

Does the chromagen blue filter lens affect the reading speed, accuracy and contrast sensitivity

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ABSTRACT

Purpose: To determine the effects of ChromaGen blue filter lens in reading speed, accuracy and contrast sensitivity.

Methods: A cross-over, randomised study was carried out on 40 individuals (11 males and 29 females) aged 21 to 30 years. The rate of reading and reading accuracy was calculated with and without ChromaGen blue filter lens in all subjects. Wilkins Rate of Reading Test was used to measure the rate of reading and reading accuracy. Contrast sensitivity was also evaluated by using with and without the ChromaGen blue filter lens.

Results: The mean rate of reading with and without ChromaGen blue filter lens was 160.58±16.03 words per minute and 150.52±15.66 words per minute respectively, with significant difference of $p<0.001$. The mean of reading accuracy (words correctly read per minute) in subjects, with ChromaGen blue filter was 149.30±0.79 words and without using filter lens was 148.53±1.11 words and found to be significant ($p<0.001$). There was no significant difference in the contrast sensitivity between subjects with and without the ChromaGen blue filter lens ($p=0.083$). No significant correlation was noted between the reading speed with age, spherical equivalent, contrast sensitivity, and reading accuracy.

Conclusion: This study concludes that there was an increase of 6.68% in the rate of reading and improvement of 0.52% in accuracy among subjects with ChromaGen blue filter lens.

KEY WORDS:

ChromaGen blue filter lens; Wilkins rate of reading test; Reading speed; Reading accuracy; Contrast sensitivity

INTRODUCTION

Reading is a cognitive process whose function is to construct meaning of a written text. It is done through gradually acquired skills of interrelating information gained by decoding symbols and information stored in memory.¹ Reading efficiency comprised of speed, accuracy and prosody of reading. There are various factors affecting normal reading rate namely contrast, luminance, readability, motivation of the readers.

Numerous studies have shown that reading speed and accuracy can be improved among patients with reading difficulties by using coloured overlays or ChromaGen filter lenses,^{2,7} suggesting that those filters produce perceived improvements in the magnocellular visual system by achieving a resynchronisation of the magno and parvocellular systems and this selectively changes the speed of the information in the pathways of dyslexic patient.^{8,9}

However, there are only few studies performed in normal individuals, and most of the papers did not show what specific types of colour was used in improving the reading speed and contrast sensitivity. The main aim of this study was to determine whether ChromaGen blue filter lens can assist in improving the reading efficiency such as reading speed, reading accuracy and contrast sensitivity in normal healthy subjects.

MATERIALS AND METHODS

A cross-over, randomised study was carried out at International University College of Technology Twintech (IUCTT), Malaysia. A total of 40 individuals (11 males and 29 females) were recruited whose age ranged from 21 to 30 years. Sample size was calculated by using pilot study data from 30 subjects. The mean reading speed for group-1 (without chromagen filter) and group-2 (with chromagen filter) were 149.99 and 159.64 words/m respectively. The common standard deviation was 15.22. The value for α (Type I error) was 0.05, where the value for desired power of the study was 0.80. Hence, a sample size of 40 subjects was obtained.

The inclusion criteria for the study was as follows: ages between 20 and 30 years, currently not on any medication, no history of seizures and prior exposure to tinted lens therapy, known emotional, psychological, neurological or systemic disorders, have Best Corrected Visual Acuity (BCVA) in each eye for distance and near at least 20/20 and N6 or better respectively, and have normal ophthalmic examination.

The best corrected visual acuity (BCVA) for distance was measured using Snellen chart. Subjects with spherical equivalent of between +0.50Ds and -0.50Ds were categorised as emmetropia group whereas the spherical equivalent of more than -0.50Ds was categorised as myopic group.

