

Range of similar colours with and without cataract experiencing goggles

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ABSTRACT

Similar colour ranges to 20 reference colours were obtained with goggles and without goggles that were composed of haze and colour filters to simulate the elderly cataract eyes. Subjects chose test patches out of 287 patches similar in colour to a reference colour under the two conditions, with and without the goggles, in a room illuminated at 0.5, 30 and 500 lx. The range did not change much in the two conditions at 500 lx but at 0.5 lx the range with the goggles became larger than that without the goggles. The enlargement of the range with the goggles was reasoned as the effect of the desaturation of the apparent colour with the goggles. The experiment was conducted to follow the previous experiment done by Sagawa¹ with two groups of subjects, young people and elderlies. Our results were opposite to the Sagawa's to the contrary to our expectation from the assumption that the eyes with goggles in our experiment may be similar to the elderlies in the Sagawa's experiment. Some possible reasons were suggested for the discrepant results.

1. INTRODUCTION

Obama et al. developed cataract experiencing goggles based on the visual impression of cataract patients after the cataract operation² and the goggles have been used in designing products to suite cataract elderlies in many industries. We reported at the AIC 2003 conference held in Bangkok on the colour appearance of colour charts with and without the goggles³. At the same conference Sagawa reported ranges of similar colours to reference colours as measured by young and aged people¹. In this report we employed Sagawa's method to measure similar colour ranges with and without the cataract experiencing goggles. It is useful to know the ranges in designing various displays such as traffic signs where combination of similar colours should be avoided.

2. GOGGLES

The goggles that we developed and used here are composed of two kinds of filters; haze and colour. The transmittance of the colour filter was about 50% with lower transmittance at short wavelengths.



Figure 1: Experimental scene.

3. METHOD

The experiment was carried out in a normal room with two ceiling lights of fluorescent lamps of daylight type. Fig.1 shows the scene of the experiment. On the table in front of a subject twenty reference colour patches were placed, each having a size 5 cm wide and 7 cm long. They were pasted on a black cardboard in a matrix and their colours were 5R4/14, 5R5/12, 5YR5/10, 5YR7/14, 5Y5/6, 5Y8/12, 5GY5/8, 2.5G5/10, 5G5/8, 5BG5/8, 5B5/8, 7.5B5/10, 5PB5/10, 5P5/10, 7.5P4/12, 5RP5/10, 7.5RP5/14, N1, N5, N9.5 to cover all the hue. The subject put one test patch out of 287 test patches on his side of the matrix and chose the reference colour patches that appeared to him “same” or “similar” in colour to the test patch by pointing out the reference patches by a stick. An experimenter recorded his answer on an experimental sheet. The subject could choose any number of reference colour patches for one test patch if they appeared same or similar to the test patch. He should not choose any if there was none. No more instruction was given to the subject beside the above expressions and the criterion for the similarity was left completely to the subject. When these 287 test patches were observed one after another, one session was over. Three sessions were conducted for both conditions of the with-goggles and the without-goggles, respectively. The test patches were prepared to cover hues, lightness and saturation. The hue was chosen at every five in the Munsell Hue such as 5R, 10R, 5YR, 10YR and so on. The lightness was 3, 5, 7 and 9, and the saturation was at every 2 in the Munsell Chroma such as 5R3/2, 5R3/4, 5R3/6, 5R3/8, 5R3/10. The maximum Chroma was limited by the available colour charts of Japanese Industrial Standards JIS.

The illuminance of the room was set at 0.5, 30 or 500 lx. Five subjects with normal colour vision participated in the experiment.

