THE EFFECT OF COLOR DIFFERENCE ON THE FUNCTIONAL VISUAL FIELD

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ABSTRACT

Previous research has revealed that the functional visual field is affected by the difference in color between the target and the background, however, few studies have been conducted on this relationship. The aim of this study is to clarify these effects. An experiment in which a subject distinguished a target from background noise was conducted. The color patterns used were red, green and blue. The target and the noise were the same color, i.e., of the same dominant wavelength, but differed in purity. The results show that the functional visual field increases as color difference increases, and then it reaches an upper limit in the normal functional visual field. The results also show that the recognition of an object is easy when the color difference is more than 80 in the CIE 1976 L*u*v* color space.

1. INTRODUCTION

Previous research has revealed that the breadth of the functional visual field is affected by the extent of the difference in color between the target and the background[1],[2]. Fuchida[1] studied color matching properties from the view point of the practical use of complex background, and expressed conspicuity quantitatively in terms of visual search time and the color difference between the target and the background. The results showed that the visual search time became negligible when the color difference between the target and the background was over 20. However, at present, few studies have been conducted on the relationship between color difference and functional visual field. It is hypothesized that while driving, distinction of color is important for identifying road signs and potential hazards in the functional visual field. Therefore, in this study, an experiment in which a subject distinguishes a target from background noise was conducted to clarify the effect of the color difference on the functional visual field.

2. EXPERIMENT

In this experiment, a computer screen was used to display an image. The image consisted of a background black and 28 circles (each with a visual angle of 0.43 °), 27 of which contributed to the background noise while one was the target. The images were shown for 0.2 seconds. The luminance of the target and noise was the same in each color. The target and noise circles were arranged so the density was the same in every quadrant without overlapping. 12 directions of presentation were used with an angular separation of 30 ° around the fixation point, and the visual angles were 2 ° 4 ° 6 ° 8 ° 10 ° 12 °. The presentation position of the target was a combination of these directions. Figure 1 shows the example of experimental image. The color patterns used were red, green and blue. The target and the noise were the same color, i.e., of the same dominant wavelength, but differed in purity. In this study, the color difference was calculated

in the CIE 1976 L*u*v* color space. Table 1 shows the color differences between the targets and the noises in this experiment.

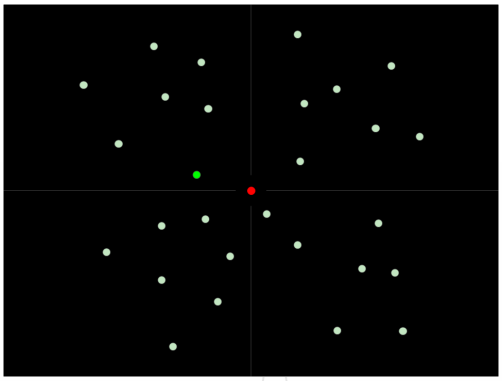

Figure 1. Example of experimental image.

Table 1: Color difference of target and noise.

	color difference level (noise)								
	1	2	3	4	5	6	7	8	9
Green	9.429	21.73	30.63	42.88	55.75	69.76	85.62	102.13	121.35
Red	17.61	32.23	48.79	64.70	79.00	92.21	107.22	121.42	133.39
Blue	18.83	35.85	50.06	62.79	73.14	82.16	91.22	98.46	105.15

In this experiment the subjects were seven males in their twenties.

The following procedure was used:

(1) Each subject adapts to the darkness for 10 minutes in a dark room.

(2) A black background image is displayed on a screen.

(3) A fixation point and an axis are displayed with a click sound, and each subject observes the fixation point.

(4) Each subject replies orally the position of the target by saying the number of the quadrant the target is in when the target and noises are shown. If a subject does not identify a target, the answer is indistinguishable.

(5) Steps (2) to (4) are repeated for all presentation positions and color differences.

(6) The whole experiment is repeated for each color (green, red, and blue) on separate days.

3. RESULTS AND DISCUSSION

Figure 1, Figure 2 and Figure 3 show the average functional visual field in each color. For any color condition, the functional visual field increased with color difference up to a limit of around 13 °, which is the normal functional visual field. Figure 4 shows the relationship between color difference and the functional visual field. The functional visual field increased in the order of red, green, and blue until a color difference of 50. Given that the dominant wavelength of blue is the shortest and red is the longest, it is hypothesized that for equal color difference, the shorter the dominant wavelength, the broader the functional visual field. Furthermore, it was found that the functional visual field for every color reaches the normal functional visual field when the color difference is more than 80. In short, the recognition of an object is easy when the color difference is more than 80.