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Table I: Comparison of Variables in Subjects With and Without Chromagen Blue Filter Lens

Variables	n=40		p value
	Without Filter	With Filter	
	mean ± SD	mean ± SD	
Reading speed (words per minute)	150.52 ± 15.66	160.58 ± 16.03	<0.001
Reading Accuracy (words correctly read per min)	148.53 ± 1.11	149.30 ± 0.79	<0.001
Contrast Sensitivity (log MAR)	1.96 ± 0.04	1.97 ± 0.32	0.083

Table II: Comparison of Variables in Spherical Equivalent Groups With and Without Chromagen Blue Filter Lens

Variables	Spherical Equivalent of < -0.50Ds n=17		p	Spherical Equivalent of > -0.50Ds n=23		p value
	Without Filter	With Filter		Without Filter	With Filter	
	mean ± SD	mean ± SD		mean ± SD	mean ± SD	
	Reading speed (words per minute)	152.09 ± 15.89		159.07 ± 16.70	0.02	
Accuracy (words correctly read per min)	148.71 ± 0.99	149.35 ± 0.79	0.02	148.39 ± 1.20	149.26 ± 0.81	<0.001
Contrast Sensitivity (log MAR)	1.96 ± 0.03	1.96 ± 0.03	0.32	1.96 ± 0.04	1.97 ± 0.03	0.16

Table III: Correlation of Different Variables with the Reading Speed and Accuracy

Variables	Reading Speed		Reading Accuracy	
	Without filter	With filter	Without filter	With filter
Age	r= 0.30; p= 0.06	r= 0.12; p= 0.47	r= 0.04; p= 0.80	r= -0.93; p= 0.57
Spherical Equivalent	r= 0.18; p= 0.28	r=-0.03; p= 0.88	r= 0.18; p= 0.28	r= 0.03; p= 0.87
Contrast Sensitivity	r= 0.19; p= 0.24	r= 0.30; p=0.06	r= 0.20; p= 0.22	r= 0.06; p= 0.71
Reading Accuracy	r= 0.14; p= 0.40	r= 0.14; p= 0.39		

Spherical equivalent of more than +0.50DS was considered as hyperopia group. Northeastern State University College of Optometry (NSUCO) oculomotor test was carried out in order to assess the eye movement function as reading consists of a series of saccades and fixations. If the patient failed the test, he or she is suspected to have oculomotor dysfunction and eventually excluded from this study.¹⁰

The best corrected near visual acuity of each subject was taken to make sure that they can read the Wilkins rate of reading test (WRRIT), which was developed by Wilkins et al., 1996.² The WRRIT was printed in Times font, 9-point, set single-spaced, with a 4-point horizontal spacing between words using Microsoft Word 2007 on a Dell Latitude e6470 with a Fuji Xerox Docuprint P205B monochrome laser printer. The text was set as a paragraph 72.5mm wide, 33.4mm high, with an interline space of 3.15mm. The letters have an x-height of 1.6mm and a width that averages 1.53mm. All the 15 words used in the passage were black printed on white paper and are used in each line, in a different random order. All the words in the test were selected from the 110 most frequent words in a count of words in children’s reading books. The participants were required to read aloud the list of 15 words that compile the WRRIT in order to confirm suitability. The participants completed the WRRIT at 35cm working distance. They read the passage out loud, quickly and clearly for a minimum of 60 seconds, trying to make as few mistakes as possible. The examiner followed the progress of the participants on a marking sheet which contains the same text but with words numbered to facilitate the scoring. Errors were deducted from the total score and from this the number of words correctly read per minute was calculated. Rate of reading (words per minute) was calculated by using the formula: 150/time taken to read passage

(seconds) x 60. Participants were asked to read the text without filter or with filter based on a result of toss a coin. A brief rest period was allowed for approximately 10-15 minutes. The participant then completed another WRRIT while wearing the ChromaGen blue filter or without the filter. In this study, the progress and the number of single word errors made during each of the two 60 second periods was noted.

Randomisation was done by using a toss of coin and it was also ensured that each group had twenty subjects. For this once one group of twenty subjects completed the test, the remaining participants were included in the next group. The first group was without ChromaGen filter which had 4 males and 16 females. The second group was with ChromaGen filter and that included 7 males and 13 females. The assessor was not blinded. All tests were carried out in the same environmental setup and supervised by the same examiner to avoid any confounding factors.

The participants were asked to sit or stand 1m apart from the Pelli-Robson contrast sensitivity chart. Contrast sensitivity was noted with and without the ChromaGen blue filter lens, using two different charts respectively.

The measured parameters were the following: rate of reading (words per minute), reading accuracy (words correctly read per minute) and contrast sensitivity. The data obtained was analyzed using SPSS version 19 for Windows (SPSS Inc, USA) and found not normally distributed. Hence, Wilcoxon signed rank test, Mann-Whitney U test and Spearman correlation were used to determine the significance difference. A p value of <0.05 was set for statistical significance.

