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Abstract

Negative effects on stereoaccuracy induced by commonly used red-green filters have been a subject of recent investigation1. This study was designed to determine if correcting, with lenses, the chromatic anisometropia induced by these red-green filters could increase the accuracy of stereopsis. The lens power difference needed to correct the chromatic anisometropia was found to be 0.37°, divided between the two eyes. In the control condition the subjects viewed the Randot Circle Stereotest with only the required polarizing glasses. One of the remaining two test conditions used the polarizers in combination with red-green filters, while for the other condition the chromatic anisometropia from the red-green filters was corrected with appropriate lenses. The amount of light transmitted by the filters was kept constant. The chromatic anisometropia correction over the red-green filters significantly reduced stereopsis errors induced by the red-green filters alone (21%, $p < 0.05$). However, the correction only partially restored stereopsis to control values. A mild anisometropic correction added to the red-green glasses could help improve stereopsis in most individuals.

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Correcting the Chromatic Anisometropia of Red-Green Glasses and its Effect on Stereoaccuracy

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ABSTRACT

Negative effects on stereoaccuracy induced by commonly used red-green filters have been a subject of recent investigation1. This study was designed to determine if correcting, with lenses, the chromatic anisometropia induced by these red-green filters could increase the accuracy of stereopsis. The lens power difference needed to correct the chromatic anisometropia was found to be 0.37^D, divided between the two eyes. In the control condition the subjects viewed the Randot Circle Stereotest with only the required polarizing glasses. One of the remaining two test conditions used the polarizers in combination with red-green filters, while for the other condition the chromatic anisometropia from the red-green filters was corrected with appropriate lenses. The amount of light transmitted by the filters was kept constant. The chromatic anisometropia correction over the red-green filters significantly reduced stereopsis errors induced by the red-green filters alone (21 %, $p < 0.05$). However, the correction only partially restored stereopsis to control values. A mild anisometropic correction added to the red-green glasses could help improve stereopsis in most individuals.

Key Words: Stereopsis, Chromatic Anisometropia , Polarizing Filters, Red-Green Filters, Chromatic Aberration

INTRODUCTION

Red-green glasses play an important role in many offices and clinics providing vision training. These glasses and associated materials are generally less expensive than polarizing materials and are probably more widely used. Concerns that the red-green materials may not be as good as polarizing materials for the testing and training of patients have been, until recently, left unanswered. Because of this concern, work has been initiated to see if differences between the red-green materials and polarizing materials exist, and if so, what are their types and magnitudes? If there are deficiencies in the red-green materials what can be done to correct them?

A study designed to test for transmittance differences between red and green filters showed that commonly used red-green glasses have a significant luminous transmittance imbalance[2] combined with their inherent chromatic imbalance. A second study aimed at determining if the transmittance or the chromatic differences had any effect on stereoaccuracy showed that the transmittance difference had no significant effect on stereoaccuracy. However the chromatic difference did have a significant role in diminishing a subject's stereoaccuracy[1]. It has been shown in other studies that chromatic differences can create a stereoacuity loss[3] and can simulate an anisometropic condition.[4,5,6] The purpose of this study was to determine if correcting the chromatic anisometropia would retrieve some or all of the lost stereoaccuracy induced by the red-green glasses.

Using the values obtained from a literature search of the chromatic anisometropia of the eye[7,8,9,10] combined with a subjective measurement of the subjects involved in the experiment, the chromatic anisometropia was determined to be 0.37^D with a range of 0.12^D. This value was divided about evenly between the two eyes and was used in one of the test conditions in the form of a correction.

The study consisted of three test conditions, all of them requiring polarizers. One condition used red-green filters with the polarizers. A second conditon used red-green filters combined with the chromatic correction and the polarizers. A third condition, the control, used only the polarizers. The number of stereopsis judgement errors on a Randot™ Circle Stereotest was monitored for each condition.

METHODS

Subjects:

Thirty subjects volunteered for this study. They consisted mostly of optometry students, some undergraduates, and staff. There were 22 males and 8 females with ages ranging from 22 to 32 with an average of 25. The subjects met or exceeded the standard of 40 arc seconds of stereoacuity as measured by a Randot Circle Stereotest at 40 cm (16 inches).

