HOW EQUIVALENT CONSPICUITY IN TWO-COLOR COMBINATIONS IS EXPRESSED IN COLOR SPACE

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ABSTRACT

If we can present color combinations of the same conspicuity to users, it may help them choose arbitrary color combinations suited for particular purposes (e.g. spatial design, color accessibility etc.). This study aims to find quantitatively how equivalent conspicuities are expressed in a color space. In the experiment, we used two center-surround type color combination stimuli: the reference and the test stimulus. A subject adjusted the saturation of the center of the test stimulus along a given direction in the a*b* plane until the test stimulus had the same conspicuity as that of the reference stimulus. The results indicate that the equivalent conspicuous points are well-expressed as an ellipse. Further, our results indicate that the degree of conspicuity was different depending on hue even if the color difference was the same. These results show the similar trends as a previous study [1].

INTRODUCTION

In 2006, a new act on accessibility went into effect in Japan. Since then, many companies tried to share the rules for sign systems, or establish guidelines for their usage. It is not too much to say that sign systems are playing an important role in universal design. In these sign systems, selecting appropriate colors as a method of achieving conspicuity is easy and highly effective, as it doesn't require any physical change of the existing properties. In fact, we can see many sign systems that use color as a property for conspicuity in places such as stations. In this case, it is necessary to select colors based on its conspicuity in addition to taking its particular purpose, such as spatial design, color accessibility, into account. However, it is difficult to choose appropriate colors which fulfill both conspicuity and the purpose simultaneously: if we emphasis its conspicuity, that color might not suit for its purpose of usage, and vice versa. As a result, the presentation of the colors is limited, and it cannot be accomplished from wide variety of choices. As for a trend of conspicuity and emotion mediated for the color combination reported in the previous researches [1] [2], it is difficult to choose specific color, and its choice is really restricted. If we can offer multiple color combinations of the same conspicuity to users, it may help them choose arbitrary color combinations suited for particular purposes. This study aims to find an attribute of the equivalent conspicuity quantitatively in two-color combinations.

METHODS

Equipment

The experiments were conducted in a booth whose walls were covered with black velvet. A fluorescent light lit the inside the booth in order to prevent subjects from dark adaptation. The illuminance of the booth was approximately 180 lx. A LCD monitor (EIZO ColorEdge CG245W 24.1 inch), which controlled by ViSaGe (Cambridge Research System), was placed in front of the

subject in order to present stimuli. The distance between a monitor and a subject was approximately 100 cm. The subject could observe the stimulus freely.

Stimuli

A schematic diagram of the stimuli used in the experiment is shown in Figure 1. The stimuli consist of two center-surround type color combinations: one for the test and the other for the reference. They were presented on a black background on the LCD. The size of the center square was 2 x 2 deg, and that of surround square was 4 x 4 deg. A gap between the two stimuli was 2.8 deg. L* of the stimuli was 50. The color used for the reference stimulus was constant throughout the experiment: its center and surround were (0,50) and (0,20), respectively, in (a*, b*) color plane. The surround of the test stimulus was set to be either (0,0), (0,20), (0,-20), (20,0) or (-20,0). The center of the test stimulus was changed along a given 16 directions that equally spaced at a 22.5 degrees interval whose center was fixed for the above mentioned colors. The ranges of the adjustment for each direction were controlled so as not to exceed the color gamut of the monitor.