3. RESULTS

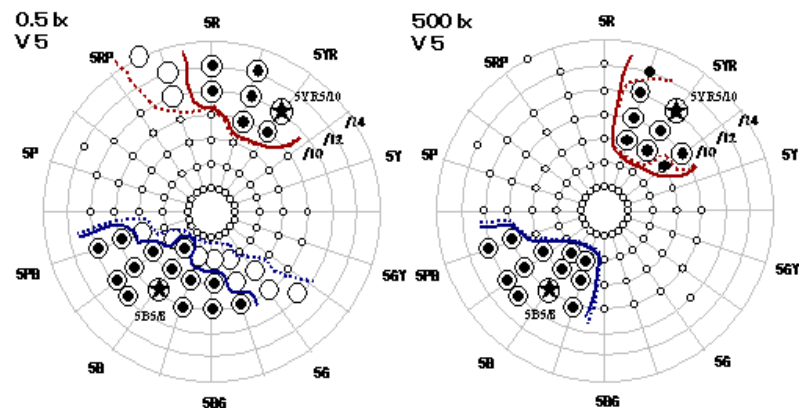


Figure 2: Results for the reference patches, 5YR5/10 and 5B5/8. Left, 0.5 lx; right, 500 lx.

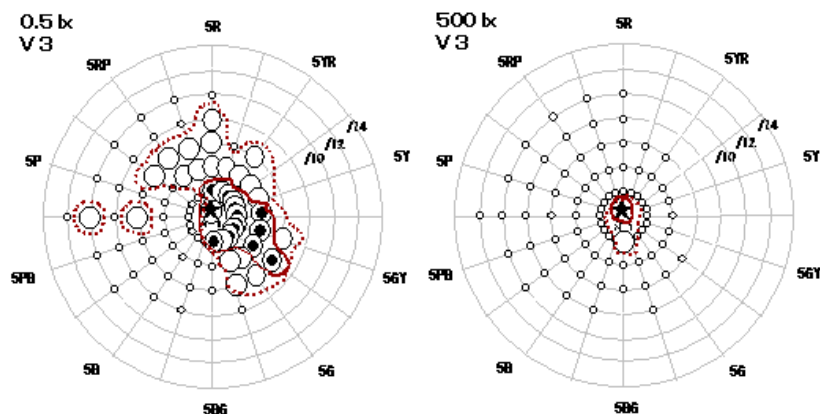


Figure 3: Results for the reference patch N1. Left, 0.5 lx; right, 500 lx.

Fig. 2 shows the results for the reference patches 5YR5/10 and 5B5/8 shown by starts plotted on the Munsell hue circle; the left figure from 0.5 lx and the right from 500 lx. Small open circles indicate the test patches of the Value 5 used. The test patches judged similar without the goggles are shown by filled circles and with the goggles by large open circles. The test patches judged same were counted as those judged very much different from others probably because of misinterpretation of the instruction and not included in the analysis. To show the range of similar colours to the reference colour we drew a solid border line for the condition of the without-goggles and a dotted border line for the condition of the with-goggles. Fig. 3 shows the results for the reference patch N1 plotted on the Munsell hue circle of Value 3.

When the illuminance was changed from 500 lx to 0.5 lx the ranges became larger in these examples. When the goggles were used the ranges became larger at 0.5 lx, but they did not change at 500 lx. The enlargement of the range with the reference patch N1 is very significant at 0.5 and with the goggles, particularly in the direction of reddish test patches. A possible reason for the increase is the intrusion of rods with the goggles. The transmittance of the colour filter of the goggles was about 50 % and the scotopic vision might be enhanced under this condition. Reddish colour becomes very black with the scotopic vision and it is likely that the reddish patches became very similar to the reference patch of N1.

4. DISCUSSION

To see the difference of the ranges with and without the goggles for other reference patches, numbers of all the selected test patches as similar were counted and those of the with-goggles condition are subtracted by those of the without-goggles condition. The results are shown along the abscissa in Fig. 4 for 14 reference colour patches. White bars indicate the results for 500 lx, gray for 30 lx and black for 0.5 lx. Most of the difference took positive values implying larger ranges with the goggles than those without the goggles. The ranges at 0.5 lx are almost always larger than those at other illuminance levels for any reference patches. This enlargement of the range was particularly evident for the reference 5BG, 5B, N5 and N1. The reason for that was suggested for N1 already as the intrusion of the rods, but reason for other three is not immediately clear.

