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On Color Adaptation

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Abstract

This paper reports on colors is appearance after adaptation to tungsten and various fluorescent lamps. The experimental method is the binocular septum matching method. The results were plotted on the x-y chromaticity diagram, so that the vectors of the chart represent color shifts in appearance with adaptation to tungsten and fluorescent lamps. Color constancy can be qualitatively found in the results.

I. Introduction

Color appearance measurements are required to detremine the color rendering properties of fluorescent lamp. Studies on this subject have been reported by sevral researchers; Burnham, Evans and Newhall[1]. In our previous study[2] we have experimented on color appearance after adaptation to tungsten, "Daylight" and "White" fluorescent lamps. Since then, as the secound step,[3] we have made the color appearance measurments for five kinds of fluorescent lamps. As the color television developed, it has become a necessity to produce optimal color under various illuminants: We used the binocular septum matching methed as the experimental technique.

II. Method and Apparatus

The apparatus and experimental technique were the same as in our previous study. The binocular septum matching method was employed to determine the colorimetric specifications of colors with the same appearance when the observer was adapted

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1) R. W, Burnham, R. M. Evans, and S. M. Newhall, *JOSA*, Vol. 42, No. 9, 1952, p. 597-605
R. W. Burnham, R. M. Evens, and S. M. Newhall, *JOSA*, Vol. 47, No. 1, 1957, p. 35-47
S. M. Newhall, R. W. Burnham and R. M. Evans, *JOSA*, Vol. 48, No. 12, 1959, p. 976-984

2) L. Mori, T. Azuma and W. Miyao, Synopsis of the lecture delivered at the Spring Meeting of the Institute of Applied Physics of Japan, 1955.

3) W. T. Miyao, Synossis of the lecture delivered at the Autum Meeting of the Institute of Applied Physics of Japan, 1959.

to different illuminants. The comparison colors mixed colorimetrically were presented to the left eye adapted to the standard (tungsten) illuminant, while variously mixed colors were viewed by the right eye adapted to a different illuminant. Thus, with the left eye perception as the fixed comparison standard, the colorimetric difference in the same perception were measured when the right eye was adapted to a different illuminant. In our experiment the left eye was used as the standard adapted to tungsten lamp, and the right eye adapted fluorescent lamp was used as the matching field. Fluorescent lamps used in our study FL-D (daylight), FL-W (white), FL-G (green), FL-PK (Pink), FL-BW (blue-white) and FL-DY (FL-D lamp with yellow glass filter). The chromaticity coordinates of these illuminants were listed in Table 1.

Table. 1. The chromaticity coordinates of fluorescent lamps

fluorescent lamps	x	y
FL-D	0.312	0.326
FL-W	0.364	0.357
FL-BW	0.220	0.275
FL-G	0.240	0.631
FL-PK	0.547	0.344
FL-DY	0.411	0.397

Three groups of three color glass filters were used in turn in the colorimeter; Red-Violet-Blue, Yellow-Blue-Red, Yellow-Blue-Green. The value of each color was adjusted with variegation, so that all the colors could be presented by adjusting three variegations. The review of apparatus (the binacular septum matching method) is shown in Fig. 1. CIE chromaticities of color glass filters and fluorescent lampe are apparent in the general chart of Fig. 2.

III. Procedure

Each of nine colors selected in color space was presented in the left visual field adapted to tungsten lamp. Three observers, with normal eye sight matched the color perceptions in both eyes by means of adjusting the tristimulus colorimeter.