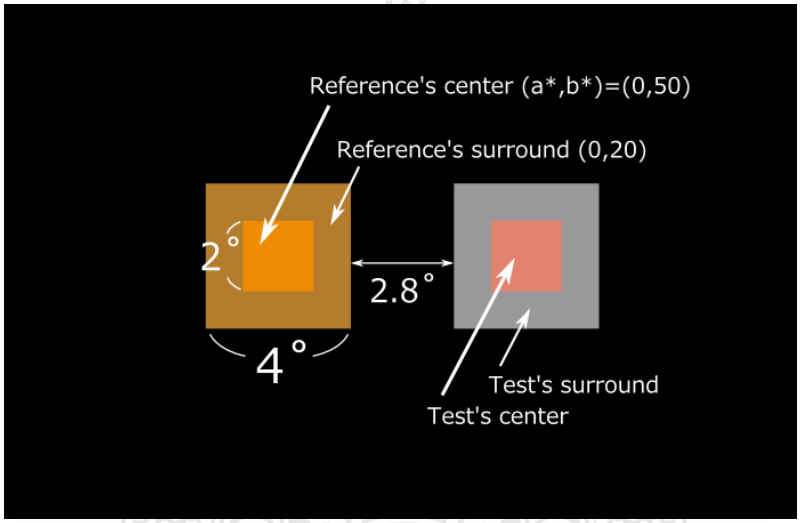

Figure 1. Example of a stimulus image

Subjects

Five subjects participated in the experiments. They were university students who had normal or corrected-normal acuity. Their color vision of all the subjects was normal, examined with Ishihara plates.

Procedure

Before starting a session, a subject stayed in an experimental booth for 5 minutes to adapt to the illumination of the booth. When the experiment started, the subject was asked to adjust the saturation of the center of the test stimulus until the test stimulus had the same conspicuity as that of the reference stimulus. Each subject conducted 5 sessions. Each session divided into 6 sets and each set consisted of 16 adjustments for each direction. In each set, the location of the test stimulus was kept constant, either to the right or the left. The order of presentation and the initial saturation were randomly selected.

RESULTS AND DISCUSSION

The results of the experiment are shown in Figures 2 and 3. In Figure 2, an example of the result obtained from one subject (KY) is shown. Orange dots indicate the results of each setting. Blue lines show the average of all the settings for each direction. In Figure 3, orange dots indicate the averaged results obtained from each subject. Blue lines indicate the average among all the subjects.

Red line shows an ellipse approximation. The green ellipses indicates the MacAdam ellipse for (0,0) and (20,0).

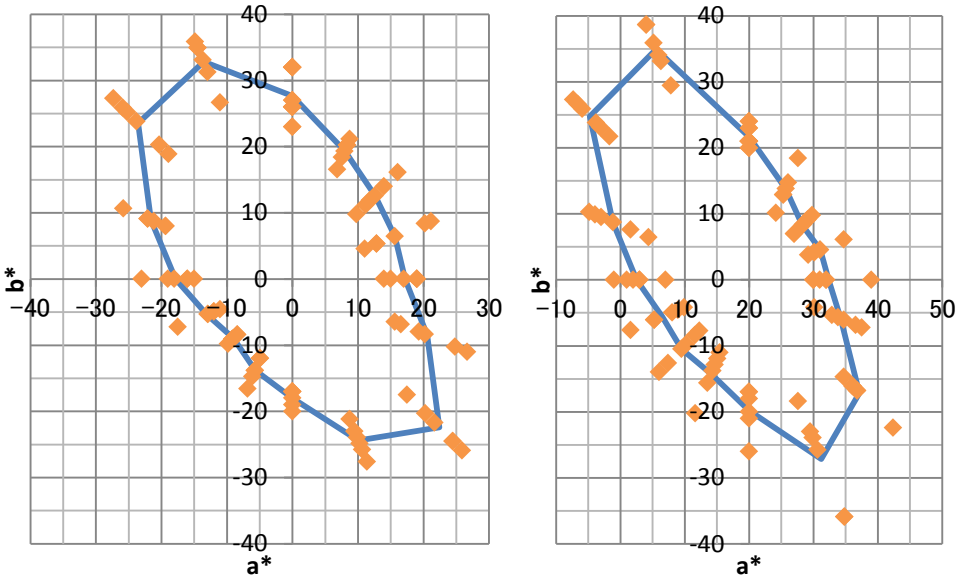

Figure 2. Results obtained from one subject KY
(a) and (b) are results for (0,0) and (0,20), respectively.