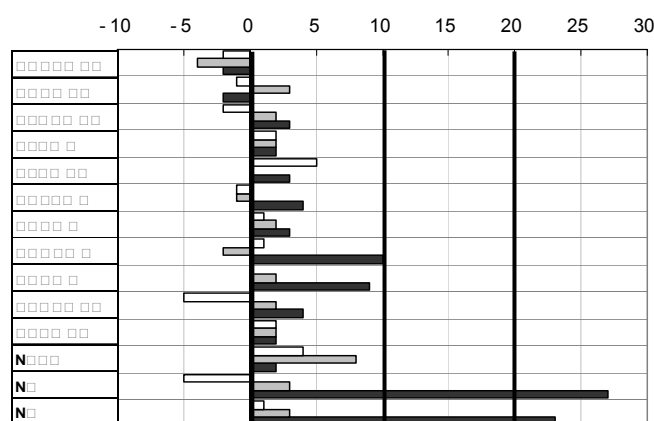


Figure 4: Difference of similar colour ranges in terms of the number of test patches.

shown in Fig.1. This suggests that the colour appearance of the test patches also became desaturated with the goggles. Fig. 5 illustrates the change. Along the abscissa the Chroma of test patches is taken, say from 0 to 10. Along the ordinate the apparent Chroma that a subject felt for the corresponding test

We found in the present experiment that range of similar colours to a reference colour increased in size in most reference patches. We like to consider the reason for the increase. When subjects wore the goggles they always felt that the saturation of the 20 reference patches decreased in accordance with our previous finding⁴. Consequently the chromatic difference among them appeared to become smaller when compared with the observation without the goggles, in the situation

patch. Normal eyes of course sees the same Chroma as the test patch and the relationship between the Chroma of the test patches and the apparent Chroma of the corresponding test patches is given by a line N with the slope of unity. With the eyes with the goggles the line of the relationship should be shallower than unity as shown by a line G. Let the Chroma of a reference patch is 10 as indicated by a filled star on the abscissa. The apparent Chroma without the goggles can be shown by a gray star and that with the goggles by an open star. We can suppose, because the same subject did the experiment with and without the goggles, that the perceptual limit for the similar colour has a same size N and G as shown by two downward arrows, one drawn from the gray star and the other from the open star. The range of the similar test patch is given as the Chroma corresponding to the tip of the arrow of the perception limit as shown by a solid circle for the eyes without the goggles and by an open circle for the eyes with the goggles. The range G is larger than the range N as shown by horizontal arrows drawn along the abscissa, which explains the present results.

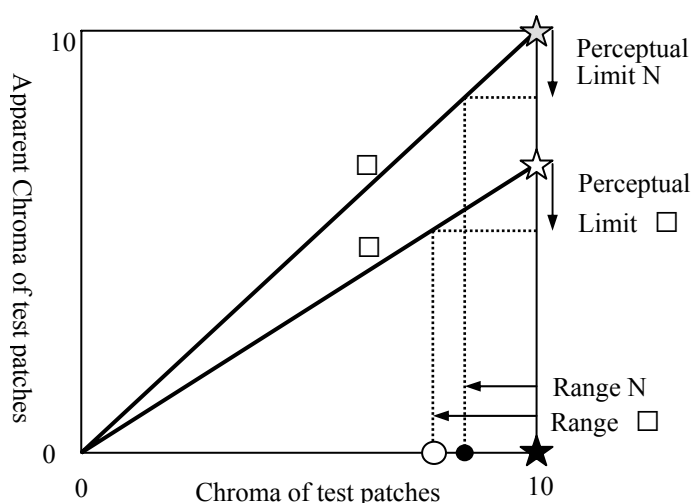


Figure 5: Scheme to explain the ranges with and without goggles.

expanded with the goggles. A possible reason could be found in the difference of the subjects. In our experiment the same subjects did the experiment for both conditions, with goggles and without goggles. In the Sagawa's experiment the subjects changed from one experiment to the other. In our experiment we could safely assume that they kept a same criterion for both conditions, the same perceptual limit N and G. In the Sagawa's case there was no assurance that the elderlies had the same perceptual limit as young people. It might be possible that the elderlies employed a narrower limit than the young by reconstructing the colour appearance space same as that of their young time in spite of the fact that their perceptual colour space became smaller because of the desaturation phenomenon. The reason should be confirmed in the future research.

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