IMPRESSION RATINGS OF COLORS PERCEIVED BY COLORBLIND PEOPLE— PRELIMINARY STUDY ON INFLUENCE OF COLOR ON IMPRESSIONS FORMED BY COLORBLIND PEOPLE

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ABSTRACT

An experiment in which colorblind subjects were asked to rate their impressions of color chips was conducted. Although the number of subjects was small, the results suggested that the structures of the impressions could be expressed by the difference in factor coefficients among people with protan and deutan colorblindness and those with normal color vision. The factors obtained were beauty, warmness, and tranquility for the former, and beauty, brightness, and tranquility for the latter. Another remarkable difference was that the former preferred vibrant colors, but the latter disliked them or did not prefer any association with them. The difference between protanopia and deuteranopia is not in the structure but the impression obtained from colors. For example, a protan perceives beauty when the color is dark, but a deutan perceives beauty when the color is bright and yellowish.

Keywords: color vision deffect, dichromatism, impression, color universal design

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INTRODUCTION

A concept and activity called "Color universal design" is becoming popular in Japan[1]. This concept was advocated by a non-profit organization "CUDO: Color Universal Design Organization". For example, the organization provides advice to companies or local authorities on the usage of color on documents in order to reduce the difficulties face by colorblind people while reading letters or for discrimination of figures. Such activities have promoted color design by considering the disabilities of colorblind people.

However, visibility is not the only factor to be considered during the design process. Information on the impression formed of colors is required to create a design that takes into account feelings such as preferable, warm, and vivid. This preliminary research is aimed at obtaining such basic information.

EXPERIMENT

Four experiments have been conducted.
1) The grouping of 147 color chips.
2) The brightness judgement of 120 color chips.
3) The ratings of 72 color chips.
4) The ratings of 60 color combinations.

This article focuses on the third experiment, in addition to a brief description of the second experiment.
In the second experiment, the subjects were asked to compare certain color chips with an achromatic color chips array at even brightness intervals (difference of 0.25 on each Munsell Value ranging from

1.50 to 9.50) and certify the Munsell Value for the same brightness. The results were used when the perceived color brightness was necessary for the analysis of the third experiment.

In the third experiment, the subjects were asked to rate 120-mm × 175-mm color chips stuck at the center of a 210-mm × 270-mm paper of N5.5 gray color. The color chips were selected from color papers on the basis of the P.C.C.S. color system issued by the Japan color research institute. The hue and tone varied to cover all the areas in the color solid, although dark colors were relatively rare. The table used in the experiments were covered with N5.5 gray paper and illuminated by D-65 fluorescent lamps for color evaluation; the value of Ra was 99. The horizontal surface illuminance on the table was 1,300–1,600 lx depending on the experiment space.

The subjects included a male protan and four male deutans. Additionaly, two female subjects with normal chromatic vision rated same color samples.

RESULTS

The judgment of the type of dichromatism and the degree of it was done using SPP (Standard Pseudoisochromatic Plates) and the Farnsworth dichotomous test Panel D-15. The following figures indicating the results of the Panel D-15 test, represent the grades of all dichromatic subjects are severe.

