

# Article ▶ Effects on Accommodation and Symptoms of Yellow-Tinted, Low Plus Lenses

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## ABSTRACT

**Introduction:** Yellow-tinted, low plus eyeglasses have been advertised as a cure for computer vision syndrome. In the first of two studies, the claims of one brand of “digital performance eyewear” are evaluated.

**Methods:** A crossover study of 36 subjects was conducted to examine the difference between low plus (+0.50D) yellow-tinted computer spectacles and placebo lenses. The two pairs of eyeglasses were in similar frames, and both sets of lenses were made of similar resin with antireflective coating, but the placebo lenses were made without optical power or tint. Measurements of dynamic accommodation and pupil size at 5 Hz, along with subjective symptoms experienced with each type of glasses, were made.

**Results:** Wilcoxon matched pair testing revealed a significant difference in the symptom of irritation or burning of the eyes. Pupil size was significantly different ( $p=0.001$ ), but differences in the accommodative responses to the two lens types were not significant ( $p=0.56$ ).

**Conclusions:** While some participant symptoms were reduced when using the yellow-tinted, low-plus eyeglasses that we studied, no objective reason was found when accommodation and pupil size were monitored five times per second. A follow-up study that will test tear film, blink rate, and quantified squinting is indicated to discover an objective reason for this preference.

**Keywords:** accommodation, computer vision syndrome, low plus lenses, yellow filters

## Introduction

The American Optometric Association (AOA) defines computer vision syndrome (CVS) as a complex of eye- and vision-related problems that result from prolonged computer use.<sup>1</sup> Many treatments for CVS have been investigated, some of which are available over-the-counter. These remedies include homeopathic<sup>2</sup> and Ayurvedic<sup>3</sup> eye drops, yoga,<sup>4</sup> and topical warming pads.<sup>5</sup>

While computers have become ubiquitous for school, work, and play, the acknowledgement of CVS is not uniform. It should not come as a surprise that the ways in which eye care professionals treat CVS are variable. When presented with a patient with CVS symptoms, traditionally, ophthalmologists will recommend artificial tears or pharmaceuticals, with less than half recommending optical intervention.<sup>6</sup>

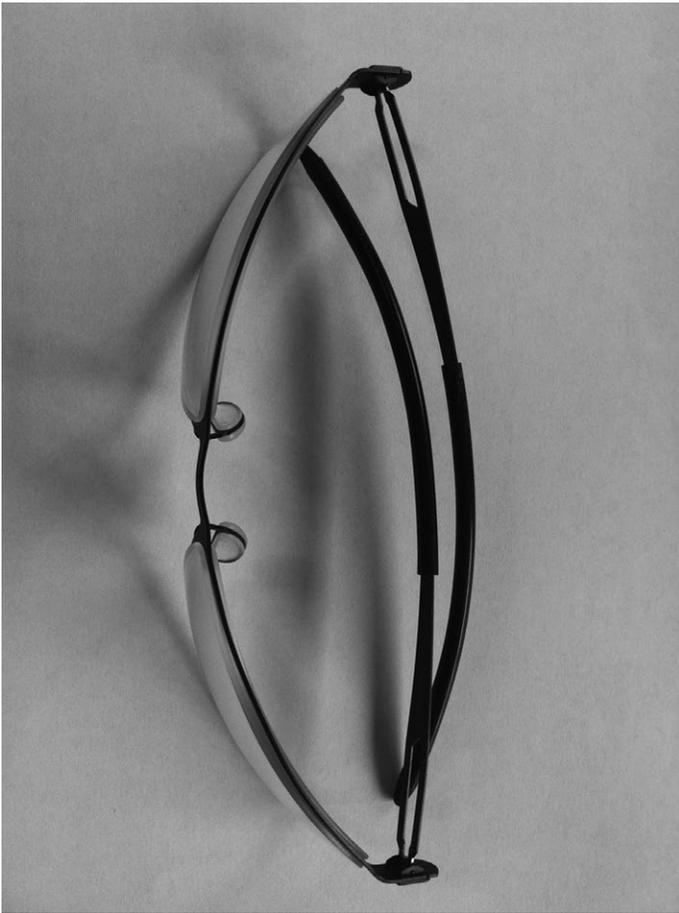
While optometric vision therapy may be the treatment of choice for many patients with CVS, unfortunately some patients are unaware of, or are disinterested in, that treatment modality. For these patients, passive optical treatments may be appealing; these are not new. Some readers may recall one of the first corporations to market low-powered plus lenses combined with light tint and an antireflective coating, the PRIO Corporation (now owned by Essilor), approximately twenty-five years ago.<sup>7</sup>

For those CVS sufferers who are emmetropic (or corrected to emmetropia with contact lenses), prescription computer eyeglasses may seem unnecessary. This is especially true of the younger pre-presbyopic population; enter companies like Gunnar Optiks. According to the company website ([www.gunnars.com/what-are-gunnars/](http://www.gunnars.com/what-are-gunnars/)), these computer eyeglasses are designed to deliver the following to the eyes: glare reduction, higher humidity, extraneous light diminution, screen magnification, and ultraviolet (UV) protection. This study is the first of two to examine these claims in detail to see whether they can be verified.

