The Effect of Colors of Sunglasses on the Visual Performance

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ABSTRACT
The best way to protect the eyes from harmful solar radiation, particularly UV, is to use sunglasses. Sunglasses are widely available with lenses in a range of different colors. This study was designed to investigate how different colors in sunglasses affect visual acuity, contrast sensitivity, stereopsis, and color vision. In this analytical-descriptive study, 65 normal subjects participated. After refractive correction, visual acuity was determined using Snellen visual acuity chart, contrast sensitivity was determined using the Cambridge low contrast grating chart, stereopsis was determined with the TNO test. The mean visual acuity in normal light and under the sun was 20/20. The repeated ANOVA test did not show a significant difference between the participants’ contrast sensitivity in room light and in sunlight with and without filters (p>0.05). Mean stereopsis with gray and gray polarized filters and without any filter in sun was considerable using the Paired Samples T-test (p<0.05). Moreover, the Wilcoxon test demonstrated significant difference between color vision status with and without filters in sunlight (p<0.05). Although, statistically, significant increase in contrast sensitivity was not seen, it is apparent that sunglasses can improve contrast sensitivity in sunlight, particularly with gray color lenses in comparison to other colors.

INTRODUCTION

Sunlight consists of different types of radiation which include ultraviolet radiation, infrared and visible light. These rays can damage the eyes depending on the individual’s activity and level of exposure to sunlight. More damage is caused by ultraviolet radiation than other types of radiation (Pascu, 2007). Ultraviolet light is subdivided into 3 groups; those with wavelengths between 315-400 nm are called ultraviolet A, 280-315 is known as ultraviolet B and 200-280 is known as ultraviolet C (Rachel, 2002). Ultraviolet C radiation is absorbed by the corneal epithelium. This light is absorbed by the earth’s atmosphere and the ozone layer which prevent it from reaching earth. Therefore, this radiation does not usually damage the eyes. Ultraviolet A is absorbed by the corneal epithelium and nuclear of crystalline lenses. Ultraviolet B can also be absorbed by corneal epithelium and nuclear of crystalline lenses. Ultraviolet A and B have been shown to cause cataracts and pinguecula (conjunctival degeneration over time). These diseases are more common for those working for long periods of time in sunlight; common sufferers include construction workers, farmers and hunters who develop these health problems more than expected in the average populace (Rachel, 1993). In Aphakic people, ultraviolet radiation can have particularly dangerous effects such as cystoid macular edema. Fortunately this danger has been reduced in recent times using intraocular lenses to protect from UV radiations (Boyd, 1991).

It is generally accepted and recommended that the eyes should be protected against the potentially dangerous effects of ultraviolet radiations. This protection can be attained using sunglasses and wide-brimmed hats. As a result, sunglasses should be equipped with ultraviolet radiation coating (Citek, 2008). Another longstanding problem of exposure to the sun is dazzle caused by intensive light which can decrease the visual performance, such as contrast sensitivity, and can be cured using black glasses. The percentage of natural light transmission for sunglasses is usually 15-30%. It is less likely that light transmission over 30% is conducive to good vision. As well as this, light transmission less than 15% causes over-blackness of the environment(Clifford,1990; Pfeiffer, 2008; Narayan, 2008)Since very dark glasses dilate the pupils and let extra light inside the eyes, in which case any damage caused by radiation will be worse, they are not generally used(Rachel,1993). In this regard, polarized lenses cancel out the dazzle of sunlight caused as a result of flat surface reflection such as the reflection of sunlight off pavement asphalt or the surface of a body of water;

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therefore polarized lenses can be very useful when driving and fishing. However, the polarization of these lenses doesn’t have any effect on ultraviolet radiation absorption (Citek, 1991).

Considering the research undertaken by scientists regarding the potential danger posed by the sun, it is essential to wear sunglasses in order to protect eyes (Dongre, 2007; Pakrou, 2008; Lagerlund, 2006). It should be considered that each different colors of lens in sunglasses are designed for specific applications. To give an example, research shows that pink lenses are used mostly for glare disorder in working and in closed environments. The best way to solve vision problems associated with a work environment is to change the lighting conditions of the workplace. Pink lenses can absorb waves similar to the wavelengths of UV radiation. In elderly people or cataract patients, who suffer from fluorescence of crystalline lenses, wearing pink lenses can ease their suffering more effectively in comparison to white lenses (Clifford, 2006). Blue and violet colored sunglasses are not suitable to use because they decrease contrast of colors. It is probable that sunglasses, especially those in bright blue colors, can damage the eyes by dilating the pupil. Yellow colored lenses are useful for foggy environments; these glasses are good while doing sports which need high speed such as skiing, because they increase the contrast by absorbing blue colors (Clifford, 2006; Defez, 1990).

