Investigation on Chromatic Mechanism Mediating the Whole Color Impressions from Multi-Colored Texture Patterns

Shoji Sunaga and Yukio Yamashita
Faculty of Design, Kyushu University, 4-9-1, Shiobaru, Minami-ku, Fukuoka, 815-8540, Japan
E-mail: sunaga@design.kyushu-u.ac.jp

We investigated the relationships between a single-color impression sensed for a multi-colored texture and the colors of elements embedded in the texture. The stimulus was a random-dot texture pattern made by two colors which were equal saturated color. We measured a single color impression as a whole of the pattern by an asymmetrical color matching method. If a single color impression appeared on a straight line connecting the two colors, the single color impression would be determined by the colorimetric average. On the other hand, if a color impression were still on the curved equal saturation locus, the color appearances of the element colors would influence the single color impression. Our results showed that single color impressions did not always agree with colorimetric averages of element colors and that the colors of the impressions tended to shift to the curved equal saturation locus for some color combinations. This suggests that the determination of the single color impression involves the visual mechanism which integrates the color appearances of the elements in the texture.

Key words: *Multi-Colored Texture, Color Impression, Saturation*

Introduction

We can often sense a color impression as a whole from a non-uniform surface that consists of tiny similar colors. For example, even when a surface consists of some colors, we can often call that surface by a single color name. However, it is not clear how such a single color impression from a multi-colored texture pattern is determined. To investigate this question, we tested two hypotheses. The first hypothesis is that a single color impression is determined by the colorimetric average of the colors in the texture. Second hypothesis is that the impression is influenced by the color appearances of the element colors in the texture.

Sunaga and Yamashita (2003a, 2003b) examined these hypotheses by using a random-dot texture pattern made by two colors which were an identical hue and different saturations. Their results indicated that the single color impressions were located on the curved identical hue loci in CIE chromaticity diagram. It was suggested that the color of the impression was not colorimetric average and might be determined by color mechanism integrating color appearance of the element's colors.

In this study, we extended their study. We examined whether the same conclusion is obtained from the different stimulus condition, or not. The stimulus was a random-dot texture pattern made by two colors which were equal saturated colors. We measured a single color impression as a whole of the pattern by an asymmetrical color matching method. If a single color impression appeared on a straight line connecting the two colors, the single color impression would be determined by the colorimetric average hypothesis. On the other hand, if a color impression were still on the curved equal saturation locus, the color appearance hypothesis would be supported.

Methods

Apparatus

We used a 17-inch color CRT display (EIZO T766) controlled by a personal computer (Dell dimension V400c). he gamma characteristics and the chromaticity coordinates of primary phosphors were measured by a spectral radiometer (TOPCON SR-1), and then the gamma characteristics were linearized for each of phosphors by programming based on the measured luminance. The display was located at 80 cm in front of observers in a dark room.

Observers

One female (MS) and one male (SS) participated in the experiment as observers. They had normal color vision, which confirmed by the Fraunsworth-Munsell 100-hue test. They also had normal acuity or corrected-to–normal acuity.

Stimuli

Fig.1 shows the stimulus used in the experiment. The stimulus consisted of two fields arranged horizontally with the distance of 1 deg: a test and a matching field of 4 deg x 4 deg. The test field was a random-dot texture pattern with two kinds of colored elements. The element size of the texture was of 4 min x 4 min, which was enough size to be able to be resolved. These two colors of the elements had an equal saturation, an equal brightness, and different hues. We used five test colors: four unique hues and ‘Purple’. The ‘Purple’ was additionally used between ‘Unique Red’ and ‘Unique Blue’, because a single-color impression was not produced in the combination of unique blue and unique red (Sunaga and Yamashita, 2004). The chromaticities of these colors for observer SS is denoted by closed squares in Fig.1. The five color combinations were used, which were shown in Table 1. The brightness and the saturation of these element colors were equal based on the previous measurements. The density ratio of the texture was one of 0:100, 16:84, 32:68, 50:50, 68:32, 84:16, and 100:0%.

The matching field was uniform, and its luminance and chromaticity could be adjusted by an observer to the impressed color sensed as a whole in the test field.