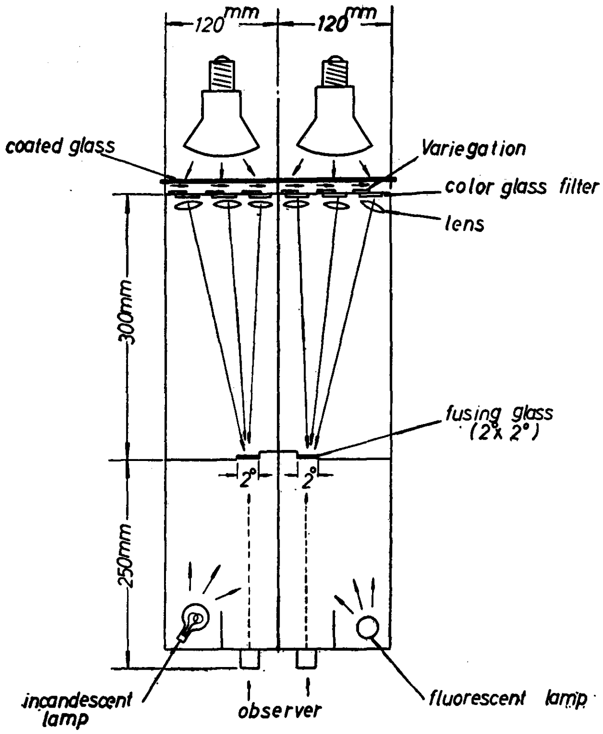

Fig. 1. Binocular color-matching apparatus

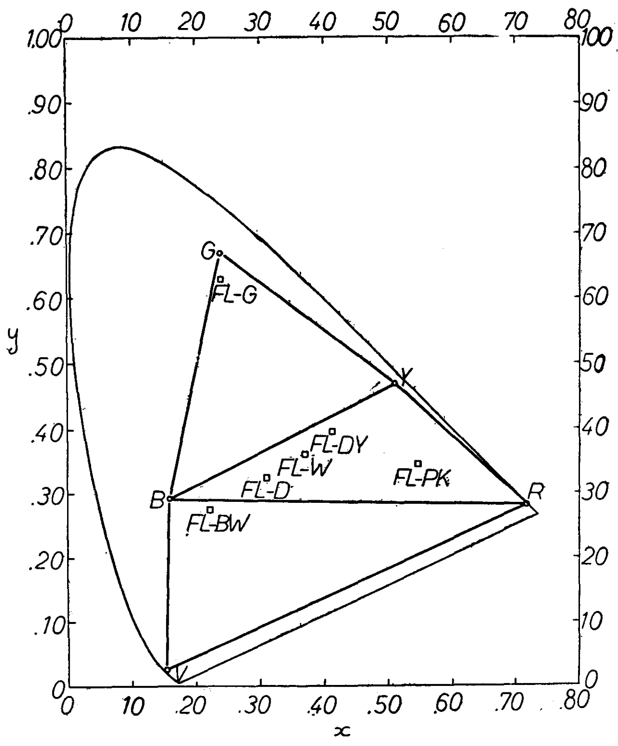

Fig. 2. CIE chromaticities of color glass filters and fluorescent lamps

For each color, observers took the data of colorimeteric specification for the matching color. The stungten lamp surrounding and the fluorescent lamp surrounding were set to about the same illuminance. The two fields were completely independent, but fused visually and had the appearance of a single divided 2×4 cm field with left and right areas side by side. Fig. 3a is a nonefused field and Fig. 3b is a completely fused field. The observer made the color matching with the adjuster of colorimeter by his own hands. Thus, we measured the appearent color shift under various fluorescent lamps from that under the incandescent lamp. It took 4 or 5 minutes to adapt to the illuminants. Brightness of visual was 150 radlux.

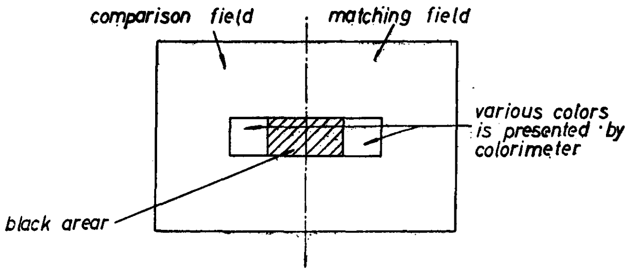

Fig. 3a. Visual field of none fused

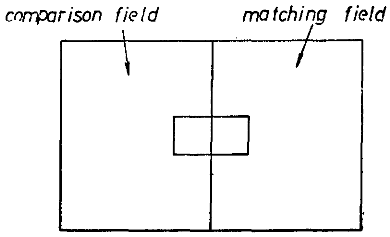

Fig. 3b. Visual field of completely fused

IV. Colorimetry

The colorimeter consists of the following three groups of glass filters; Red–Violet-Red, Yellow–Blue–Green, Yellow–Blue–Green. The characteristics of each glass filters is listed in Table 2.