A study was done by Dain on 20 visually normal people and 49 patients with color deficiency to evaluate the effect of different colors of sun glasses on color vision. He pointed out that most of the colors of sunglasses which are allowed to be used by drivers result in color recognition disorders (Dain, 2009). Considering the important effect of various colors of sunglasses on visual performance, this study was aimed to evaluate the effect of different colors of sun glasses on visual acuity, contrast sensitivity, stereopsis and color vision.

MATERIALS AND METHODS

In this analytical-descriptive study, students at Zahedan University of Medical Sciences were randomly selected from a list of students. 65 students (40 female, 25 male), who met inclusion criteria and had given informed consent, were entered into the study. In addition, we assured subjects that their information was kept confidential in accordance with the tenets of the Declaration of Helsinki.

All subjects had best corrected visual acuity of 6/6, normal color vision and full visual fields by confrontation with finger counting. They had no manifest strabismus and no history of ocular or systemic disease.

Refractive errors were determined objectively by hand held retinoscopy (Heine β-200 Retinoscopy), refined by subjective refraction and finalized with dissociated red-green balance test. Then, the best corrected visual acuity was measured for right, left and both eyes using Snellen visual acuity chart. Contrast sensitivity was measured, monocular and binocular, at distance of 6 meters from the eyes using Cambridge low contrast grating chart.

Color vision and stereopsis were tested by D-15 and TNO, respectively.

Next, these tests were repeated in sunlight using green, gray, brown and polarized gray sunglasses. We used colored lenses randomly for each subject and for each filter in order to allow light and dark adaptation they each had to adapt to the lenses for 20 minutes before examination. Also because colored filters can affect on red green filter of TNO test, stereopsis was only measured for the gray lenses.

Total light transmission of color filters was 17.65, 20.32, 20.57 and 20.28% for Polaroid gray filter, gray, brown and green filter respectively and the luminance of room was 476 cd m⁻² in and in sun was 1610 cd m⁻² for the distance and near tests as measured with a Hugner universal photometer Model S3.

After data collection, data was analyzed in SPSS.19 software using Paired-samples T, repeated measure ANOVA and Wilcoxon on tests. The significance level was set at P<0.05.

Results:

65 students aged 20-22 were evaluated. Average visual acuity in the room with normal light was 20/20 as well as in the sunlight, whether or not a filter was used.

Mean contrast sensitivity in the room and in the sunlight before and after the insertion of filters with different colors in front of the eyes presents in Table 1.

Table 1: Mean and SD of contrast sensitivity in the room and in sunlight with and without filters.

<table>
<thead>
<tr>
<th>Status Statistical index</th>
<th>Without filter in the room</th>
<th>Without filter under the sun light</th>
<th>Gray filter</th>
<th>Gray Polaroid filter</th>
<th>Brown filter</th>
<th>Green filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean±SD</td>
<td>432.24±106.95</td>
<td>421.60±114.77</td>
<td>434.80±970.58</td>
<td>427.20±499.36</td>
<td>425.80±90.26</td>
<td>419.20±96.20</td>
</tr>
</tbody>
</table>

Using the Paired Samples-T test, there was no significant difference between contrast sensitivity in the room and under the sun without filter (p=0.616). Moreover, the Repeated Measures ANOVA test indicated no difference between mean contrast sensitivity without filter in the room and in the sunlight with gray, green, brown and polarized gray filters(p=0.985). However, Paired Samples-T test showed significant difference.
between stereopsis without filter and with gray filter and with polarized gray filter in the sunlight (p <0.001)(Table 2).

Table 2: Mean and SD of stereo-acuity in sunlight with and without filters.

<table>
<thead>
<tr>
<th></th>
<th>Without filter</th>
<th>Gray filter</th>
<th>Gray Polaroid filter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>43.75</td>
<td>65.50</td>
<td>58.75</td>
</tr>
<tr>
<td><strong>SD</strong></td>
<td>16.02</td>
<td>40.50</td>
<td>33.15</td>
</tr>
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</table>

Table 3 demonstrates the status of color vision with and without filters. Having data analyzed with the Wilcoxon test, it showed that there was significant difference between color vision without filter and with gray, green, brown and polarized gray filters (p=0.006 for polarized gray, p=0.010 for green, p=0.014 for brown, and p=0.004 for gray filter).

Table 3: Color vision status with and without filters.

