Influence of focal colors in color memory

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ABSTRACT: Precious studies show that the memory of color is decided by the color category of a stimulus. However, we cannot predict a color shift in the memory using this knowledge. In this study, we investigate the relationships among eight focal colors, which are typical colors in every color category, to clarify the mechanism of the color shift in memory. The results show a possible relationship between the color shift in memory and the focal colors. However, the results also show that we require other color categories to explain the color shifts in all stimuli.

Keywords: color memory, focal color, color difference, L*a*b* color space

1. Introduction

Some visual content is delivered every day on TV, internet, and in magazines. Colors in these advertisements are essential visual elements, which are often very important for the transmission of information to consumers or the audience. Because of this, we must choose the colors carefully taking into account the effect of color impression for establishing the visual content. In particular, because there is a time lag between the moment that individuals watch the visual content and when they watch the real things, we think that it is necessary to pay attention to the memory of colors. The color memory is the recognition or regeneration of colors recently seen. At present, there have been only few reports about the visual content and the color memory. Investigations about the color memory for making visual contents have been hardly conducted. We think that the effects of color memory lead to a decline of the consumer's buying motivation or establishing a brand image. To cope with these problems, it is necessary to know color shifts in memory.

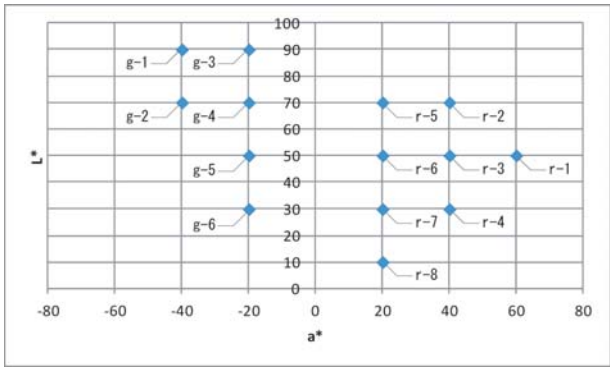

Fig. 1 Colors selected for stimulation.

The previous study [1] investigated the relationship between the color memory and the color category. In this paper, participants are engaged in a recognition experiment after having memorized a single test color. The results show that all recognition colors have been distributed in each category domain, indicating a possibility that the color memory was decided by each test color category. In addition, the following things are known about the relationship between the shift of color memory and the category domain; 1, the shift of memory color is limited the category domain of the color [2]. 2, it does not spread to the other category domains. 3, the shift of memory color tends to go to the focal color position. However, the results cannot predict quantitative color shifts in memory. In this study, we have examined the color shift in the memory and the relationship between the memory of colors and the focal colors representing the category domains.

2. Experiment

Participants reproduced a memorized color by manipulating a personal computer after watching a single color on the computer's display. They also answered questions about nine focal colors using the same PC system.

2.1. Participants

Thirty undergraduate and graduate students participated in this experiment (ages 19-29 years; 15 female and 15 male). All were native about the purpose of the study and had normal or corrected-to-normal vision.

2.2. Stimulus

We selected 27 colors as test stimuli from sRGB color space. Figures 1 and 2 show the selected colors. These were on the a* axis and b* axis in L*a*b* color space.

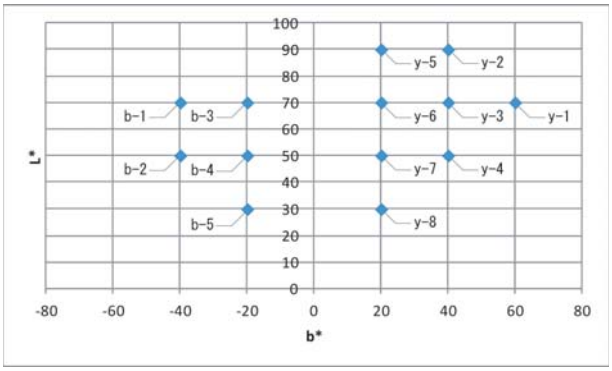

Fig. 2 Colors selected for stimulation.