Methods and Materials:

Standard Bernell[a] red-green filters and polarizing glasses were used with a standard Randot Circle Stereotest[b]. The light source illuminating the target consisted of either three or five 150 watt bulbs depending on the amount of illumination needed on the target. A uniformly gray partition about 47 cm (19 inches) wide and 30 cm (12 inches) high separated the subject from the target. In the center of the partition was a small rectangular opening large enough for one cell of the Randot target to be viewed without the subject knowing which cell was presented. A forehead and chin rest system was used to support the subject's head comfortably at eye level with the test cell. Standard lenses from a trial lens case[d] were used to correct the chromatic anisometropia.

The light level for each condition was established by measuring luminance through the filter combinations at 1 meter from the target, the location of the subject during testing. This was accomplished by using a Tektronix J-16 Photometer- Radiometer joined with a J-6523 Luminance Probe[c] aimed just above the aperture of the partition. Photometric conditions for the experiment are summarized in Table 1.

Insert Table 1 about here

For each test condition subjects were presented each of the ten Randot cells four times in a computer generated random pattern. The condition sequence was also randomized among subjects. The subjects were required to make a response on each cell presented within a ten second time limit. One experimenter manipulated the target and monitered the subject while the other experimenter recorded responses.

In order to determine the chromatic anisometropia induced by the particular red-green filters used, subjects were given a monocular subjective test to determine their chromatic interval. A manifest refraction was done to determine baseline data. Two more forced choice refractions with the same instructional set were done; one with the red filter placed over the phoropter aperture and another with the green filter placed over the aperture. The result was a consistent choice of 0.37D difference between red and green with an occasional subject choosing 0.50D. It was decided that the chromatic anisometropia correction to be used was 0.37D with +0.12D over the red filtered eye and -0.25D over the green filtered eye. This agrees with results found in the literature where chromatic anisometropia induced by similar red-green filters was found to be close to 0.37D.[7,9,10] The three conditions are listed below.

CONDITION 1:

Control: Subjects viewed the cell through only the polarizing filters and were asked to make stereo judgements.

CONDITON 2:

Red-Green Chromatic Imbalance: Subjects viewed the cells through both red-green filters and polarizing filters with the red filter over the right eye and the green filter over the left eye.

CONDITION 3:

Red-Green Chromatic Anisometropia Corrected by Lenses: Subjects viewed the cells with a polarizing and red filter over the right eye and a polarizing and green filter over the left eye. The 0.37D anisometropia correction was divided into+0.12D over the right eye and -0.25D over the left eye.

RESULTS

The total number of stereo judgement errors for the entire group in Condition 1 was 309; in Condition 2 there were 548 errors, in Condition 3 there were 435 errors. (Table 2 and Figure 1)

Insert Table 2 & Figure 1 about here.

Using a t-test and ANOVA (Analysis of Variance) with repeated measures, Conditions 1 and 2 differed significantly, as expected and previously shown.[1] Conditions 1 and 3 also differed significantly. The comparision of Condition 2 to Condition 3 showed that the effect of correcting the chromatic anisometropia was statistically significant. All significances were at or above the 0.05 level. (Table 2)

Also, when questioned, over 63 % of the patients preferred Condition 3 to Condition 2 with the rest saying they could see no difference.

DISCUSSION

These results show a statistically significant improvement in stereoaccuracy when the chromatic anisometropia of red-green filters is corrected by low power lenses. Although the original stereoaccuracy is not completely recovered, enough is recovered to show promise in improving the red-green materials presently in use.

Red-green filters have a variety of uses, such as motor and sensory fusion testing and training, stereopsis testing and training, monocular fixation in a binocular field, and other activities. Since red-green materials are commonly used in visual training oriented offices a specific tailoring of the filters and the lens correction can be designed for each patient. The use of lenses to correct the induced anisometropia can provide a more balanced binocular task for the patient.

