLBG could theoretically advance their circadian rhythm. Intrinsically photosensitive retinal ganglion cells (ipRGCs) are a type of neuron within the retina, whose photopigment of melanopsin is highly reactive to light mainly in the blue portion of the visible spectrum. They send signals along the optic nerve to the suprachiasmatic nucleus (SCN), the so-called master clock of the brain. As high intensity blue light hits a human eye, the body attempts to synchronize its internal clock to the supposed 24-hour solar cycle (Pickard, G. E., & Sollars, P. J., 2012) In reaction, the pineal gland suppresses melatonin secretion, increasing alertness and reducing sleepiness. By reducing the blue light with BLBG, the body believes the decrease in blue light indicates reducing sunlight, hence advancing the circadian rhythm, and increasing melatonin secretion (Blume, C., Garbazza, C., & Spitschan, M., 2019) On the other hand, BLBG are known for their slight controversy over their effectiveness, as they do not block all blue light and may vary in their effectiveness for treating SWSD.

Aim

To determine if blue light blocking glasses are effective in treating Shift Work Sleep Disorder's symptoms. More specifically, to find; what percentage of blue light frequencies may be reduced through different blue light blocking glasses if any, how this will affect the circadian cycle if at all, and the overall effectiveness of utilizing this method.

Scientific Research Question

Do blue light blocking glasses reduce a significant amount of blue light (450-490nm), and hence are they a viable non-pharmacological treatment for Shift work sleep disorder?

Hypothesis:

Blue light blocking glasses will reduce the intensity of blue light (450-490nm) received by the retina significantly and hence reduce the severity of shift work sleep disorder.

[Should null be stated?]

Methodology

An experiment was conducted to determine what percentage of blue light frequencies (450-490nm) may be filtered through blue light blocking glasses. The assessed glasses included two polycarbonate and two anti-reflective pairs of glasses. The experiment involved an artificial light source (to mimic the device screens and LED lights in common workplaces of those who suffer from SWSD) shining through a pair of blue light blocking glasses that was attached to a dark pipe (to reduce external, uncontrolled light levels). The resultant light was picked up by a spectrometer at the other end of the pipe. The changing independent variable was the distance from glasses to the light source. This determined how the external factor of distance from source affected those who suffer from SWSD. The average distance away from screens that people typically sit can be from 0.3m – 0.7m, hence the distance from lens to source that was used was 0.3, 0.5, and 0.7 metres. The four glasses were tested individually for a variety of samples. Each set of glasses was measured 3 times for each distance, as well as the exposed measurements for comparison. The glasses are advertised to reduce blue light levels by 30-35%, however there is nearly no information about how they were tested. This could mean that they may have been tested under unrealistic conditions to optimise their performance due to the company's potential bias. To test under appropriate conditions, the glasses did not cover the pipe fully, with small gaps left as light can go around glasses in realistic conditions.

The initial gathered data was a large data set, as 45 measurements were taken, with each of these containing nearly 800 different wavelengths. This was so when it was evaluated it will show if a statistically significant level of blue light has been blocked for each pair of glasses at each distance, and therefore if melatonin levels can be drastically affected. As the ipRGC's photopigment (melanopsin) is mostly reactive to blue light in the visible spectrum, the data was initially cut down to this (450-490nm). To make the sample range practical, 14 equally spaced samples were taken for each length and pair of glasses. The average intensity of each set of glasses/exposed measurement for each distance was taken. To calculate the average change in intensity from exposed to each pair of glasses, the previously taken average intensity (of each pair of glasses) was divided by the average exposed intensity. This gave a decimal figure that indicated the following:

Figure = 1: no change in intensity

Figure < 1: reduced intensity

Figure > 1: increased intensity

The remaining data (n=168) was organised in a final table, where each set of data (14xλ for each set of glasses and distance) was tested using a one sample t-test individually, comparing them with a null hypothesis mean of 1. This allowed for each set of glasses to either accept or reject the null hypothesis for each distance (0.3m, 0.5m, 0.7m).

Results

Visual displays

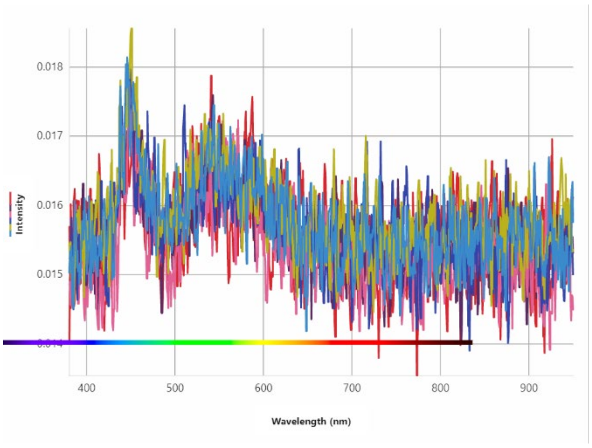

Figure 1: Graph showing a range of intensity measurements for the artificial light source on the electromagnetic spectrum.