RESULTS

A total of 40 students (mean: 24.05±2.26 years) were examined, with 11 (27.5 %) males and 29 (72.5%) females. Based on the refractive error classification, there were 17 (42.5%) emmetropia and 23 (57.5%) myopia. None of them were hyperopia.

There was a significant difference in reading speed and accuracy among those who used the filter lens ($p<0.001$). No significant difference in contrast sensitivity between subjects with and without using ChromaGen blue filter lens was noted ($p=0.083$). The mean rate of reading and accuracy with ChromaGen filter showed an increase of 6.68% and 0.52% respectively when compared with subjects without filter. And also an increase of 0.51% in contrast sensitivity was noted with ChromaGen filter. (Table I)

In the emmetropia group, the mean of reading speed and accuracy with ChromaGen blue filter showed an increase of 4.59% and 0.43% respectively as compared to without filter. The myopic group showed an increase of 8.26% in reading speed and 0.59% of accuracy with filter. In both emmetropia and myopia group, we observed significant difference for reading speed ($p=0.02$; $p<0.001$) and accuracy ($p=0.02$; $p<0.001$) while contrast sensitivity did not show significant difference ($p=0.032$; $p=0.16$) respectively as shown in Table II.

There was no significant correlation of reading speed and accuracy with study variables; age, spherical equivalent and contrast sensitivity as shown in Table III.

DISCUSSION

This study had shown a small improvement of 6.7% in the rate of reading test with the ChromaGen blue filter lenses in compare to normal individuals. This is similar to previous report by Harris and MacRow-Hill (1999) which has shown that the mean rate of reading increased by 16.7% with the ChromaGen contact lenses among non-colour deficit individual.¹¹ Most of the previous studies were performed under coloured overlays to determine the reading speed. The increment of reading speed in this study by using ChromaGen blue filter had an agreement with the previous studies with coloured overlays.^{3-5,12}

Generally, the use of colour is function to increase the magnocellular activity.¹³ Research suggests that cells in the magnocellular system are suppressed in red light. It can be assumed that the colour blue can help to reduce the relative contribution of the parvocellular pathway and therefore restoring the balance between the two parallel systems which are required for tracking while reading.¹² Blue light enhances faster information transfer compared to red and green light.¹⁴ Therefore, the reading speed increased when the subject wore the ChromaGen blue filter lens.

In our study, there was a slight increase of 0.52% in the reading accuracy compared with and without ChromaGen blue filter. This supports the study done by Robinson and Foreman in year 1999, where the treatment groups with blue filters showed a significant greater rate in reading accuracy and reading comprehension.¹⁵ Previous study had reported that less accommodation was found when human subjects

read in blue (peak at about 440nm) than red light (above 600nm).¹⁶ Blue and yellow colours helps to improve vergence and accommodation as the system probably responds differentially to different cone isolating stimuli.¹⁷ An improvement in vergence and accommodation, the subjects will be able to maintain the AC/A ratio (Amount of accommodation convergence required for each dioptre of accommodation) in order to maintain a stable fixation while reading. This enhanced them to read the words more accurately. As a result, the reading mistakes will eventually be reduced.

There were no changes in the contrast sensitivity in subjects with and without ChromaGen blue filter lens. This is in an agreement with de Fez and his colleagues which showed that green, brown and blue filters did not cause significant changes in contrast sensitivity compared with a grey filter of equal luminance.¹⁸ Blue colour causes the least amount of contrast threshold increase.¹⁹ Sustained cells in the parvocellular pathway function to mediate the visual acuity, contrast sensitivity, colour vision and high spatial frequency. The ChromaGen blue filter lens restricts the incoming light by reducing the stimulation of the red and green cones relative to blue. Thus, the activity in the sustained cells might be limited, and no significant effect on the contrast sensitivity of the subjects using the blue filter lens.

There are some limitations in this study. We are still not aware of the effects of ChromaGen blue filter lens in medium and high cognitive demand text as Wilkins Rate of Reading Test (WRRT) is a low cognitive demand text. Another limitation is the fixation and regression of the eye movement was not measured, by using Visagraph. As the assessor was not blinded it is considered one of the limitations of this study. The wavelength of the ChromaGen blue filter lens is unknown as the company is not willing to disclose the particulars.

CONCLUSION

ChromaGen blue filter lens increases the reading rate and accuracy. It also provides better reading performance among individuals and more likely in myopic subjects. Contrast sensitivity was not affected by ChromaGen blue filter lens.

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