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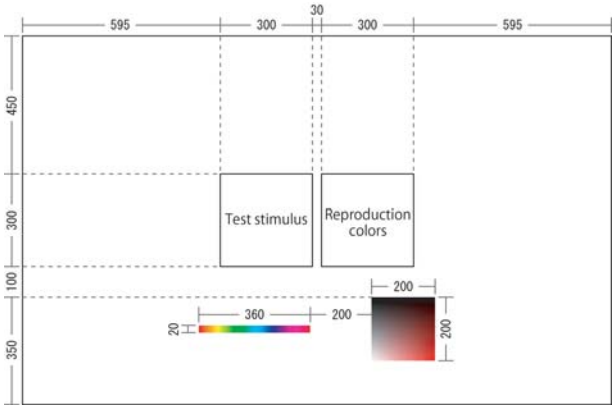

Fig. 3 Arrangement of the stimulilation and the digital color palette on the 24.1 inch LCD monitor. The unit is pixel.

2.3. Procedures

Test stimulation was shown on the left side of a liquid crystal display (LCD). The background color was black to prevent halation of the stimulation and the background color. Participants memorized the scene for five seconds. Subsequently, they regenerated the memorized color using a mouse and a digital color palette on the LCD. The digital color palette had a controllable bar to select hue and a controllable plane to select chroma and lightness that was interlocked by the selected hue. Twenty-seven colors of test stimulation were shown in random order. Participants were trained three times in this procedure before the experiment. Figure 3 shows the arrangement of stimulation and digital color palette.

After the above procedure, participants answered questions about nine focal colors (red, green, yellow, blue, brown, orange, purple, pink, and gray) using the same digital device. The focal colors were basic color terms selected by Berlin and Kay [3]. Red, green, yellow, and blue were considered to be members of the primitive color category. Brown, pink, purple, orange, and gray were considered to be members of the derivation color category.

The experiment was conducted in a darkroom. Light for illumination was provided by a three-wavelength fluorescent lamp. Illumination around the display was approximately 200lx. The LCD (EIZO, CG243W, 24.1 inch, 1920*1200 pixel, refresh rate: 60Hz) was corrected to the sRGB color system using a color calibration system (x-rite, Color Munki Photo). The visual distance was approximately 60 cm and visual angle of stimulation about 10 degrees. The eye level of participants was fixed to the same height as was the center of display. We used a programming language (processing 1.2.1) to represent the stimulation and manipulation of the digital color palette.

3. Results and Discussion

We measured all test stimuli and reproduced colors using a two-dimensional high-speed color luminance meter (DELTA, ICAM). The test stimuli and reproduction colors were represented by values of L*, a*, and b* the color difference of each pair of test stimuli and reproduced colors were calculated. A paired t-test showed that the 25 reproduction colors among all 27 test stimuli were significantly different in each test stimulus.

We measured all focal colors answered by participants using the same device. We plotted the results about color shift in memory and focal colors on the a*b* plane (Fig. 4). Figure 4 shows that the right direction is + a* and that, the upper direction is + b*.

We investigated the relationships between color shift in memory and focal colors. As the first index, we calculated distances between test stimuli and the averages of focal colors. As the second index, we calculated the angles of two vectors; vector 1 (reproduced color vector) towards a reproduced color from a test stimulus and vector 2 (focal color vector) towards the average of a focal color from a test stimulus in L*a*b* color space. Since the angle of reproduced and focal colors was small, the reproduction color shifted in the direction of the focal color.

The results showed the following tendencies in the test stimuli of hue r. (The reproduced color of the test stimulus r-4 did not have significant difference.) At first, we confirmed whether the reproduced colors were relevant to the four focal colors in the primitive color category. The distances from the test stimuli to the averages of focal colors were close to red and green focal colors. However, the differences of distances were not large. On the other hand, all reproduced color vectors (in hue r) had the smallest angle with the focal color vector of blue. With all these results, it is thought that the reproduced color of hue r received almost no influence from the four focal colors.