## Methods

Subjects were between the ages of 22 and 39, with a mean age of 24 years. There were 37 subjects who qualified for the study, and 36 who completed it (18 male, 19 female). After initial recruitment and qualification, each participant had their visual symptoms surveyed with the Digital S Symptom Survey. This survey aimed to uncover external and internal visual symptoms, like dry eyes and accommodative insufficiency, respectively.

Those qualified for this study had to meet the criteria of 20/20 visual acuity in each eye with either no optical correction or contact lens correction. In addition, autorefractometry (over



**Figure 1:** Gunnar Optiks “Digital Performance Eyewear”

existing refraction, if any) was performed on all participants to ensure that all refractive error was corrected to within 0.50 D of emmetropia. If one or both eyes required correction, the subject had to wear contact lens until the study was complete. Participants were excluded if they had a history of long-term or continuous eyestrain but needed to use a computer at least one continuous hour per day. These criteria resulted in disqualification of three out of forty would-be participants. Of the 37 qualified subjects, most were contact lens wearers (n=29). The remaining eight participants had uncorrected visual acuity of 20/20 and nearly-emmetropic refractive error within the limits of the study.

Because it was a crossover design, each subject was given either a pair of low-power (+0.50 D) spectacles with a light yellow tint, anti-reflective coating, and relatively steep (8D) base curve and face form (the Gunnar design - Figure 1), or



**Figure 2:** Grand Seiko WAM 5500

a placebo pair of clear plano spectacles in an identical frame made with a similar coating and base curve but no tint. These were sent home with each subject to evaluate for one week, for at least one hour per day, while using a computer. Eighteen participants received the control spectacles, and the remaining nineteen received the experimental spectacles.

The subjects were further instructed to complete the symptom survey online three times during the week. After a week of randomized spectacle wear, the participants were evaluated. At the first of two visits, the subjects read under one of the following conditions for five minutes each:

- With five 15W compact fluorescent lights, causing 300W equivalent glare. These lights have a color temperature of 6500 K.
- With low (about 5%) contrast text.
- With control text (12-point, full contrast).

Each condition was tested in Latin square order while the research subject read an electronic book with either placebo glasses or yellow-tinted, low-power computer glasses (the Gunnar design). During reading, participants had their accommodation measured with the Grand Seiko WAM-5500 open-field autorefractor (Figure 2). Although the autorefractor has no way of “knowing” that it is not measuring refractive error, with this type of open-field model, a reading rod can be used, and if the patient is corrected to emmetropia, the accommodative response can easily be calculated so long as working distance is known. For the purpose of this study, a 40 cm working distance on the reading rod was used (Figure 3).



**Figure 3:** Setup for reading text with pull-down pages on the open-field autorefractor.

The WAM-5500 has a dynamic mode in which both the accommodative response and pupil size are obtained at 5 Hz and automatically recorded to an Excel spreadsheet via a serial computer cable. Measurement of accommodation and pupil size while reading continuous text (rather than fixating at a single letter or line on a reduced Snellen chart) has been shown to be reliable in previous studies by the Vision Performance Institute.<sup>8</sup> After each condition, the Digital Symptom Survey was administered, for a total of three times each visit.

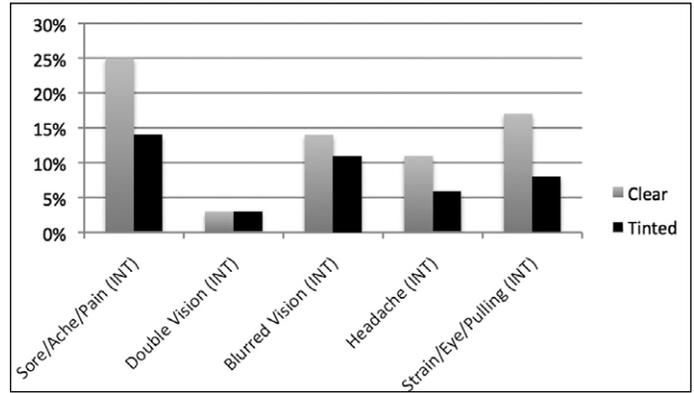
After these in-lab measurements were made at the end of the first week, the subjects turned in their first pair of experimental spectacles and were given the other type of eyeglasses (placebo versus low-power spectacles with a light tint) for one additional week. During each week of home study, the symptom survey was administered online three times, asking the participants about their experience while using the glasses on the computer.