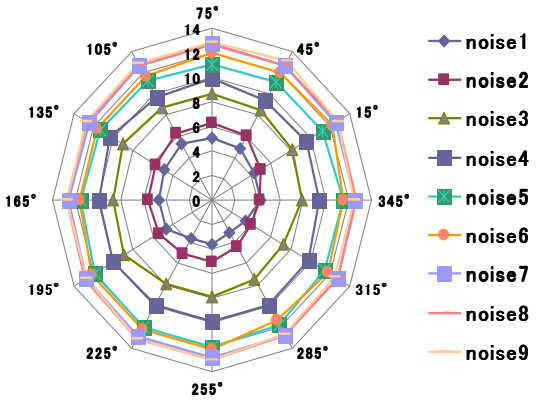

Figure2. Average of the functional visual field. (Green)

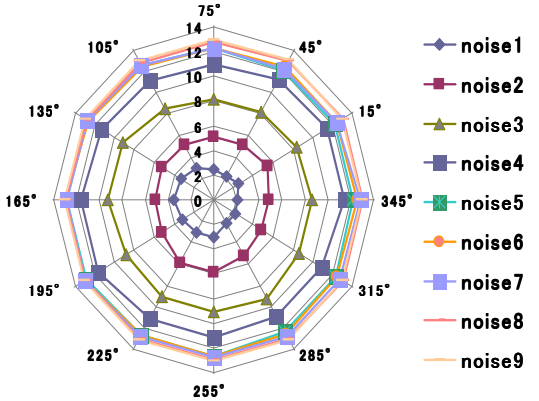

Figure3. Average of the functional visual field. (Red)

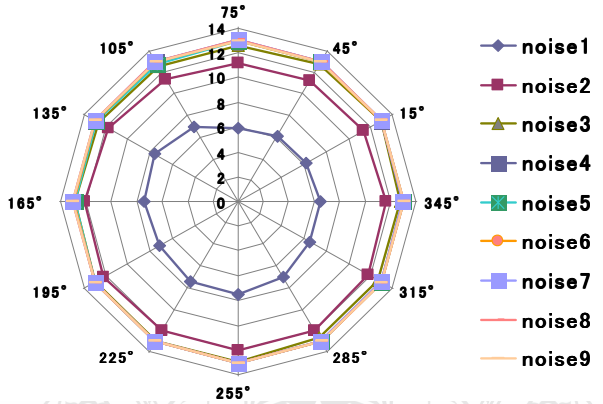

Figure 4. Average of the functional visual field. (Blue)

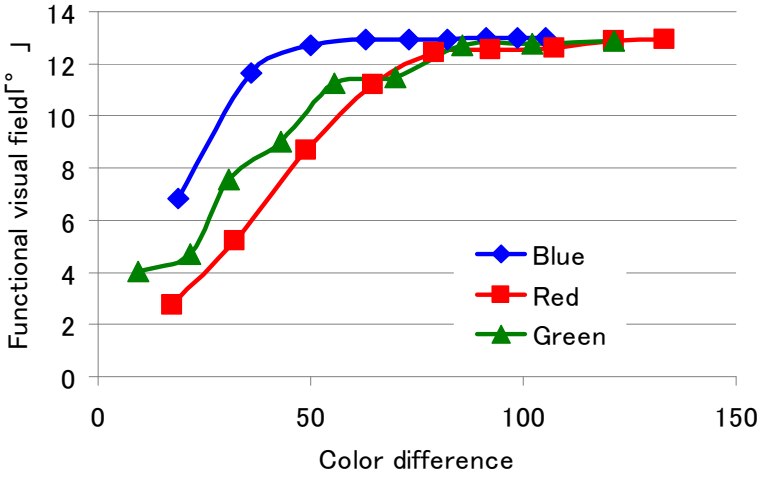

Figure 5. Relationship between color difference and the functional visual field.

4. CONCLUSION

The effect of color difference on the functional visual field was investigated by conducting a visual experiment in which subjects distinguished targets from background noise. The results are summarized as follows:

(1) The functional visual field increases as color difference increases, and then it reaches an upper limit in the normal functional visual field.

(2) The recognition of an object is easy when the color difference is more than 80.

REFERENCES

1. Takayoshi Fuchida, "Color Discrimination, Color Conspicuity and Visual Search for CRT Displays" *Journal of the Illuminating Engineering Institute of Japan*, 80(11), pp.803-810(1996)
2. Mitsuhiro Kawaguchi, Yoshito Mekada, Miyoshi Ayama, Masao Kasuga, "The influence of the visual and the conversation loads and the target color in the functional visual field on the dynamic background" *The Institute of Image Information and Television Engineers*, 25(44), pp.23-28(2001)