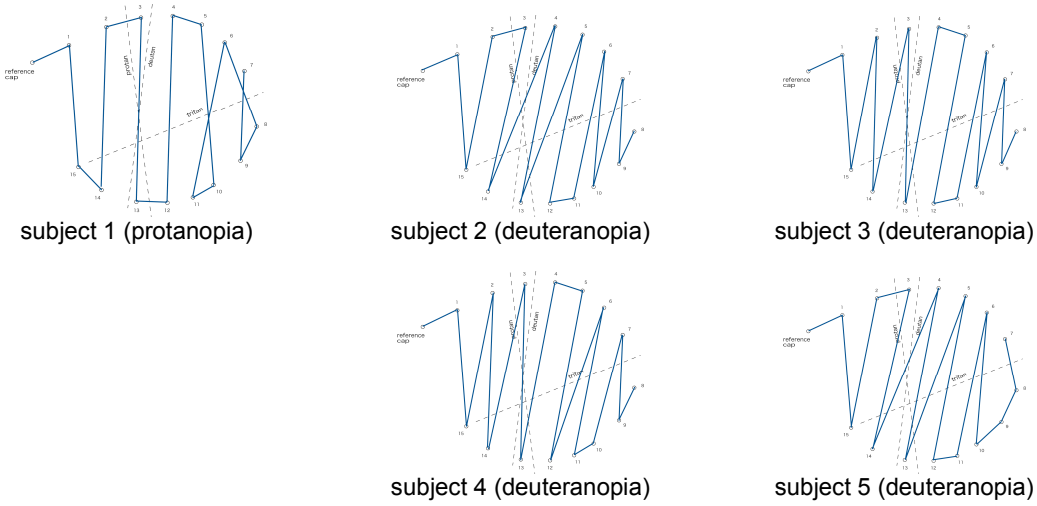


Fig 1. Results of Panel D-15 test

Factor analysis

Factor analyses using the data corresponding to the ratings were conducted separately for the chromatic type of vision. As a result, three factors were obtained regardless of the type of vision. The factor coefficients varied among a protan, deutans, and those with normal color vision. They represented beauty, warmness, and tranquility for the former, and beauty, brightness, and tranquility for the latter (Table 1). Another remarkable difference was that the former preferred vibrant colors, but the latter disliked them or preferred not to be associated with them[2].

Table 1. Factor Coefficients obtained in the experiment 3

(1) Subject 1 (protanopia)

Scales	Fac.1	Fac.2	Fac.3	Communality
Beautiful - Unbeautiful	0.91	0.09	-0.04	0.84
Conspicuous - Inconspicuous	0.91	0.12	-0.21	0.88
Like - Dislike	0.89	0.06	-0.06	0.80
Vibrant - Somber	0.86	0.18	-0.10	0.78
Bright - Dark	0.74	0.40	-0.14	0.73
Loud - Modest	0.74	0.27	-0.42	0.79
Hard - Soft	-0.15	-0.89	0.10	0.83
Warm - Cool	0.15	0.86	-0.02	0.77
Tranquil - Restless	-0.17	-0.07	0.97	0.98
Factor coefficient(%)	48.28	20.46	13.47	82.21

(2) Subject 2-5(deuteranopia)

Scales	Fac.1	Fac.2	Fac.3	Communality
Beautiful - Unbeautiful	0.88	0.25	-0.19	0.87
Like - Dislike	0.87	0.13	0.15	0.79
Vibrant - Somber	0.76	0.19	-0.51	0.87
Bright - Dark	0.69	0.37	-0.39	0.77
Conspicuous - Inconspicuous	0.67	0.27	-0.55	0.82
Loud - Modest	0.61	0.35	-0.58	0.83
Hard - Soft	-0.20	-0.87	0.19	0.84
Warm - Cool	0.25	0.85	-0.22	0.83
Tranquil - Restless	-0.04	-0.22	0.88	0.83
Factor coefficient(%)	38.96	21.96	21.84	82.76

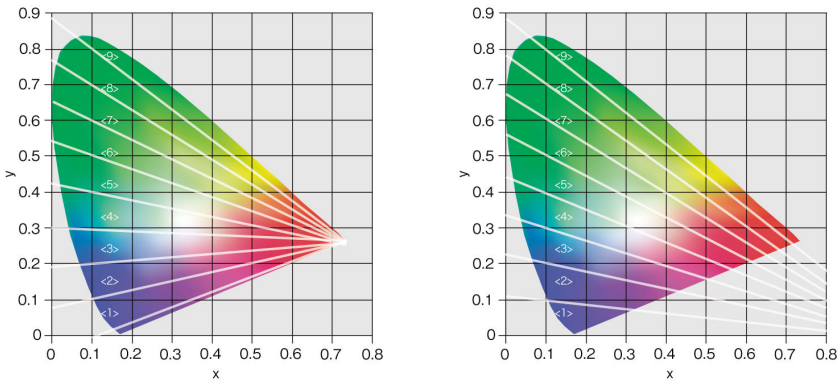
(3) Subject 6-7 (normal)