After the second week of spectacle wear, one additional visit was scheduled to evaluate the same three conditions as the first visit (glare, low contrast, and control). At this visit, both pairs of spectacles were given to the subjects to choose, so that they were able to keep their preference. Preference exit surveys were administered to close the study.

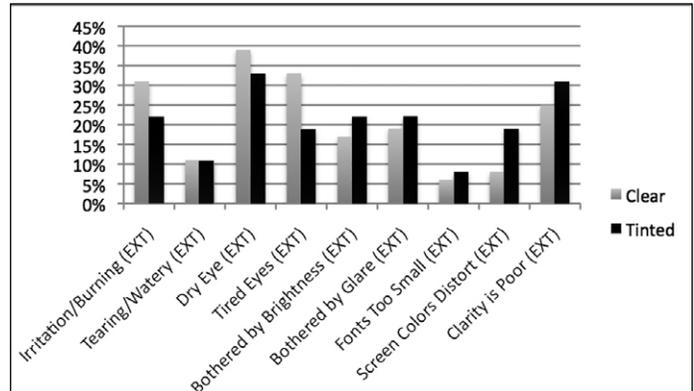
Each subject's most severe symptom was noted among the three conditions presented in-lab. Differences between glasses for each of the 23 symptoms was analyzed separately with a Wilcoxon matched pair test. Subjects expressing a symptom level of moderate or greater were noted as having a symptom. Mild or no symptoms were defined as no symptoms. The percentages of subjects expressing each symptom are provided in Figures 4, 5, and 6.

## Results

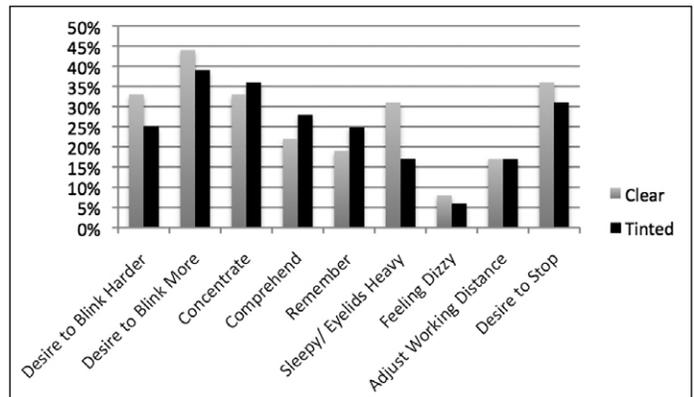
Twenty-three symptoms were surveyed both in-office and at home. Dividing the subjective surveys into those caused by external factors, such as glare and dryness, and those caused by internal factors, such as blur and double vision, some statistically significant differences were found. This analysis



**Figure 4:** Frequency of Internal Symptoms



**Figure 5:** Frequency of External Symptoms



**Figure 6:** Frequency of Miscellaneous Symptoms

and the analysis of the symptom scores were by mixed model analysis of variance with condition and type of glasses.

## Survey Results

In the Digital Symptom Survey, participants were asked if they experienced mild, moderate, severe, or very severe symptoms, if any at all, in each of 23 categories. Figures 4, 5, and 6 show the percentage of the subjects expressing symptoms in each of the experimental conditions. The vast majority of participants responded that they had none of these symptoms, with the mode of their responses showing a zero response. Of the 23 symptoms, only the number of subjects reporting eye irritation was significantly greater for placebo

than tinted glasses ( $p=.04$ ). There was essentially no difference between the types of glasses with respect to symptom scores.

Lastly, in the exit survey, 22 of 37 (59%) subjects preferred the yellow-tinted magnifying glasses (the Gunnar design) compared with no lenses (41%) in a forced choice. However, the subjects also admitted to wearing their glasses for less than one hour a day on their computers, despite computer use of 4-12 hours per day. This can be most likely explained by the fact that these subjects were recruited from those least likely to wear corrective spectacles. Those who needed correction had chosen to wear contact lenses, in many cases to avoid using spectacles in the first place.