Wavelength(nm)	EL1.1:Inte	EL1.2:Inte	EL1.3:Inte	Avg	AL1.1:Inte	AL1.2:Inte	AL1.3:Inte	Avg
450.5	0.01707	0.01856	0.01778	0.0178	0.01739	0.01701	0.01666	0.01702
454.3	0.01749	0.01709	0.01598	0.01686	0.01574	0.01661	0.01629	0.01621
458.1	0.01681	0.01686	0.01645	0.01671	0.01675	0.01592	0.01668	0.01645
461.9	0.01668	0.01673	0.01604	0.01648	0.01618	0.01708	0.017	0.01675
465.7	0.0168	0.01639	0.01591	0.01637	0.01637	0.01642	0.01551	0.0161
469.5	0.01652	0.01585	0.01685	0.01641	0.01527	0.0156	0.01646	0.01578
473.3	0.01596	0.01625	0.01576	0.01599	0.01632	0.01567	0.01565	0.01588
477.1	0.01598	0.01603	0.01696	0.01633	0.01563	0.01624	0.01543	0.01577
480.9	0.01689	0.01541	0.01578	0.01603	0.0151	0.01544	0.01602	0.01552
484.7	0.0159	0.0156	0.01551	0.01567	0.01593	0.01444	0.01446	0.01494
488.5	0.01546	0.01643	0.0158	0.01589	0.01584	0.01557	0.01528	0.01557
492.3	0.01602	0.01502	0.01531	0.01545	0.01452	0.0161	0.01603	0.01555
496.1	0.01532	0.01557	0.01556	0.01548	0.01486	0.01535	0.0157	0.0153
499.9	0.01606	0.01585	0.01606	0.01599	0.01466	0.01545	0.01568	0.01526

Wavelength(nm)	BL1.1:Inte	BL1.2:Inte	BL1.3:Inte	Avg	CL1.1:Inte	CL1.2:Inte	CL1.3:Inte	Avg
450.5	0.01662	0.01656	0.0166	0.01659	0.01762	0.01669	0.01783	0.01738
454.3	0.01725	0.01557	0.01618	0.01633	0.01563	0.01621	0.01623	0.01602
458.1	0.01619	0.01569	0.01679	0.01622	0.0153	0.01641	0.01529	0.01566
461.9	0.01649	0.01595	0.01679	0.01641	0.01624	0.01587	0.01646	0.01619
465.7	0.01579	0.01618	0.01602	0.016	0.0155	0.01608	0.01579	0.01579
469.5	0.0157	0.01641	0.0155	0.01587	0.01499	0.015	0.01517	0.01505
473.3	0.01583	0.0159	0.01596	0.0159	0.01575	0.01513	0.01551	0.01546
477.1	0.01602	0.01579	0.01588	0.01589	0.01589	0.01581	0.01551	0.01573
480.9	0.01549	0.01562	0.01536	0.01549	0.01589	0.015	0.0155	0.01547
484.7	0.01508	0.01486	0.01502	0.01499	0.01503	0.01549	0.01532	0.01528
488.5	0.01568	0.01493	0.01556	0.01539	0.0153	0.01497	0.01467	0.01498
492.3	0.01528	0.01605	0.01493	0.01542	0.01511	0.01532	0.01478	0.01507
496.1	0.01605	0.0158	0.01524	0.0157	0.01546	0.01537	0.01582	0.01555
499.9	0.0162	0.01564	0.01547	0.01577	0.01546	0.01549	0.01507	0.01534

Wavelength(nm)	DL1.1:Inte	DL1.2:Inte	DL1.3:Inte	Avg
450.5	0.0177	0.01808	0.01764	0.0178
454.3	0.01666	0.01653	0.01545	0.01621
458.1	0.01607	0.01689	0.01627	0.01641
461.9	0.01631	0.01744	0.01639	0.01671
465.7	0.01587	0.01607	0.01642	0.01612
469.5	0.01581	0.01635	0.01551	0.01589
473.3	0.0164	0.01643	0.01536	0.01606
477.1	0.01652	0.01618	0.01666	0.01645
480.9	0.016	0.01546	0.01599	0.01582
484.7	0.01524	0.01483	0.01482	0.01496
488.5	0.01545	0.01525	0.01636	0.01569
492.3	0.01553	0.01554	0.0165	0.01585
496.1	0.01571	0.01546	0.01616	0.01578
499.9	0.01519	0.01627	0.01535	0.0156

Table 1: Each set of data shows the remaining 14 wavelengths. Each set of glasses (A, B, C, D) and the exposed (E) measurement is shown. Each have 3 samples (columns) and have their averages found. This is for 1 distance.

