Article ▸ # Effect of Colored Overlays on Computer Vision Syndrome (CVS)

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ABSTRACT

Background: Colored overlays may produce an improvement in reading when superimposed over printed materials. This study determined whether improvements in reading occur when the overlays are placed over a computer monitor.

Methods: Subjects (N=30) read from a computer screen for 10 minutes with either a Cerium or control overlay positioned on the monitor. In a third condition, no overlay was present. Immediately following each trial, subjects reported ocular and visual symptoms experienced during the task.

Results: Mean symptom scores following the Cerium, control, and no overlay conditions were 12.83, 17.37, and 15.65, respectively (p=0.47). However, a subgroup of 7 subjects (23%) reported significant improvements with the Cerium overlay. The mean symptom scores for the Cerium, control, and no overlay trials for this subgroup were 12.14, 29.86, and 28.93, respectively (p=0.03). No significant improvements in either reading speed or reading errors were observed in this subgroup.

Conclusion: The use of colored overlays may provide a treatment method for some subjects reporting symptoms during computer use.

Keywords: colored overlays, computer vision syndrome, Meares-Irlen syndrome, reading, visual stress

Introduction

Computer vision syndrome (CVS) is defined by the American Optometric Association as the combination of eye and vision problems associated with the use of computers.[1] This condition has also been referred to as digital eye strain.[2] These symptoms result from the individual having insufficient visual capabilities to perform the computer task comfortably. In 2011, the United States Department of Commerce estimated that 96% of working Americans use new communications technologies as part of their daily life, while 62% of working Americans use the internet as an integral part of their jobs.[3] Further, when combined with non-vocational computer use for activities such as e-mail, internet access, and entertainment, computer usage is now almost universal.[4] Indeed, a recent report indicated that adults may spend, on average, approximately 8.5 hours per day viewing electronic screens.[5]

It is difficult to estimate accurately the prevalence of ocular and visual symptoms associated with viewing electronic screens because both working conditions and the methods used to quantify symptoms vary widely.[6,7] Nevertheless, Thomson[8] suggested that between 64 and 90% of computer users experience visual symptoms that may include eyestrain, headaches, ocular discomfort, dry eye, diplopia, and blurred vision either at near or when looking into the distance after prolonged computer use. Furthermore, a recent investigation of office workers in New York City noted that 40% of subjects reported tired eyes "at least half the time," whereas 32 and 31% reported dry eye and eye discomfort, respectively, with this same frequency.[9]

In addition, there have been a large number of reports documenting the use of both colored lenses and overlays to improve reading comfort and performance,[10-12] although this therapy is not universally accepted.[13] A syndrome termed either Meares-Irlen syndrome[10] or scotopic sensitivity syndrome[14] has been described, whereby subjects describe symptoms of visual stress or asthenopia which can be alleviated by the introduction of colored overlays over the text.[11] In a review of this topic, Evans[11] noted that while no satisfactory mechanism has been elucidated to describe the mechanisms underlying any benefit resulting from the introduction of colored filters, potential theories include changes in oculomotor responses,[15] attenuation of a defect in the transient visual system,[16] or changes in focal cortical hyperexcitability.[17] These filters have also been reported to improve both reading speed and accuracy following a stroke.[18]

It should also be noted that in some cases the symptoms identified as Meares-Irlen syndrome were actually related to accommodation or binocular anomalies, which were subsequently eliminated when treated with conventional ophthalmic lenses, prisms, or vision therapy.[15] Furthermore, relatively few studies using colored filters included a masked control condition (an exception being the investigation of

Table 1: The symptom questionnaire comprised the following 10 questions (taken from Hayes et al. 2007). The total symptom score was calculated as the sum of the 10 responses on a scale from 0 to 100.

During the task that you just completed, did you experience any of the following symptoms either during or immediately after the task? If no, please circle zero for each question. If yes, please rate the intensity of the symptom on a scale from 1 (very mild) to 10 (very severe), with 5 being a moderate response.	
Blurred vision while viewing the computer screen	0 1 2 3 4 5 6 7 8 9 10
Blurred vision when looking into the distance	0 1 2 3 4 5 6 7 8 9 10
Difficulty or slowness in refocusing my eyes from one distance to another	0 1 2 3 4 5 6 7 8 9 10
Irritated or burning eyes	0 1 2 3 4 5 6 7 8 9 10
Dry eyes	0 1 2 3 4 5 6 7 8 9 10
Eyestrain	0 1 2 3 4 5 6 7 8 9 10
Headache	0 1 2 3 4 5 6 7 8 9 10
Tired eyes	0 1 2 3 4 5 6 7 8 9 10
Sensitivity to bright lights	0 1 2 3 4 5 6 7 8 9 10
Discomfort in your eyes	0 1 2 3 4 5 6 7 8 9 10

Wilkins et al.[19]), and so a placebo effect cannot be ruled out in many cases.