## Accommodation Results

Objective data were also obtained using the Grand Seiko WAM 5500 open-field autorefractor. In dynamic mode, this instrument is capable of capturing accommodative and pupil data up to five times per second (5 Hz) while the participant reads on a reading rod. The results were as follows:

**Table 1: Accommodation**

Accommodation	Gunnar Lenses	Placebo Lenses
Mean (Diopters)	1.092	0.675
Standard Error (Diopters)	0.156	0.158
Difference	61.940	63.673
Lower Bound	0.780	0.359
Upper Bound	1.404	0.990

1. For the dependent variable, the spherical equivalent accommodative response mean, there was no statistically significant difference ( $p=0.56$ ). This was determined by mixed model analysis of variance with condition and type of glasses. However, there was a clinically significant difference of approximately 0.40 D (Table 1). This accommodative response mean reveals a lag of accommodation, which was typically 0.50 D less than the near demand of 2.50 D for the 40 cm working distance used on the Grand Seiko reading rod. It is also interesting to note the stability of accommodation, as measured five times per second by the open-field autorefractor.
2. For the dependent variable, pupil size, there was a significant difference ( $p<0.001$ ) for both pairs of glasses at the 95% confidence interval (Table 2). Of course, the pupil size represents the light sensitivity of the retina behind the lenses, both tinted and untinted.
3. There was no significant difference for pupil standard deviation ( $p=0.087$ ) for either pair of glasses at the 95% confidence interval (Table 3). This represents hippus, or fluctuations in pupil size.

**Table 2: Mean Pupil Size**

Pupil Size (mm)	Gunnar Lenses	Placebo Lenses
Mean	3.436	3.273
Standard Error	0.089	0.089
Difference	37.848	38.240
Lower Bound	3.256	3.092
Upper Bound	3.617	3.454

**Table 3: Pupil Standard Deviation (mm)**

Pupil Standard Deviation (mm)	Gunnar Lenses	Placebo Lenses
Mean	0.3	0.28
Standard Error	0.0	0.01
Difference	53.0	55.55
Lower Bound	0.2	0.25
Upper Bound	0.3	0.31

## Discussion

Under the experimental conditions and as measured by open-field autorefractor in dynamic mode, this study demonstrated a statistically insignificant effect of accommodation of +0.50 D sphere lenses compared with plano controls ( $p=0.56$ ). However, if you examine the numbers closely, it is apparent that accommodation was about 0.40 D less with the +0.50 D glasses, as expected. This is a clinically significant result, but only slightly. However, the standard deviation in accommodative response was large using either type of glasses. Thus, statistically, the low plus “digital performance eyewear” did not change the accommodative response or stability of accommodation as measured by dynamic open-field autorefractor.

One difference seen in the two groups studied was in pupil size. With regard to pupil size, it is not surprising that it was notably larger with the yellow-tinted lenses. Although the Grand Seiko WAM-5500 cannot always acquire pupil size at the same 5 Hz with which it measures accommodation, enough pupil measurements were obtained to see a 0.2 mm difference in pupil size, with larger pupils seen behind the yellow-tinted Gunnar lenses. This is not a clinically significant difference, but because of a small standard deviation, it was a statistically significant result. More importantly, this small difference might be expected to intensify symptoms of photophobia. This is because the area of the pupil is proportional to the radius squared. In this case, the size of the pupil was found to be about 9 mm<sup>3</sup> with Gunnar Optiks, and 8 mm<sup>3</sup> otherwise.

With regard to symptoms, one external symptom was shown to be statistically improved with the Gunnar vs. placebo design, namely, the symptom of irritation or burning of the eyes. It is well known that this symptom may be related to increased evaporation of the tear film during activities that decrease blink rate, such as reading. This symptom, while subjective, certainly warrants further investigation. This is

the purpose of our follow-up study, in which the base curve and face form wrap of the Gunnar design is investigated using Zone-quick phenol-red thread testing for dry eye and electromyography of the orbicularis to quantify squinting. Perhaps this follow-up study can help explain why 22 of 37 (59%) participants still preferred the Gunnar design when given the forced choice between yellow lenses and none. This was true despite less than one hour per day of self-reported compliance in wearing them during a minimum of four hours per day of self-reported computer use.

## Conclusions and Recommendations

The Gunnar Optiks glasses reduced external symptoms of irritation or burning of the eyes. They also affected pupil size, but not accommodation or other subjective symptoms.

Compliance with either pair of computer spectacles was generally less than one hour a day, even among those who worked on computers at least four hours a day. Compliance could potentially be increased by making prescription Gunnar Optiks available to regular spectacle wearers, those who are accustomed to eyeglass wear and therefore are more likely to wear them.

In light of the two differences between the Gunnar Optiks and placebo glasses, namely the optical power and tint, further research is indicated to explore the following:

1. Why are the external symptoms of irritation and burning subjectively different when the curvature of the lenses and frames was the same in the two types of eyeglasses?
2. The effects of these two types of eyeglasses on squinting have not been explored. It can be investigated with electromyography (EMG) of the eyelid.
3. Objective measurement of dry eye and blink rate has not been explored, but should be examined using an objective measurement of tear volume and different base curves from the Gunnar design, perhaps under a stressor condition such as forced air cooling, as many computer users experience.

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*The online version of this article contains digital enhancements.*