Australian Orthoptic Journal 1991; 27: 37-41

THE EFFECT OF SPECTRAL COMPOSITION OF LIGHTING ON VISUAL PERFORMANCE OF PERSONS WITH RETINAL PATHOLOGY

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Abstract

Clinically it has been observed that visually impaired patients have definite preferences for lamp lights of certain wavelength compositions. A pilot study was conducted to assess the visual function of subjects with retinal pathology under three different lighting conditions. It was found that subjects with foveal function had higher levels of visual acuity under green light. Subjects without foveal function did not show this preference. All subjects demonstrated greater levels of contrast sensitivity under blue and green lights.
Key words: *Wave length, colour, visual acuity, contrast sensitivity, retinal pathology, visual function.*

White light is composed of many waves each of a slightly differing length. Groups or bands of wave lengths are seen as different colours. Artificially created light ie lamp light is composed of a broad range of wave lengths or specific groups of wave lengths. Light can be described in terms of the colour (spectral distribution), or in terms of the intensity (brightness).

Several authors have studied the effect of luminance levels on visual acuity. Sheedy, Bailey and Raasch 1984[1] found increased luminance within a specified range improved visual acuity on a letter chart. Conversely Comerford, Thorn and Corwin 1987[2] found contrast sensitivity in myopes did not vary significantly with changes in luminance levels. Brown and Garner 1983[3] and Brown, Zadnik, Bailey and Colenbranders 1984[4] studied the effects of luminance on contrast sensitivity and visual acuity in patients with senile macular degeneration. This work indicated that peak contrast sensitivity function was moved to the lower spatial frequencies at all luminance levels. Visual acuity in these patients showed a greater than expected decrease at lower luminance levels. Hyvarinen, Rovamo, Laurinen and Peltomaa 1981[5] reported the use of contrast sensitivity as an indicator of visual performance for patients with retinitis pigmentosa at low levels of illumination.

Clinically it has been observed that patients with central field loss show a preference for artificial illumination of the cool white, daylight type light as opposed to warm white light. Ninety percent of patients with senile macular degeneration indicated a preference for the cool white, daylight lighting.

The human retina has three cone types each responding maximally to wavelengths of light in the blue, green and red bands of the spectrum Davson 1980.[6] The clinical response of patients indicating preference for lamp lighting of specified wave lengths and the physiological occurrence of different cone types within the human retina suggests a relationship between the viable retina present and the wavelength of light for optimal visual function. From the literature it appears that luminance level can influence visual function of both normal and visually

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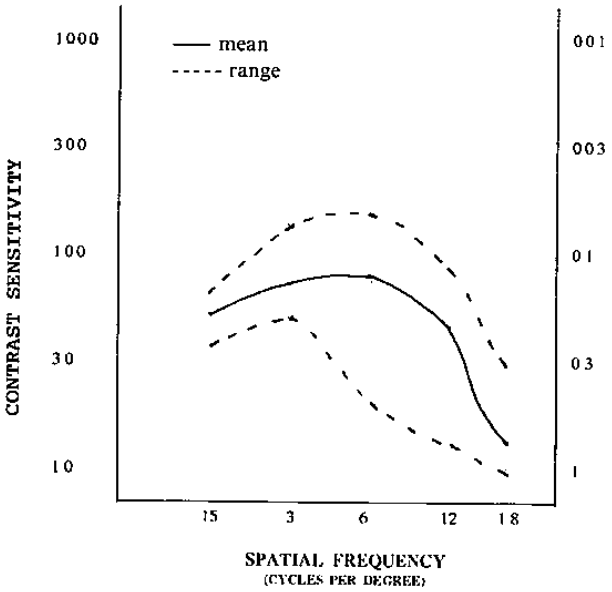

Figure 1: Contrast sensitivity blue light/normals.

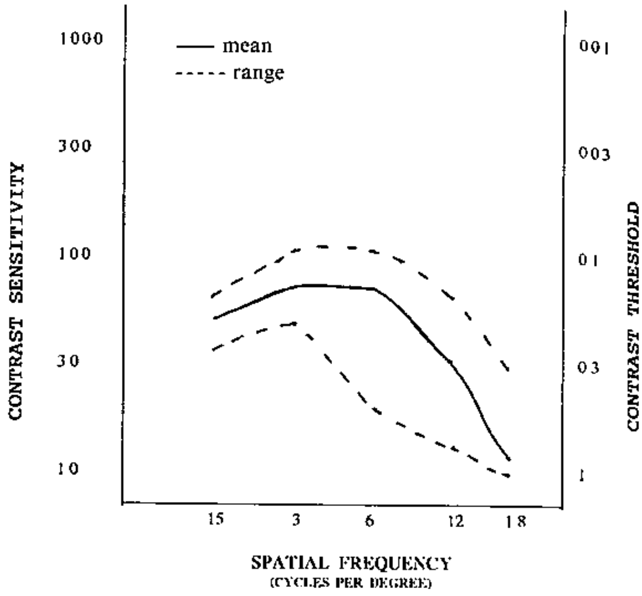

Figure 3: Contrast sensitivity red light/normals.

impaired subjects. This research was intended to study the effect of specified wavelengths of light on the visual function of subjects with peripheral or central field loss.