Even in the absence of a clear underlying mechanism, these reports of improved reading comfort and performance might suggest the use of colored filters as a potential therapy for CVS. Accordingly, the aim of the present study was to determine whether improvements in either reading performance or post-task symptoms occurred when colored overlays were superimposed over a desktop computer monitor during a reading task. A control condition was added to eliminate the possibility of a placebo effect.

Methods

The experiment was carried out on 30 visually-normal subjects (16 male, 14 female) between 18 and 27 years of age. All had habitual distance visual acuity of at least 6/6 (20/20) in each eye. None had strabismus or manifest ocular disease. The study followed the tenets of the Declaration of Helsinki, and informed consent was obtained from all subjects after an explanation of the nature and possible consequences of the study. The protocol was approved by the Institutional Review Board at the SUNY State College of Optometry.

Subjects were required to read text aloud (to ensure compliance) from a desktop computer screen (Dell Optiplex GX620 with 17" flat panel monitor; Dell Corp, Round Rock, TX) at a viewing distance of 50 cm for a continuous 10-minute period. The task involved reading paragraphs of unrelated words produced by copying the first and last word of each line from two fiction novels. This task has been used in previously published studies from our laboratory[7,20] and has been shown to be cognitively demanding. A fixed chin rest was used to maintain constant viewing distance and angle. The screen was positioned so that about 75% of the visible screen area was positioned below the subject's eye level. The upper and lower edges of the visible screen area lay approximately 7.5° above and 22° below eye level, respectively. Sufficient material was provided for 10 minutes of reading without repetition. The computer text was displayed using Microsoft Word software (Microsoft Inc., Redmond, WA) with the monitor set at a pixel setting of 1280 by 1024. The text was black Arial font of 12 point size with a contrast of approximately 80%. This is a commonly used sans-serif font, and the vertical height of a lower case letter without ascenders or descenders was approximately 2.5 mm. Target luminance was approximately 15 cd/m^2.

Three different reading trials were completed, each of which was separated by a period of at least 30 min. The order of performing the three trials was counterbalanced across subjects. Either a specialized Cerium overlay (i.e., a colored overlay designed to improve reading disability, Cerium Visual Technologies Ltd, Tenterden, Kent, U.K.) measuring 296 mm by 210 mm of a color selected by the subject or a control overlay (a colored plastic sheet cut from an acetate file folder purchased from a local stationary store and selected to match the Cerium overlay as closely as possible) was placed over the computer monitor for the duration of the reading task. Five different colored Cerium overlays (goldenrod, leaf, orange, rose, and yellow) were presented to the subject, and they were invited to select the one that they felt gave the most comfortable vision when placed over the computer screen. A control overlay was then chosen to match the selected Cerium overlay (matched by eye; the spectral characteristics of the overlays were not measured). In a third condition, subjects performed the task with no overlay present.

During the reading task, subjects were recorded using an audio digital recorder (Sony ICD-PX820; Sony Corp., Tokyo, Japan). Immediately following completion of each reading task, subjects completed a written questionnaire (taken from Hayes et al.[21]) asking about their level of ocular discomfort during the task. The 10 symptoms examined are listed in Table 1.

Subjects wore their habitual refractive correction (either spectacles or contact lenses) during the three reading tasks. Post-task symptoms were reported on a scale from 0 (none) to 10 (very severe), with a score of five representing a moderate response. The mean findings for the 3 different conditions were compared using analysis of variance performed using StatistiXL software (www.statistixl.com; Broadway-Nedlands, Western Australia).

Results

The mean total CVS symptom scores following the Cerium, control, and no overlay conditions were 12.83, 17.37, and 15.65, respectively (F=0.76; df=2,89; p=0.47). These findings are shown in Figure 1. The results for each individual subject (Cerium overlay minus control), plotted as a function of the finding for the control overlay, are shown in Figure 2.