<table>
<thead>
<tr>
<th></th>
<th>Normal color vision N (%)</th>
<th>Protan-like defect N (%)</th>
<th>Deutan-like defect N (%)</th>
<th>Tritan-like defect N (%)</th>
<th>Tetratran-like defect N (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Without filter</strong></td>
<td>65 (100.00%)</td>
<td>0 (0.00)</td>
<td>0 (0.00)</td>
<td>0 (0.00)</td>
<td>0 (0.00)</td>
</tr>
<tr>
<td><strong>Brown filter</strong></td>
<td>55 (84.60%)</td>
<td>1 (1.50%)</td>
<td>0 (0.00)</td>
<td>6 (9.20%)</td>
<td>3 (4.60%)</td>
</tr>
<tr>
<td><strong>Green filter</strong></td>
<td>54 (83.10%)</td>
<td>1 (1.50%)</td>
<td>0 (0.00)</td>
<td>7 (10.80%)</td>
<td>3 (4.60%)</td>
</tr>
<tr>
<td><strong>Gray filter</strong></td>
<td>58 (89.20%)</td>
<td>0 (0.00)</td>
<td>0 (0.00)</td>
<td>5 (7.70%)</td>
<td>3 (4.60%)</td>
</tr>
<tr>
<td><strong>Gray Polaroid filter</strong></td>
<td>56 (86.20%)</td>
<td>2 (3.10%)</td>
<td>0 (0.00)</td>
<td>6 (9.20%)</td>
<td>1 (1.50%)</td>
</tr>
</tbody>
</table>

Discussion:

Results of this study indicated that sunlight does not change visual acuity. Decreased contrast sensitivity in the sun was not statistically significant, but requires more cautions clinically. Contrast sensitivity showed that the greatest increase was while wearing a gray filter in the sun. In contrast, the greatest decrease of contrast sensitivity occurred with a green filter. Thus, decreased contrast sensitivity in the sun without wearing a filter can affect visual performance and reduce vision quality for doing sensitive activities such as driving. This decrease can be removed using sun glasses, especially gray and brown colored lenses. The brown color has properties similar to yellow lenses in terms of high absorption of short visible light wavelengths. These lenses are suitable for polluted environments and foggy days since they reduce the light scatter of blue light and increase contrast (Modarreszadeh, 2001). In a study conducted by De Fez through doing grating contrast tests on 10 subjects, it was demonstrated that contrast sensitivity of blue, brown and green filters is the same as the gray filter under lighting but yellow filter increases contrast sensitivity (de Fez, 2002). We came to the same results regarding brown and gray filters, but differences regarding green filters can be attributed to contrast sensitivity testing type and sample size (65 versus 10 subjects). Sakamoto Y demonstrated the CSF did not change under day light conditions for the younger group but improved in the elderly and conducted sunglasses not only protect against glare but also stabilize visual quality under various light conditions (Sakamoto, 2002). Gray glasses are the best choice for driving and general use. These glasses give a very good contrast (Modarreszadeh, 2001). This study’s results also indicated that the gray filters increase contrast sensitivity more than the other colors tested.

Also, regarding stereo acuity, gray filter had a negative effect on stereopsis. In a study conducted by Hovis on yellow lenses in comparison to a neutral density gray filter, results showed that these lenses increase contrast sensitivity as gray filters do, but don’t change the stereopsis (Hovis, 1989).

In the present study, gray and green filters caused the least and the largest color vision deficiency respectively. This finding is consistent with De Fez’s study, he also pointed out that brown and green filters create more color vision deficiency in comparison to gray ones (de Fez, 2002). Gray is a very common color used in sun glasses. The most important property of theses lenses is the role they play in the uniform cross of visible light which causes colors to be seen in their natural state. Gray lenses are appropriate for those with color vision deficiency, but they do not improve color deficiency. People with normal color vision can adapt themselves to the color change created by colorful lenses; in contrast, those with color vision deficiency are deprived from such ability. Colorful lenses, other than gray, increase color differentiation error (Clifford, 2006). Many sunglasses tinted currently used for driving be cause significant detriment in the ability of chromatic discrimination to detect and recognize traffic signals (Dain, 2009). According to the results of this study, green color causes the least contrast sensitivity for the users as well as more deficiency in color vision. This finding is consistent with a study done by Brock et al. Based on their research, green color, against gray glasses, doesn’t provide suitable perception of color (Clifford, 2006).

In this study, although results were not statistically significant for contrast sensitivity, increased contrast sensitivity was created by gray filters in comparison to other colors. This can be important in improving the visual performance of the users especially given that the least disruption of color vision with gray filter is vital for sensitive work such driving. According to the results of this study, green color causes the least contrast sensitivity for the users as well as more deficiency in color vision.
REFERENCES