METHOD

Thirty one subjects were tested. Twenty were visually normal, six had central retinal pathology with absolute central scotoma and five had peripheral retinal pathology with reduced peripheral fields.

Each subject was assessed for visual function using a Log-MAR distance acuity test and the Vistech distance contrast sensitivity system VCTS 6500. Each of these measures of visual function were performed in a light proof room using only Tungstram blue, Tungstram red and Sylvana green 40 watt fluorescent tubes. Luminance for each of these tubes on each of the test instruments was also measured.

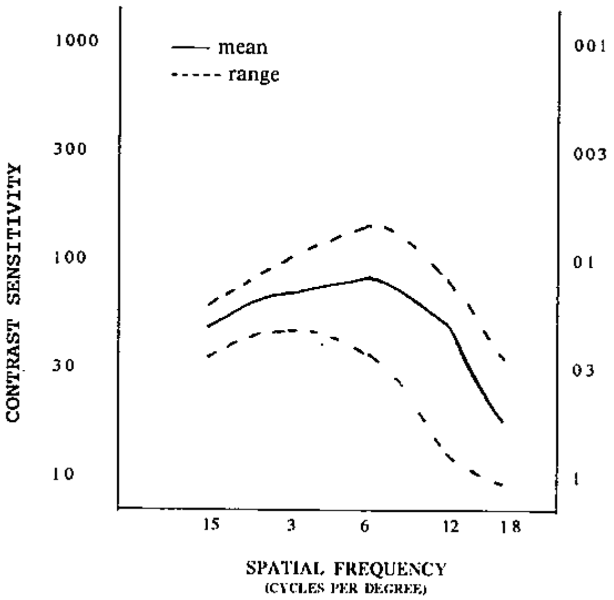

Figure 2: Contrast sensitivity green light/normals.

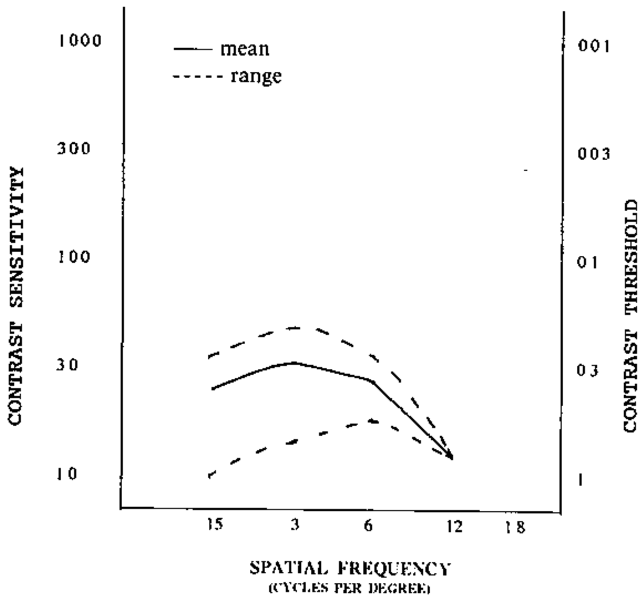

Figure 4: Contrast sensitivity blue light/peripheral field loss.