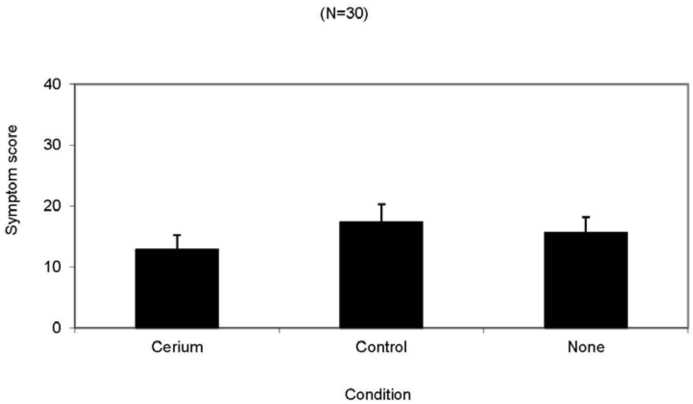

Figure 1: Mean total symptom scores for the 3 overlay conditions immediately following the computer task for the total sample of 30 subjects. Error bars indicate 1 standard error of the mean (SEM).

It may be observed that a subgroup of 7 out of the 30 subjects (23%) showed an improvement in total symptom score greater than 10 with the Cerium overlay when compared with the control overlay. The mean symptom scores for the Cerium, control, and no overlay trials for this subgroup were 12.14, 29.86, and 28.93, respectively (F=4.21; df=2,20; p=0.03, Figure 3). In view of the small number in this subgroup, it was not possible to detect any trends in the preferred color of the Cerium overlay.

The mean number of reading errors made during the 10-minute task for the Cerium, control, and no overlay conditions was 10.9, 12.6, and 12.0, respectively (F=0.24; df=2,89; p=0.79). In addition, no significant difference between the number of errors made was observed for the subgroup showing the largest reduction in CVS symptoms (F=0.33; df=2,20; p=0.73). The mean reading speed during the 10-minute task for the Cerium, control, and no overlay conditions was 108.7, 107.6, and 110.8 words per minute, respectively (F=0.17; df=2,89; p=0.84). In addition, no significant difference in the reading speed was observed for the subgroup showing the largest reduction in CVS symptoms (F=0.38; df=2,20; p=0.69).

Discussion

While no significant improvement in either symptom score or reading performance was observed with the Cerium colored overlays for the entire group of 30 subjects examined, the Cerium filters did produce a significant reduction in CVS symptoms in a subgroup (23%) of the subjects studied. However, this was not accompanied by a significant improvement in reading speed or in the number of reading errors. Nevertheless, the use of colored overlays may provide a potential method of treatment for a subgroup of subjects reporting significant CVS symptoms. It should also be noted that this study included a placebo control, so that subjects were unaware of whether they were reading through the Cerium or the control overlay (although the experimenter was not masked as to which filter was being used). The only other study we are aware of that used a colored control filter was that of

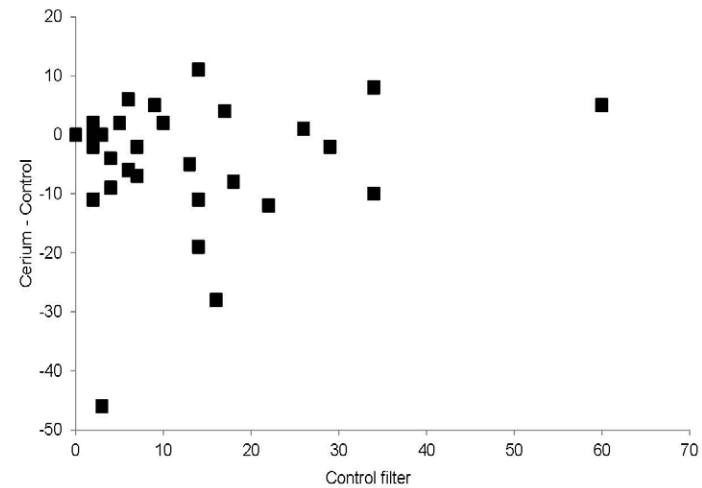

Figure 2: Difference between the symptom scores for the Cerium and control filters for each subject (N=30), plotted as a function of their score for the control filter.

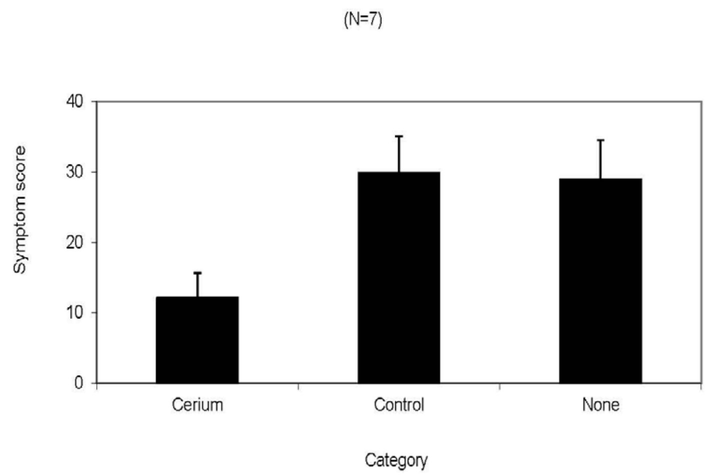

Figure 3: Mean symptom scores for the 3 overlay conditions immediately following the computer task for the 7 subjects who showed the biggest effect with the Cerium filters. Error bars indicate 1 SEM.