Scales	Fac.1	Fac.2	Fac.3	Communality
Loud - Modest	0.92	-0.06	0.26	0.91
Conspicuous - Inconspicuous	0.90	-0.10	0.27	0.88
Vibrant - Somber	0.87	0.01	0.20	0.80
Tranquil - Restless	-0.83	0.28	0.22	0.82
Hard - Soft	0.14	0.89	0.04	0.82
Bright - Dark	0.48	-0.77	0.02	0.82
Warm - Cool	0.21	-0.56	0.45	0.56
Beautiful - Unbeautiful	0.52	-0.17	0.70	0.78
Like - Dislike	0.01	0.04	0.93	0.87
Factor coefficient(%)	40.65	20.32	19.84	80.80

In Japanese		
(hadena	-	jimina)
(medatsu	-	medatanai)
(azayakana	-	kusunda)
(oshitukinoaru	-	oshitsukinonai)
(katai	-	yawarakai)
(akarui	-	kurai)
(atatakai	-	tsumetai)
(utsukusii	-	utsukusikunai)
(sukina	-	kiraina)

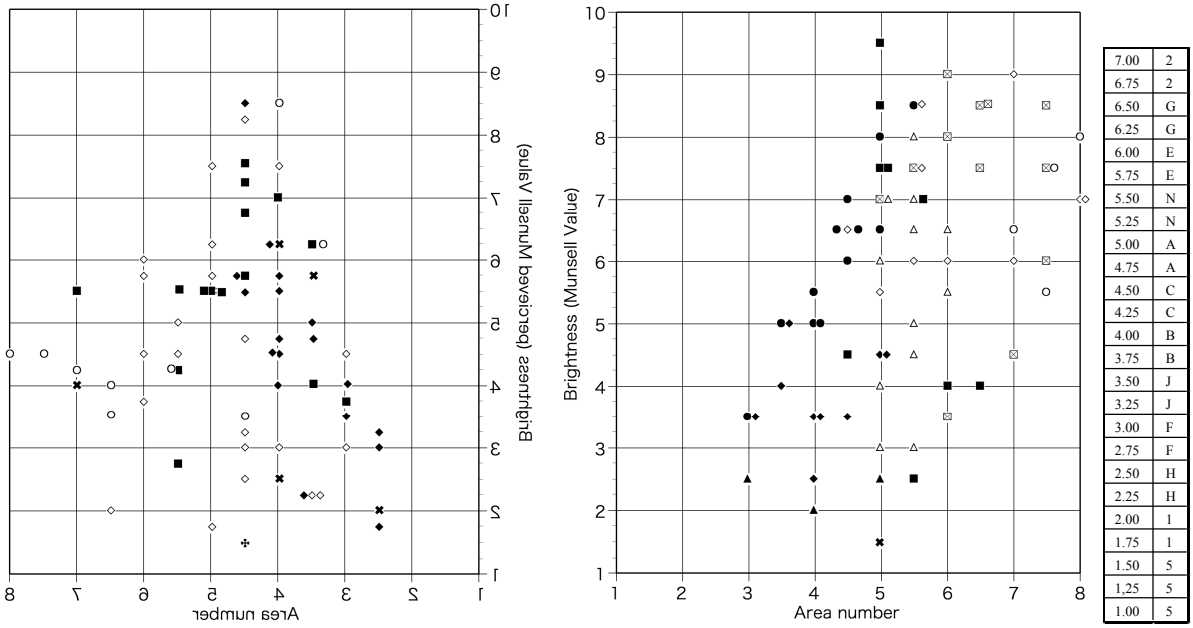
Relationship between ratings and the attributes of colors

Fig. 2 represents the area numbers on the xy chromaticity diagram in which the divided area shows similar chromaticness for colorblind people depending on the type of vision. Figs. 3 and 4 represent the ratings of warmness and beauty. The marks on the figures indicate the mean values of the ratings of the same type.