TABLE 1
Visual Acuity of Normal Subjects Under Specified Light Conditions

Subject	Lighting Condition					
	Red		Green		Blue	
	RE	LE	RE	LE	RE	LE
1	4/4	4/3	4/2.5	4/2.5	4/3	4/3
2	4/4	4/2.5	4/4	4/2	4/4	4/2.5
3	4/2	4/2	4/2	4/2	4/2	4/2
4	4/3	4/3	4/3	4/2.5	4/4	4/4
5	4/3	4/2.5	4/2	4/2	4/3	4/2.5
6	4/3	4/3	4/2	4/2.5	4/3	4/2.5
7	4/3	4/3	4/2.5	4/2.5	4/3	4/2.5
8	4/5	4/4	4/4	4/3	4/5	4/3
9	4/4	4/3	4/3	4/2.5	4/4	4/3
10	4/6	4/6	4/5	4/5	4/6	4/8
11	4/11	4/4	4/2	4/2	4/2.5	4/2.5
12	4/3	4/3	4/3	4/3	4/3	4/3
13	4/2	4/2.5	4/3	4/2.5	4/2	4/2
14	4/3	4/3	4/2.5	4/2.5	4/2.5	4/2
15	4/4	4/3	4/2	4/2	4/2.5	4/2
16	4/3	4/4	4/3	4/3	4/2.5	4/4
17	4/4	4/5	4/2	4/2.5	4/2.5	4/3
18	4/2.5	4/3	4/2	4/2.5	4/2.5	4/2.5
19	4/3	4/3	4/2	4/2	4/2.5	4/3
20	4/2.5	4/3	4/3	4/3	4/4	4/3

RESULTS

The visual acuity of normal subjects (table 1) was enhanced under green lighting and reduced under red lighting. This was significant at the 95% level of confidence using one factor ANOVA repeated measures Fisher PLSD 0.114 and Scheffe F test 14.047. Contrast sensitivity function of the normals Figures 1, 2 and 3 indicated that the finest gratings were seen under the blue and green light sources. The finest gratings with lowest contrast were seen under the green light source. The differences in contrast sensitivity performance were significant at the 95% level of confidence using one factor ANOVA repeated measures: blue versus red Fisher PLSD 2.972 and Scheffe F-test 13.294 and green versus red Fisher PLSD 2.972 and Scheffe F-test 41.341.

The central field loss subjects performed slightly better under green light in terms of visual acuity (Table 2). The differences between blue and red and green and red being significant at the 95% level Fisher PLSD 5.644, no significant difference was found between blue and green

TABLE 2
Visual Acuity of Centre Field Loss Subjects Under Specified Lighting Conditions

Subject	Lighting Condition					
	Red		Green		Blue	
	RE	LE	RE	LE	RE	LE
1	4/32	—	4/32	—	4/40	—
2	4/40	4/40	2/20	2/20	4/40	4/40
3	2/40	1/40	1/24	1/32	2/40	1/40
4	1/32	—	1/32	—	1/32	—
5	4/20	1/32	4/16	1/32	4/20	1/32
6	1/24	1/40	2/32	2/32	2/40	2/32

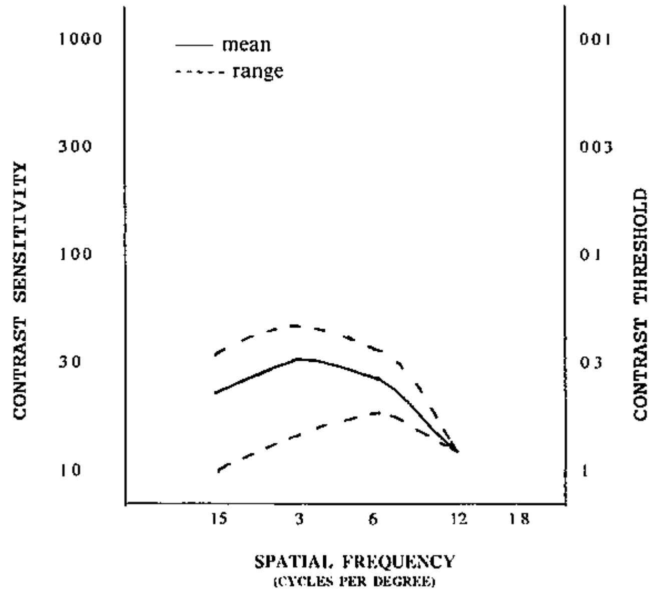

Figure 5: Contrast sensitivity green light/peripheral field loss.

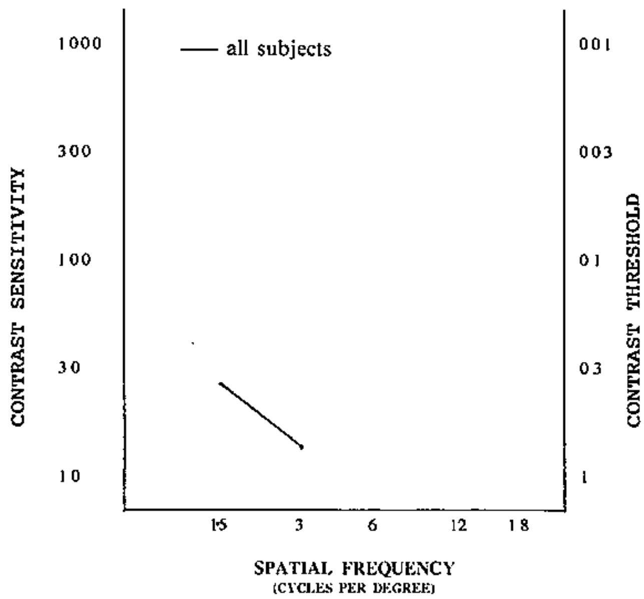

Figure 6: Contrast sensitivity red light/peripheral field loss.