Procedure

The experiment started after the dark adaptation for five minutes. Experimental data was corrected by means of the method of adjustment. The multi-colored texture test pattern was presented next to the matching field in a random order. The observer adjusted the chromaticity and luminance of the color of the matching field to produce a single-color impression perceived in the multi-colored test texture. The observer was also instructed to ignore the color appearance of the texture pattern in periphery and to move their eyes to see each field alternately. The side positions of the test field and the matching field were interchanged at random for every trial. Twenty adjustments of the single-color impression were performed for each condition.

Table 1 The hue combinations used in the test field. The chromaticity coordinate of each test color is shown in Fig. 1.

Hue combination			
Unique Red	—	Unique Yellow	(R-Y)
Unique Yellow	—	Unique Green	(Y-G)
Unique Green	—	Unique Blue	(G-B)
Unique Blue	—	Purple	(B-P)
Purple	—	Unique Red	(P-R)

Results and discussion

Fig.3 shows the results for observer SS in the CIE u’v’ chromaticity coordinates. Closed squares indicate the chromaticities of five test colors used in the test field. The looped curve connecting them represents equal saturation previously measured. Closed circles represent the colorimetric averages of the texture patterns for each condition. The matched results for the single color

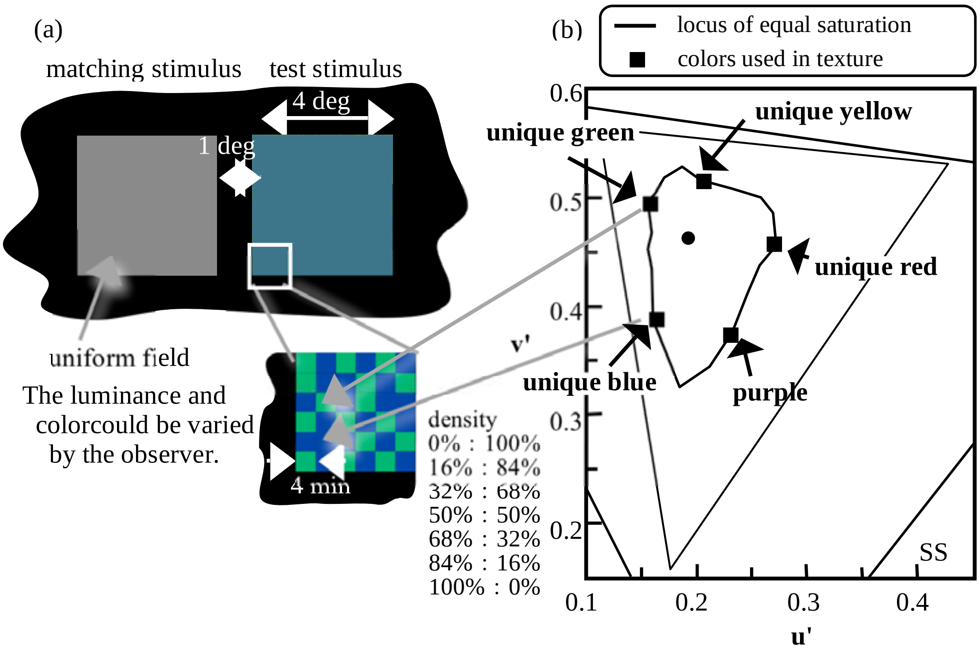

Fig.2 The stimulus used in the evaluations of the single color impressions from two-colored texture patterns.