Wilkins et al.[19] These authors used the Intuitive Colorimeter to determine the optimum colored filter (provided as a tinted spectacle lens) for children who all reported benefit from colored overlays when reading. A second pair of lenses (the control) was also provided which was of similar color, but of a chromaticity outside the range over which target perception was reported to improve. Interestingly, these results showed that 22 subjects preferred the experimental spectacles, and 26 subjects preferred the control pair. However, the prevalence of symptoms was reduced on those days when the experimental lenses were worn. It was suggested that the benefit derived from the control filters may have resulted from the control tints being "so similar" to the experimental pair.

It is unclear why no effect was observed with the control filters, which at least by eye appeared to be a very similar color to the Cerium filters. We did not measure the transmission ccharacteristics of the experimental overlays. While the spectral properties of other therapeutic filters (e.g., Intuitive

Overlays, I.O.O. Sales, London, U.K.) have been reported previously,[22] it is unknown whether the Cerium filters are similar. Nevertheless, these findings suggest that the benefit will not accrue by simply providing a colored background. A more detailed analysis of the spectral composition of the filters is necessary to determine the specific characteristics which lead to the improvement in symptoms.

It is not surprising that the majority of subjects in the present investigation did not show any significant effect when reading through the colored filters. This study made no attempt to pre-screen the subjects, and so many (probably most) did not have any reading difficulties. Had the investigation been restricted to individuals with reading limitations, then the results might have been different. Nevertheless, a subgroup (23%) showed a reduction in the total symptom score of at least 10 points. This criterion was chosen because previous studies performed in our laboratory have observed mean total symptom scores when reading from a desktop computer screen and printed hard copy material of 30.6 and 24.7, respectively ($p=0.04$), i.e., a difference of 5.9 points.[23] Of course, had a different threshold been chosen, then the proportion of subjects showing a significant effect would have varied. Interestingly, only one subject showed an increase in symptoms greater than 10 (that subject exhibited an increase of 11 points in the total symptom score), so the results are not evenly distributed (that is, with an approximately equal number of subjects showing increased and decreased symptom scores, respectively).

While the results presented here do not allow determination of the physiological mechanisms underlying this subjective improvement, one possibility is that the effect is mediated via a change in accommodative response. Studies into the effect of colored filters on accommodation are equivocal. For example, Allen et al.[24] observed a reduced accommodative response in subjects with pattern-related visual stress. Interestingly, introducing color into the background of the laptop computer screen made the accommodative response significantly more accurate in symptomatic subjects but not in the symptom-free group. While some investigations have also noted accommodative differences in subjects with Meares-Irlen syndrome,[25,26] others have found no significant effect.[27] As a result of the longitudinal chromatic aberration of the eye, different wavelengths are not focused in the same plane relative to the retina, thereby potentially altering the accommodative stimulus. Accordingly, longitudinal chromatic aberration may alter the L-cone to M-cone contrast ratio [L-cone and M-cone refer to retinal cones that are most sensitive to long (≈ 564-580nm) and medium (≈ 534-545nm) wavelengths, respectively], since this ratio may provide a signal to the direction of accommodation.[28] Chase et al.[29] reported that individuals with higher L/M cone-contrast sensitivity ratios had weaker reading performance as a result of an increased accommodative demand. Indeed, Drew et al. found that the preferred color preference for subjects with reading symptoms correlated with accommodative function.[28] However, this raises the question of whether the use of colored filters and/or colored computer backgrounds is a viable alternative to conventional optometric therapies (typically plus lenses and vision therapy) for the treatment of computer vision syndrome in those subjects with accommodative issues. This is worthy of further investigation.

Conclusion

This study has demonstrated that the use of Cerium colored overlays can produce a significant reduction in CVS symptoms in a proportion of subjects when compared with a control colored filter. However, it should be pointed out that no significant improvement in either reading speed or reading errors was observed in this subgroup. While the mechanisms underlying this improvement remain unclear, this may provide a useful therapeutic intervention for the millions of individuals experiencing significant symptoms while viewing digital electronic screens.

Conflict of Interest

None of the authors have any financial interest in any of the products described in this study.

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