	0.3 Metres				0.5 Meters				0.7 Meters			
Wavelength (λ)	A	B	C	D	A	B	C	D	A	B	C	D
450.5	0.95587	0.9319	0.97618	1.00002	0.99938	0.99675	0.92706	0.96703	0.97081	0.9893	0.97623	0.95995
454.3	0.96182	0.96896	0.95046	0.96182	1.00991	1.00469	0.94142	0.98477	0.94995	0.98961	0.98758	0.99631
458.1	0.98453	0.97088	0.93757	0.98238	1.0022	1.01734	0.98339	0.97811	0.9588	0.9571	0.9478	0.98222
461.9	1.01636	0.99546	0.98217	1.014	1.002	0.96212	0.94009	0.97313	0.9399	0.95623	0.9635	0.96343
465.7	0.98365	0.97748	0.96476	0.98502	1.03036	1.01053	0.98257	0.97592	0.98329	0.99544	0.97655	1.01125
469.5	0.9616	0.96721	0.91757	0.96852	0.95867	0.9319	0.93073	0.95584	1.03536	1.04234	1.04165	1.02525
473.3	0.99309	0.99433	0.96704	1.00455	0.98652	0.98657	0.97794	0.98565	0.96836	0.98994	0.98448	1.03425
477.1	0.9658	0.97363	0.96374	1.00783	0.9745	0.9653	0.98006	0.9879	0.98234	0.98101	1.01529	0.99326
480.9	0.96836	0.96672	0.96495	0.98684	0.92998	0.97882	0.95485	0.94979	0.99071	0.98066	0.98261	0.99719
484.7	0.95363	0.95637	0.97508	0.95482	0.9952	1.00784	0.98997	0.9657	0.96318	0.96933	0.98165	0.99966
488.5	0.97938	0.96815	0.9426	0.98689	1.00319	1.01144	0.98714	1.02142	1.03651	1.03507	1.03922	1.05508
492.3	1.0067	0.99807	0.97549	1.02628	0.97288	1.01007	0.97634	0.96179	0.98689	0.95802	0.9826	0.97761
496.1	0.98847	1.01397	1.00449	1.01905	1.00449	0.99135	1.00051	0.98188	1.01566	1.0265	1.03439	1.03865
499.9	0.95445	0.98612	0.95931	0.97559	0.98067	0.97594	0.97689	0.95424	0.98951	0.96132	1.02133	1.00737

Table 2: The final condensed table. Outcomes demonstrate the % of intensity remaining for its given wavelength after comparing the exposed to the glasses.

Key: AL1.1

A is the specific lens (E means no lens)

L1 is the 1st distance from source to lens

.1 is the 1st sample

Description

Initially, the intensity of the wavelengths in the blue light region were seen to minimally change as shown in figure 1. While the measurements were close to each other in each repeated sample, they still deviated significantly relative to the change seen when the independent variables were changed (seen in table 1). In table 2, the calculations showed that for many of the average samples, the light did not increase but remained close to or over 1 (1 being 100% of light retained).

The following calculations were done:

After getting rid of unnecessary data, the average was taken for each set of glasses for each distance (average intensity per wavelength). This is shown in Figure 2.

$$Average\ Intensity = \frac{Intensity1 + Intensity2 + Intensity3}{3}$$

Figure 2.1: Average intensity formula for each wavelength

$$Average\ Intensity = \frac{AL1.1 + AL1.2 + AL1.3}{3}$$

Figure 2.2: Average intensity formula example as done in Table 1

Following this, the percent of intensity of light remaining was calculated by comparing the data of no lens versus the data of each set of glasses. This was done for each distance, and each wavelength as shown in Figure 3.

$$\%\ average\ intensity\ remaining = \frac{average\ intensity\ (glasses)}{average\ intensity\ (no\ glasses)}$$

Figure 3.1: Percent average intensity remaining formula for each wavelength

$$\%\ average\ intensity\ remaining = \frac{average\ intensity\ AL1}{average\ intensity\ EL1}$$

Figure 3.2: Percent average intensity remaining formula example to convert from Table 1 to Table 2

Finally, the resultant data is shown in Table 2, where only relevant, compatible data is remaining.