Table 2. Trichromatic specifications of color glass filters

sign	name of filter	x	y	Y (%)
R	VR-2A	0.718	0.283	5.55
Y	VY-1B	0.511	0.469	78.60
G	VG-1B	0.237	0.668	6.52
B	VB-3C	0.156	0.294	6.17
V	VV-2	0.153	0.025	0.25

Colors with colorimeter were obtained by the following equations. where r, y, g, b, and v are relative slit areas in percentage.

a) R—V—B filters group

$$X = 0.718r + 0.153v + 0.156b$$
$$Y = 0.283r + 0.025v + 0.294b$$
$$Z = -0.001r + 0.822v + 0.550b$$
$$x = \frac{X}{X+Y+Z} \qquad y = \frac{Y}{X+Y+Z}$$

b) Y—B—R filters group

$$X = 0.511y + 0.156b + 0.718r$$
$$Y = 0.469y + 0.294b + 0.283r$$
$$Z = 0.020y + 0.550b - 0.001r$$

c) T—B—G filters group

$$X = 0.511y + 0.156b + 0.237g$$
$$Y = 0.469y + 0.294b + 0.668g$$
$$Z = 0.020y + 0.550b + 0.095g$$

V. Results

The results of color matching for each observer were transformed from the instrument coordinates to the trimulus values and were averaged for all observers. Then, chromaticities were computed from these averages, and the x-y data were plotted in chromaticity diagrams (see Fig. 4). These vectrs represent color shift from the object color under the incandiscent lamp to that under various fluorescent lamps. It was almost proved that color constancy was consisted in these date.

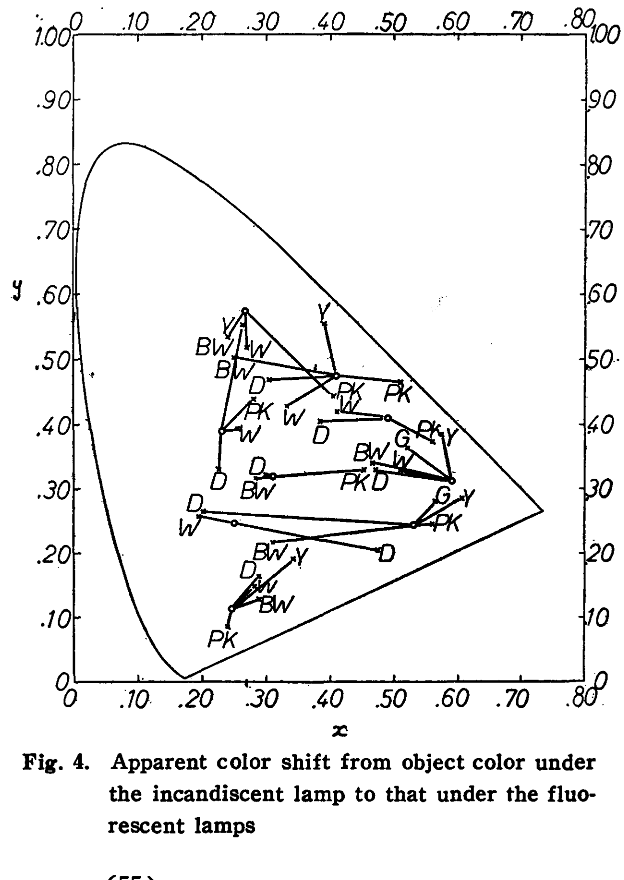

Fig. 4. Apparent color shift from object color under the incandiscent lamp to that under the fluorescent lamps

VI. Discussion aud Conclusion

On account of the lack of trained observers, sometimes data for different observers were not in accord. It is known that the fundamental stimulus value of each observer was different, although they have normal eyes. So, the results of Fig. 4 is the normalized value of individulity. Then, we found in this experiment that the number of observers need to be more than five or six. It is neccessary, indeed, that we decide upon a standard eye be the statistial management of data with large number of observers. In this study, we were unable to go beyond discovering that there seems to be qualitatively color constancy. As the color mixture elements in the colorimeter employed were not too accurate, considerable measuremental and psychological errors creeped in.

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