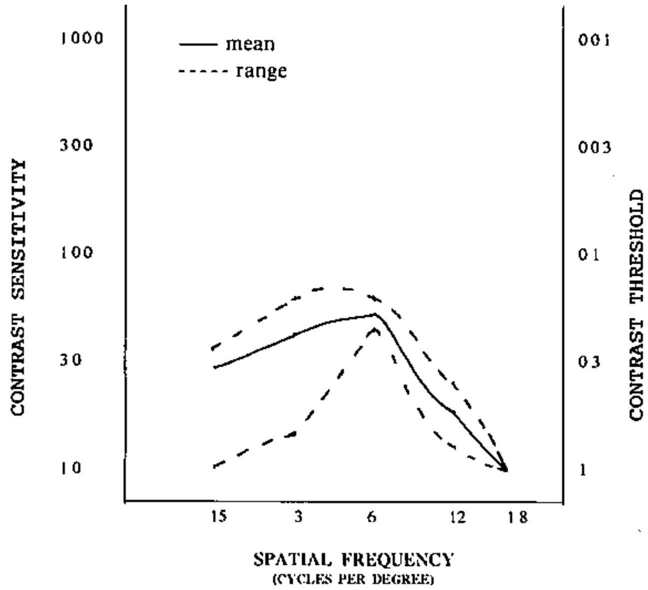

Figure 7: Contrast sensitivity blue light/centre field loss.

conditions. The finest contrast sensitivity gratings were seen under blue light with the lowest levels of contrast being seen under both blue and green light. Contrast sensitivity was reduced under red light. (Figures 4, 5, 6). The differences between blue and red, and green and red were significant at the 95% level one factor ANOVA Fisher PLSD 5.644.

The visual acuity performance of peripheral field loss subjects was better under green light and the most reduced under red light (Table 3). This was significant at the 95% level one factor ANOVA blue versus red Fisher PLSD .085 and Scheffe F-test 7.646 and green versus red Fisher PLSD .085 and Scheffe F-test 16.03. The finest gratings and lowest contrast being seen under both blue and green lights (Figures 7, 8, 9). This was significant at the 95% level one factor ANOVA blue versus red Fisher PLSD 5.649 Scheffe F-test 32.41 and green versus red Fisher PLSD 5.649 Scheffe F-test 36.397.

Comparison of the subjects with pathology indicated a significant difference in visual acuity results between central and peripheral field loss groups under both green and blue light; green one factor ANOVA Fisher PLSD 0.146 Scheffe F-test 21.407; blue Fisher PLSD 0.115, Scheffe

TABLE 3
Visual Acuity of Peripheral Field Loss Subjects Under Specified Lighting Conditions

Subject	Lighting Condition					
	Red		Green		Blue	
	RE	LE	RE	LE	RE	LE
1	4/24	4/32	4/16	4/32	4/20	4/24
2	4/32	4/40	4/10	4/10	4/12	4/12
3	4/16	4/12	4/6	4/6	4/8	4/8
4	4/40	<2/40	4/6	2/40	4/10	2/40
5	2/40	4/24	2/8	4/8	2/12	4/10

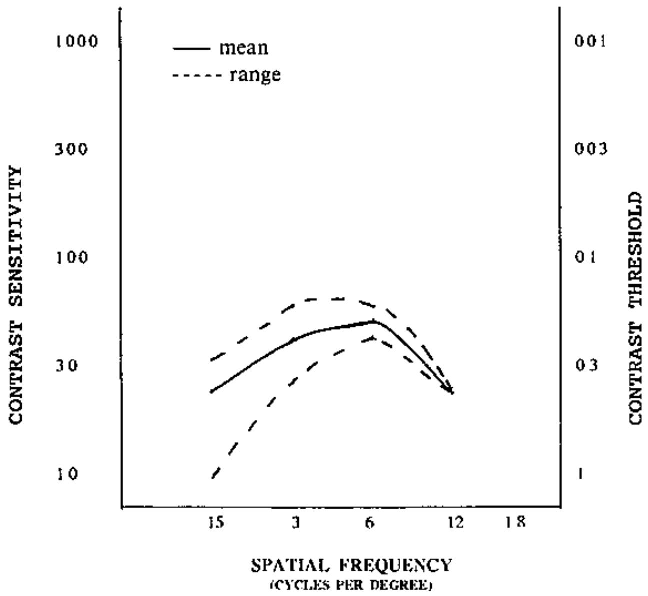

Figure 8: Contrast sensitivity green light/centre field loss.