Cornforth, Johnson, et.al. reported that cell 7, which is 40 arc seconds, on the Randot Circle Stereotest evoked the greatest number of errors of all the cells, even greater than the cells with smaller disparities.[1] This irregularity has been noted by other clinicians with no apparent explanation. During this testing it was also noted that this cell evoked the highest number of stereo judgement errors. Cell 7 had nearly twice as many error judgements as the cell with the second highest number of errors, cell 10 (20 arc sec). See Figure 1.

Insert Figure 1 about here

CONCLUSION

We conclude that a significant improvement in stereoaccuracy occurs when the chromatic anisometropia due to red-green filters is corrected, as shown by fewer errors on the Randot Circle Stereotest. Even with the anisometropic correction, however, results were not at the level of polarizing materials alone. We feel that more work should be done to try to equalize the red-green materials as much as possible. Even though the retinal illuminance difference was found not to have a significant effect, in this study, we feel that it too, should be corrected, for reasons stated in a previous publication.[1]

Future studies should investigate whether changing contrast sensitivity has an effect on stereopsis. If they are related a determination should be made as to how red, green, and polarizing filters affect contrast sensitivity and stereopsis.

More work should be done to determine why cell 7 of the Randot Cicle Stereotest produces an increased error frequency when compared to cells of smaller disparity. Testing of other Randot circle tests, and test-retest data should be gathered. Comparisons to other tests are warranted. Possible consultation with the manufacturer of the test could help. Microscopic evaluation of the cell's disparity test pattern may reveal an inherent defect.

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a. Bernell Corporation, South Bend, Indiana.

b. Stereo Optical Company Randot Stereotest, Chicago, Illinois.

c. Tektronix Inc., Beaverton, Oregon.

d. National P. Optical, Forest Grove, Oregon.

Table 1: Lighting Summary

	CONDITION 1	CONDTION 2	CONDITION 3
Distance sub. to target	1 meter for all condtions	-	-
Number of lights on	3	5	5
Dist. lights to target	160 cm	73 cm	73 cm
Luminance of target	24.3 nits for all conditions		-

Table 2: Values and Statistics

	CONDITION 1	CONDITION 2	CONDITION 3
TOTAL ERRORS	309	548	435
AVERAGE ERRORS	10.3	18.27	14.5
STD. DEVIATION	5.74	5.35	5.82
t-TEST VALUE (N=30)	5.8		
3 vs. 2 PROBABILITY	0.0001*		
ANOVA VALUE			
PROBABILITY	1.861*		