Convergence point is x = 0.747, y = 0.253 (protanopia), x = 1.080, y = –0.080 (deuteranopia)

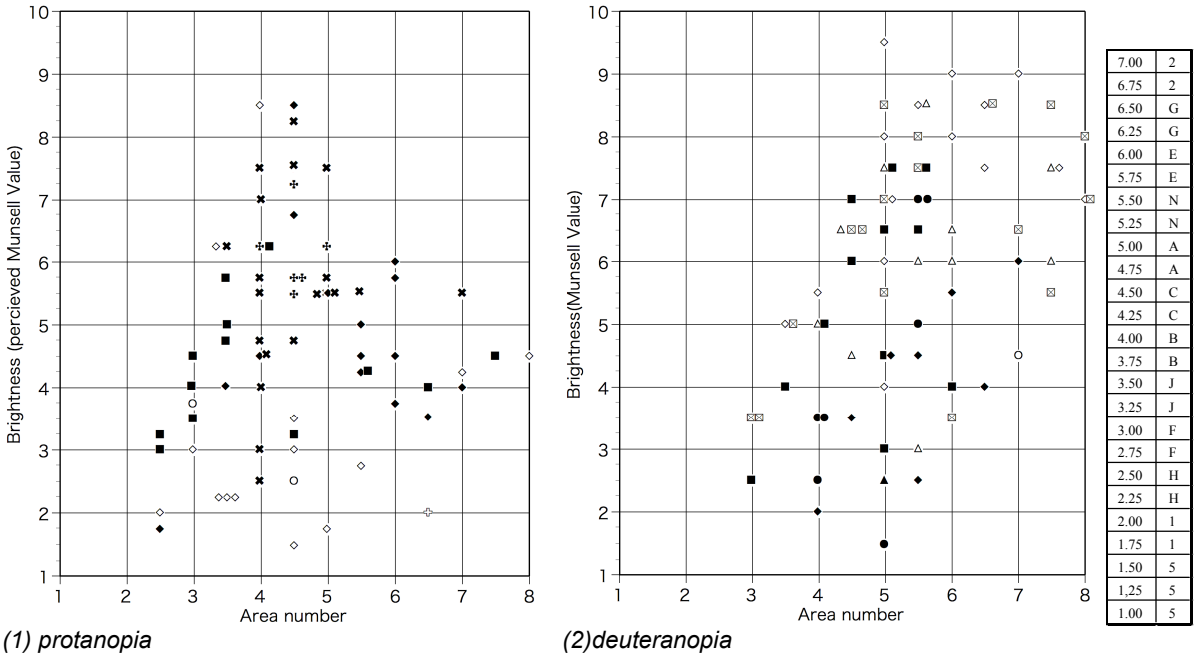
Fig 2. Area number that indicates the chromaticness of protanopia and deuteranopia



(1) protanopia (2)deuteranopia

Fig 3. Rating values of warmness on the dimension of brightness and area number

It is known that people with normal color vision judge warmness according to the hue of a color. Deutans show a similar tendency. If the area number is approximately 4.5, it indicates a neutral color; a larger number implies a yellowish color, and a smaller number implies a bluish color. The ratings by deutans vary roughly with change in the area number. Although the rating distribution of a protan shows similar tendency, overlapping on the distribution occurs.



(1) protanopia *(2)deuteranopia*

Fig 4. Rating values of beauty on the dimension of brightness and area number

A protan subject perceives dark colors as beautiful. Deutan subjects perceive the brightest colors as beautiful, particularly yellowish ones. Moreover, the most saturated colors at the edge of the distribution are felt as beautiful by the subjects. However, there are several colors that are felt as beautiful at the center of the distribution. Such interpretations are complicated.

CONCLUSION

The impression difference between colorblindness and those with normal color vision was obtained. However, the number of the subjects was small. Further information on the impressions of colors formed by colorblind people is required to understand the tendency of people with such disabilities. In particular, the reason for overlapping of different ratings for similar colors should be investigated. The author aims to conduct interviews to clarify the meanings colorblind people associate with colors, because colorblind people may form different impressions of the same color on the basis of their experiences.

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