Discussion

A one-sample t-test was conducted upon the final results (Table 3) for each set of glasses within each distance group. The results were sporadic and minimal patterns became apparent. In some samples, the remaining blue light maintained a very similar intensity, and even appeared to have gained in some instances. Glasses A, B, and C appear to function at 0.3m, but progressively work less the further away from the light source. Blue light blocking glasses C appeared to work for the furthest distance, however they still only blocked between 0% – 8% of blue light at their strongest (0.3 metres). All but glasses A failed to block a statistically significant amount of blue light at 0.7 metres. However, A's reliability may be questioned as it fails to maintain the pattern of the other glasses where once they ceded to reject the null hypothesis, they continued to accept it for the remaining distances. Overall, the greatest amount of light reduced was only 8.24%, which would not be of much effect towards the circadian rhythm, and this was found at the best functioning sample (C, 0.3m), meaning that for most of them, the glasses did not function properly as a potential treatment for shift work sleep disorder.

0.3 Metres				0.5 Metres				0.7 Metres			
A	B	C	D	A	B	C	D	A	B	C	D
reject	reject	reject	accept	accept	accept	reject	accept	reject	accept	accept	accept

Table 3: One sample t-test results

Glasses A and B were anti-reflective (acrylic) and made by the same brand. This may explain their similar trend of rejecting the null hypothesis for 0.3 metres and accepting beyond that (however the 0.7m measurement of A may be unreliable). The polycarbonate glasses (C, D) performed worse than the anti-reflective ones but were not made by the same brand, likely leading to their different performances. Testing of the blue light blocking glasses may have had bias environmental variables in order to promote them and out-do competitors. Since the glasses were advertised to block 30-35% of blue light, some of these variables may have been distance from light source, and distance from lens to photoreceptor, where while the results may have technically been true, it was performed under unrealistic conditions.

The experiment's capabilities were limited due many reasons. One reason was that most of the equipment used was improvised and not made to the most precise quality due to budgetary issues. However, the spectrometer used was fully functional, meaning that it was most likely the unstable supporting materials and other equipment that may have held back the full accuracy of experiment. Also due to limited access to facilities, the experiment was conducted in a room with block-out blinds. While the blinds allowed for control of majority of external light level changes, some light would still have gotten through, potentially effecting the results.

Unless a person has blue light blocking goggles, where nearly all blue light can be filtered (ascertaining the supposed 30-35%), blue light blocking glasses would not function as an effective method of treatment for shift work sleep disorder. The small amount of blue light reduced at best would still not be enough, as throughout the 24-hour solar cycle, the natural changing light levels being received by the intrinsically photosensitive retinal ganglion cells are significantly larger than what was recorded. However, some glasses might work for extremely mild cases of shift work sleep disorder as they appear to vary largely between brands and materials. Also, as the distance increased, the effectiveness of the blue light blocking glasses was seen to decrease, showing that in a typical night shift environment of LED lights and computer screens, the glasses would have minimal effect.

Further research is needed to understand how blue light blocking glasses may be applied as a treatment for circadian disruptions disorders. Their current inconsistencies in design has largely contributed to their inability to function as a reliable treatment, so perhaps large standardising may need to be implemented to ensure effective research. Shift work sleep disorder remains to be one of the most prominent disrupted circadian rhythm disorders and new nonpharmacological treatments must be developed to treat it while no cure exists. Until this, perhaps the most reliable method to treat SWSD is soporific drugs, melatonin supplements, and wake-promoting agents.

Conclusion

After investigating and testing whether blue light blocking glasses could be an effective treatment for shift work sleep disorder, the results demonstrated that they may not be very reliable due to the sporadic changes in remaining blue light over multiple distances and glasses. The varying results actually appeared to both decrease the intensity of blue light by up to 8% and actually increase above the original intensity. The further away the glasses were from the artificial light source, their function became even worse, showing that in someone who suffers from shift work sleep disorder's work environment, the surrounding LED lights and computer screens would not be effectively blocked by blue light blocking glasses.

Some aspects of the method to collect the results could have been improved such as the quality of the equipment, and the control of external light sources. Overall, blue light blocking glasses are not an effective treatment for shift work sleep disorder as the small amount of blue light that is blocked is not significant enough to control the circadian rhythm when compared to the 24hour natural solar cycle's change in light levels. Continued research may be done in both the areas of blue light blocking glasses and shift work sleep disorder. Blue light blocking glasses are currently being produced in an inconsistent manner. So, in order for effective trials and experiments to be conducted, perhaps standardising must be implemented for their material and construction. Until nonpharmacological treatments can be efficiently developed for shift work sleep disorder, pharmacological treatments are most likely the most effective.

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