*Significant at 99%

Figure 1: Errors by Conditon

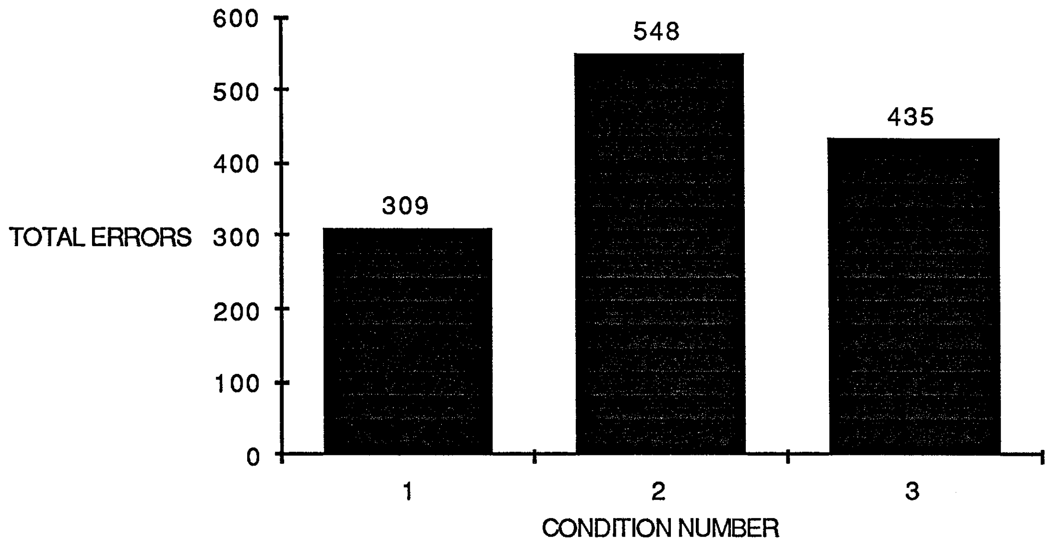
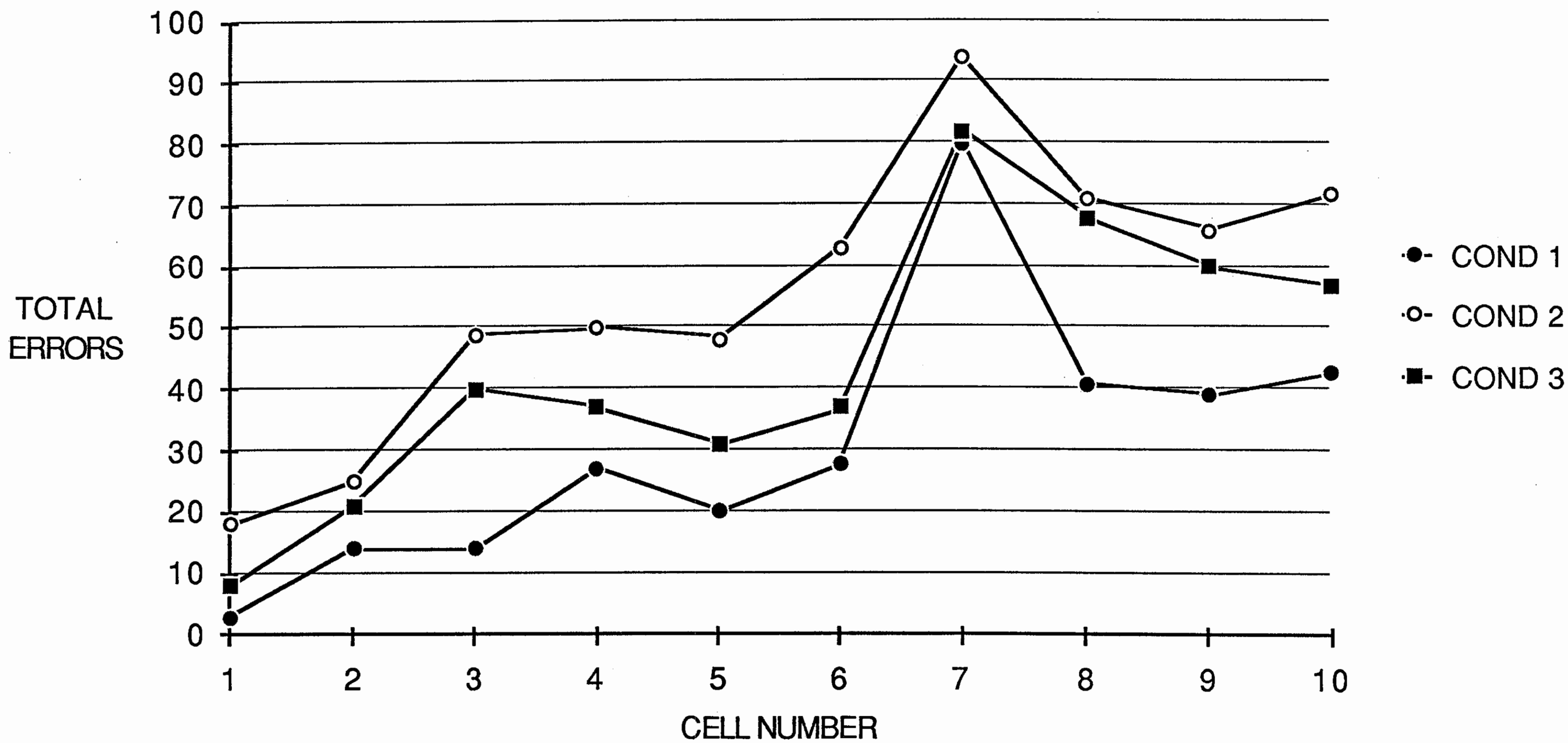


Figure 2: Total Errors by Cell Number per Conditon



Appendix: Additional Figure 2:
Total Errors by Cell Number per Conditon