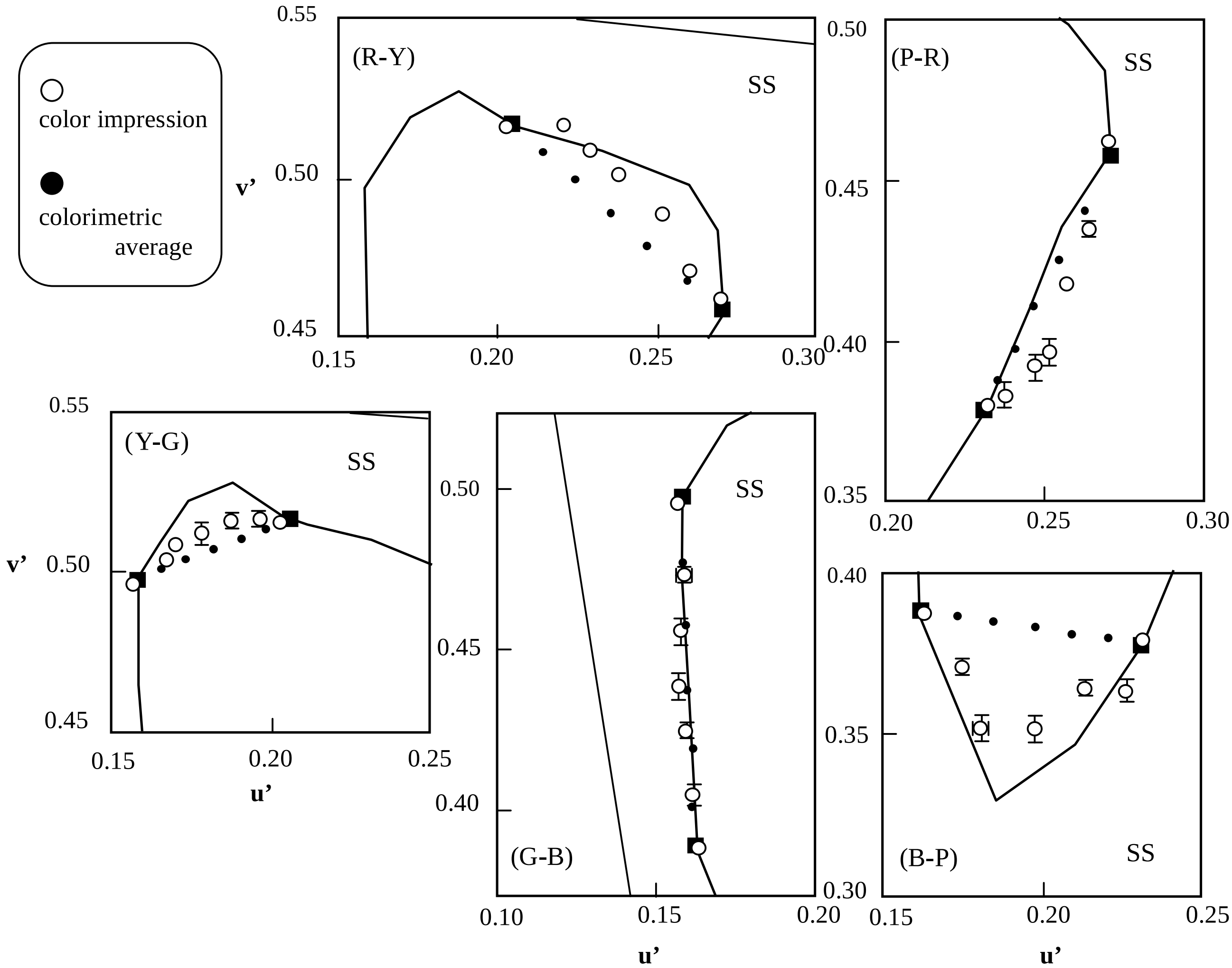

Fig.3 CIE 1976u'v' chromaticity coordinates of single color impressions from two-colored texture patterns.

impression perceived as a whole in the test field are shown by open circles. As seen in Fig. 3, the locations of the matched colors shifted toward to the looped locus of equal saturation. It was remarkable in the case of B-P especially. Although this tendency was ambiguous in the cases of G-B and P-R because the locations of equal saturation of their conditions were nearly identical to those of the colorimetric averages of them, it is considered that the result indicates that the single-color impression perceived in the two-colored texture did not agree with a colorimetric average of the element colors. The similar results were obtained for the other observer. These results support our previous proposals that a single-color impression might be determined by a perceptual color mechanism that integrates color appearance of elements' colors, rather than by a receptoral mechanism that produces additive color mixtures.

Acknowledgement

This work was supported in part by a Grant-in-Aid for the 21st Century COE program and User Science Institute of Kyushu University.

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