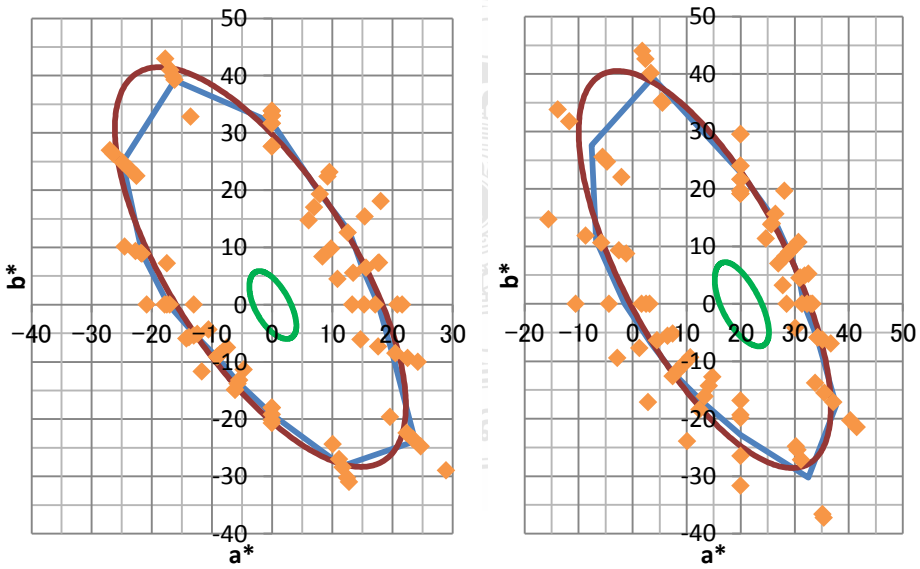

Figure 3. Results obtained from all subjects
(a) and (b) are results for (0,0) and (0,20), respectively.

Subjects reported that the color of the same conspicuity was not found for some directions in (0,-20) and (-20,0) conditions. It may partly be because the gamut of the monitor used in the experiment was not large enough to obtain the color in those particular directions.

A fitted ellipse had a longer axis which is inclined approximately 30 degrees counterclockwise from the b* axis. The MacAdam ellipse centered around (0,0) also has the same degree of inclination. A similar trend was also seen in the other points. These coincidences come from the non-uniformity of the L*a*b* color space.

Next, we calculated the color differences using CIEDE2000 color difference formula, which was defined to decrease discrepancies between colorimetric and visual color differences in CIELAB. Color differences between the surround color and the center colors with the same conspicuity obtained for all the directions are shown in Figure 4. The color differences between the surround color and the center colors of the similar hue with higher saturation were smaller. Moreover, these outlines inclined counterclockwise from the b* axis. This result suggests that the degree of conspicuity was different depending on hue even if the color difference was the same. These results show a similar tendency as previous reported research [1].

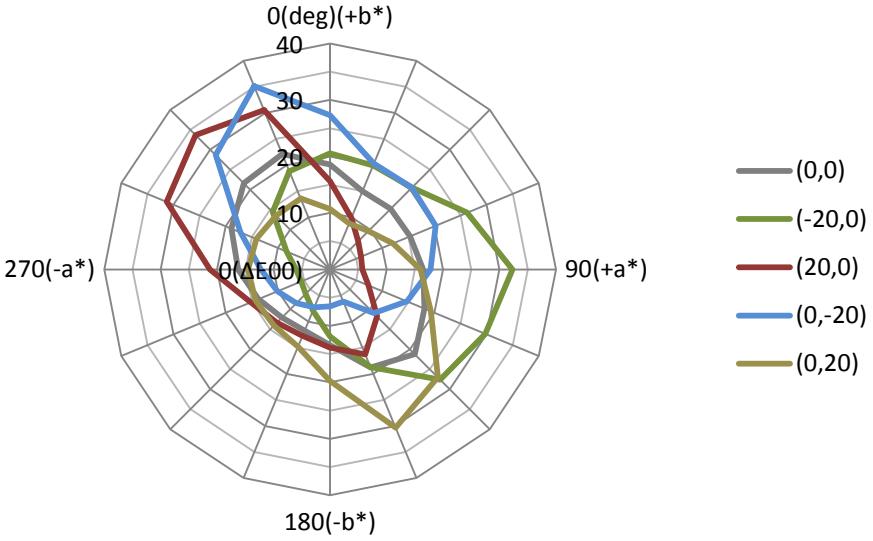

Figure 4. Color differences between the surround color and the center colors with the same conspicuity

CONCLUSION

The experimental results indicated that the equivalent conspicuous points were well-expressed as an ellipse and inclination was the same as the MacAdam ellipse. Furthermore, color differences obtained from CIEDE2000 showed a trend of smaller color differences in the first and in the third quadrant and larger differences in the second and in the fourth quadrant. These indicated that the degree of conspicuity was different depending on hue even if the color difference was the same, however, some colors may have been affected by the monitor color gamut.

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