Next, we added the four colors from the derivation color category as analysis subjects. In this case, the distances from the test stimuli to the four focal colors of the derivation color categories were shorter than the distance between the focal colors of the primitive color category mentioned previously. In addition, the smallest angle was the angle between the reproduced color vectors and focal color vectors of purple and pink. Considering all these results, the test stimuli of hue r may be affected by the focal colors of purple and pink.

The results showed the following tendencies in the test stimuli of hue y. (The reproduced color of the test stimulus y-3 did not have significant difference.) First, we confirmed whether the reproduced colors were relevant to the four focal colors in the primitive color category. We compared the distances from the test stimuli with the averages of focal colors, the results of which showed that the distances were close to green and yellow. On the other hand, in almost all the stimuli of hue y, the reproduction vectors were near to the focal color vector of green. The reproduced color vector of y-7 had the smallest angle with the focal color vector of yellow. The vector of y-6 had large angles with every focal color vector from the primitive color category.

From these results, it is thought that the reproduced color of hue r received almost no influence from the four focal colors.

Next, we added the four colors from the derivation color category as analysis subjects. In this case, the distances from the test stimuli to the focal colors of orange and brown were shorter than the distances to the focal colors from the primitive color category. However, there was no smaller angle than the case of green from the primitive color category. Considering all these results, it is thought that colors of middle luminosity and chroma in hue y were influenced by the focal color green.

The results showed the following tendencies in the test stimuli of hue g. At first, we confirmed whether the reproduced colors were relevant to the four focal colors from the primitive color category. We compared the distances from the test stimuli to the averages of focal colors, the results of which showed that the distances were close to the green focal color. However, the smallest angles in every test stimulus did not show any consistency. Considering all this information, it is thought that the reproduced color memory of hue g received almost no influence from the four focal colors.

Next, we added the four colors from the derivation color category. In this case, the distances from the test stimuli to the focal colors of brown were shorter than the distances to the focal colors of the primitive color categories. However, like in the primitive color category case, the results of reproduced color vectors had no consistencies. Almost none of the eight focal colors were distributed around the stimuli of hue g. From this fact, it is thought that the reproduced color of hue g received almost no influence from the eight focal colors, including those in the derivation color category. Therefore, we think that it is necessary to make another color category, and to examine it by the same method.

The results showed the following tendencies in the test stimuli of hue b. First, we confirmed whether the reproduced colors were relevant to the four focal colors in the primitive color category. The distances from the test stimuli to the averages of focal colors were close to the blue and green focal colors. However, these distances in hue b were larger than the distances in hues r, y, g. In addition, the coherent tendency was not seen in the angles of two vectors. From these results, it is thought that the reproduced color of hue b received almost no influence of any of the four focal colors.

Next, we added the four colors from the derivation color category. In this case, the distances from the test stimuli to the focal colors of purple, pink, and brown were shorter than the distances to the focal colors from the primitive color category. In addition, the following tendencies were seen about the angles of two vectors. The reproduced color vectors of b-1 and b-2 were similar to the focal color vectors of green and yellow and orange and brown. The reproduced color vector of b-5 was similar to the focal color vectors of blue and purple. The reproduced color vectors of b-3 and b-4 were not similar to any focal color vectors. With all these factors, the coherent tendency was not seen in the results of hue b. Like the results of hue g, almost none of the focal colors were distributed around the test stimuli of hue b. Therefore, we think that it is necessary to make another color category, and to examine it the same method.

4. Summary

In this study, we have investigated the relationships between the color shift in the memory and the focal colors. To do so, we have used two indices. The first was the average of distance between a test stimuli and a focal color. The second was an angle between two vectors: vector 1 towards a reproduced color from a test stimulus and vector 2 towards the average of a focal color from a test stimulus in the *L*a*b** color space. As a result, a coherent tendency was not seen when we analyzed the relationships using only four colors from the primitive color category. When we added other four focal colors from the derivation color category as analysis subjects, it was observed the reproduced colors of hues *r* and *y* in relation with the added focal colors. On the other hand, the results in hues *g* and *b* did not show any coherent tendency. As a result, focal colors selected by Berlin and Kay aren't enough to explain relations with the color memory. We showed that it is necessary to make other color categories for examining the recognition of color memory.