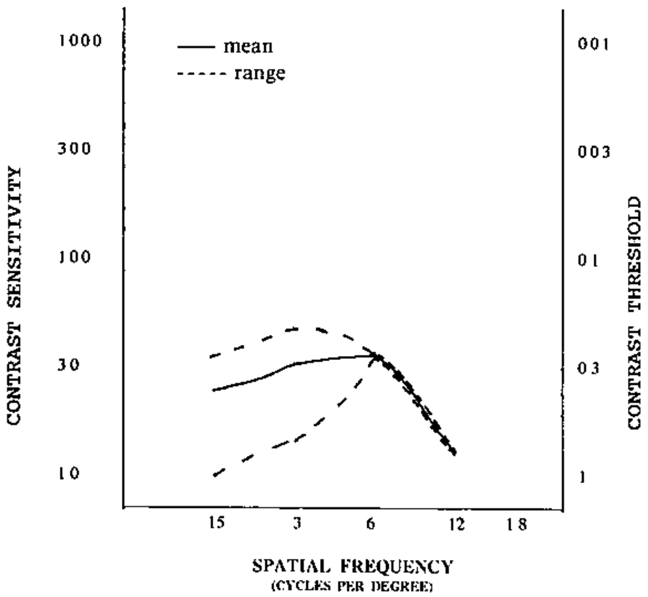

Figure 9: Contrast sensitivity red light/centre field loss.

TABLE 4
Mean Light Intensity

Light Type	Light Intensity (lux)
Red	3.83
Green	57.08
Blue	16.50

F-test 20.627 at the 95% level. The only significant difference for contrast sensitivity was under green light, one factor ANOVA Fisher PLSD 12.243 Scheffe F-test 6.764 at the 95% level.

DISCUSSION

Normal subjects and subjects with peripheral field loss achieved their best levels of visual function under green light. Subjects with central field loss did not perform significantly better under green or blue light. All subjects recorded the most reduced visual function under red light. Subjects with central field of vision do appear to perform better under green light whereas subjects lacking central field are less influenced by colour. The intensity of the light (Table 4) may also influence this result as the red was the least intense light source, green the highest with blue between but toward the low intensity of red. This data tends to support Sheedy, Bailey and Raasch 1984 that visual acuity will increase with increased luminance. The central field loss group showing no preference between the blue and green lighting reflects the findings of Brown, Zadnik, Bailey and Colenbranders 1984 that persons with senile macular degeneration are less likely to show improved visual acuity with increased luminance.

The extent to which intensity as compared to colour composition influenced visual function cannot be deduced from this experiment. Visual function did improve with increased luminance when taking the visual acuity parameter in isolation. However when contrast sensitivity is considered all three groups of subjects demonstrated improved visual function under both blue and green lights, indicating intensity was not the sole factor.

This study appears to support the hypothesis that the wavelengths present in light can influence visual performance. There is some support for the clinical observation that the wavelengths of light which will enhance visual function will vary in the presence of retinal pathology and subsequent field loss. The extension of this study to a wider range of light sources and at controlled levels of illumination would be of benefit to the field of visual rehabilitation and to the commercial lighting industry.

ACKNOWLEDGEMENT

This pilot study was funded by a grant from the Lincoln School of Health Sciences research committee La Trobe University.

References:

1. Sheedy JE, Bailey IL, Raasch TW. Visual acuity and chart luminance. Am J Optom Physiol Opt. 1984; 61: 9; 595-600.
2. Comerford JP, Thorn F, Corwin TR. Effect of luminance level on contrast sensitivity in myopia. Am J Optom Physiol Opt 1987; 64: 11; 810-814.
3. Brown B, Garner LF. Effects of luminance on contrast sensitivity in senile macular degeneration. Am J Optom Physiol Opt 1983; 60: 9; 788-793.
4. Brown B, Zadnik K, Bailey IL, Colenbranders A. Effect of luminance, contrast and eccentricity on visual acuity in senile macular degeneration. Am J Optom Physiol Opt 1984; 61: 4; 265-270.
5. Hyvarinen L, Rovamo J, Laurinen P, Peltomaa A. Contrast sensitivity function in evaluation of visual impairment due to retinitis pigmentosa. ACTA Ophthalmologica 1981; 59: 763-773.
6. Davson H. The physiology of the eye 4th edn. New York: Academic Press, 1980.