References

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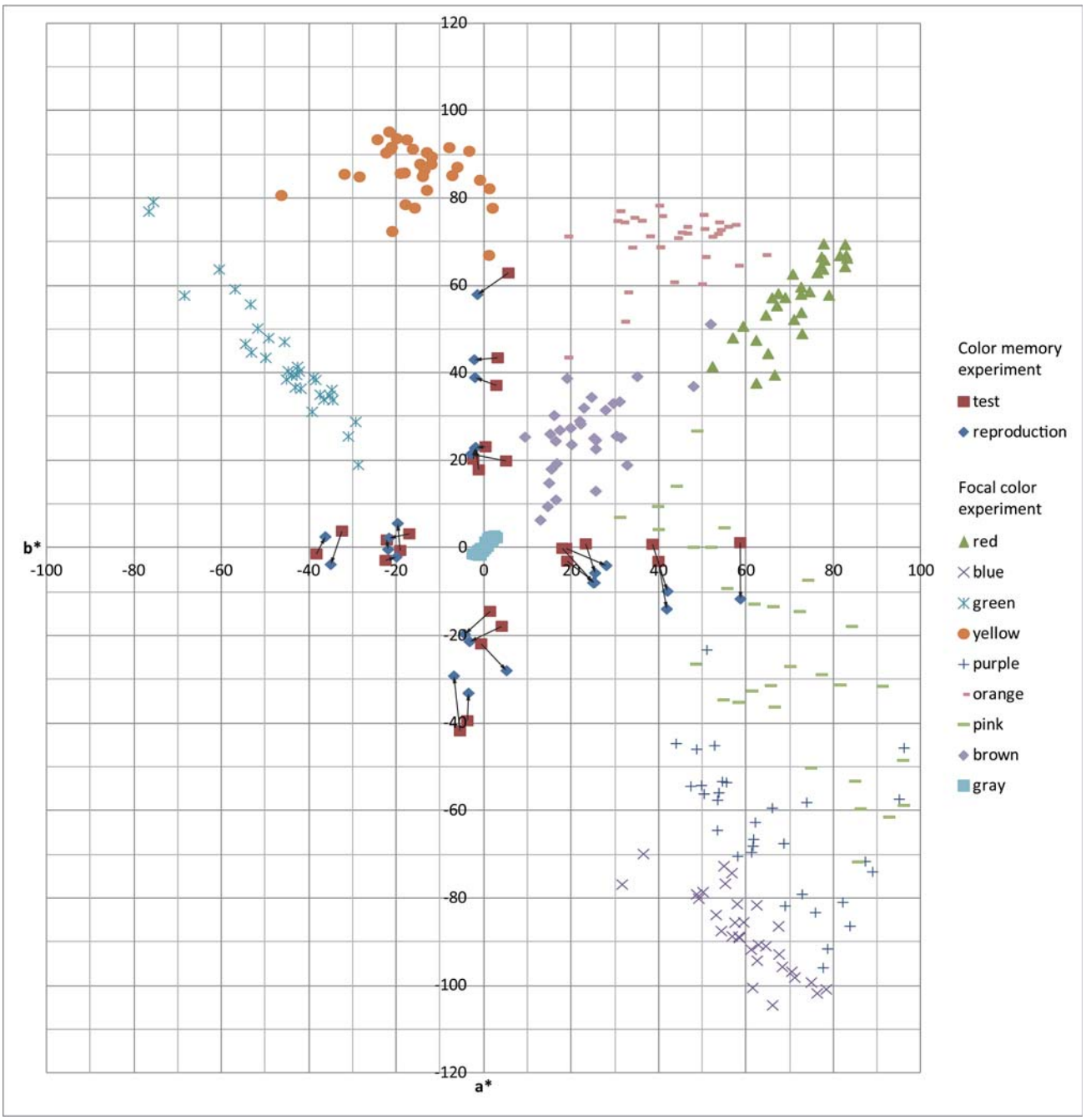

Fig. 4 The **color shift in memory and focal colors on a*b* plane.**