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THRESHOLD METRIC CHROMA OF IMAGES FOR CHROMATIC PERCEPTION

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THRESHOLD METRIC CHROMA OF IMAGES FOR CHROMATIC PERCEPTION

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Abstract

Having a final goal to reveal psychological effect of saturation increase in digital images, BCACI, Border Chroma between Achromatic and Chromatic Impression, was investigated for normal and shuffled-mosaic natural images as the first approach. Observers were asked to respond total color impression by choosing one color name among 14 color names including basic categorical colors. BCACI was obtained by the effective metric chroma C_{ab}^* where 50% of responses were achromatic color names. Results of normal images indicate that when the metric chroma C_{ab}^* exceeds 7, observer's perception of the whole image turns from achromatic to chromatic, except "pink" and "purple" images. BCACI of shuffled-mosaic images is significantly lower than that of normal images, suggesting the effect of the meaning of contents on color impression.

Keywords: Metric chroma, Chromatic and achromatic impression, Color image, Image content

1 Introduction

Color was introduced in the movie in early in the 20th century, spread to color TV broadcast and color photography by 1970s, and then expanded to computer display with a rapid spread of PC. In the time of development, people in related fields eagerly elaborated to devise new technique that made beautiful color image possible. Nowadays, HDR wide color gamut display is available as a consumer product and even a small display of mobile phone has satisfiable color quality.

Most people prefer color image to monochromatic image generally. However, why people seek or prefer color image has not been investigated systematically. Nowadays, real time color processing to enhance or reduce colors becomes possible, and any imaging device such as camera, display, and TV has its own color processing engine to render colors. In this time and age, psychological effect of color should be reconsidered, and systematic approach to reveal the effect of color is needed. Psychological effect here means how and to what degree color of image contributes to various subjective impressions, such as preference, powerfulness, comfortableness or beautifulness. These are called KANSEI evaluation recently and considered as important factor to increase image quality.

Effects of gamut volume, luminance, and colorfulness on perceived image quality, preference, or visual comfort have been reported in previous studies using various images presented on a display [1-5]. Generally, preference rating increases with gamut volume and luminance for natural and/or human images, indicating that ordinary observers prefer brighter and more saturated images [1-4]. On the other hand, visual comfort tends to decrease with saturation for interior scene images [5]. Such a dependency on the kind of evaluation, as well as dependency on the contents of images are important issues to be solved, but not clarified yet. In these studies, saturation of test stimuli was all supra-threshold, i.e., observers were asked to make subjective evaluation on the test images of various saturation that appear more or less chromatic. No study has investigated threshold saturation at which observers begin to perceive the image chromatic. It is a border between achromatic and chromatic impression. We call it BCACI, Border Chroma between Achromatic and Chromatic Impression here. The aim of this study is to measure BCACI for various images. Our final goal is to investigate effects of saturation increase on various subjective evaluations of images of different contents. BCACI might be one of underlying factors to explain image-contents dependency.

2 Experiments

Nine different images representing the following color names, “red”, “green”, “orange”, “yellow”, “pink”, “blue”, “purple”, “red and green”, and, “yellow and blue”, were chosen as original images. Color names of each image were based on our previous study [6]. Metric chroma C_{ab}^{*} was calculated for each pixel of original image and then multiplied by multiplying factor k from 0 to 0.2. Eight or 10 different C_{ab}* images were prepared for each of the original images. Total of 98 images were prepared as test stimuli. In addition to these test images that are called normal images here, shuffled-mosaic images (one block was 100 x 100 pixels) of each test images were also prepared to examine the contents dependency. Total of 105 images were prepared as test stimuli for mosaicked version. Examples of normal and mosaic images are shown in Figure 1.

Observer took 5-min dark adaptation at the beginning of each session. A test stimulus was presented on the display (EIZO ColorEdge CG277) with the visual distance of 120cm. The observer was asked to choose a color name among 14 color names, as the color name to represent the color of the image as a whole. Color names of “red”, “green”, “blue”, “yellow”, “orange”, “pink”, “blown”, “purple”, “red-green”, “blue-yellow”, “gray”, “white”, “black” and “monochromatic”, were written in the answer sheet. The last one, “monochromatic” is not a color name, but the expression is quite appropriate for some of the test images of very low k. They appeared neither white, gray, nor black, but “monochromatic” as a whole. Test stimulus was presented continuously until the observer made the response. Uniform gray image (R, G, B = 38, 1.94 cd/m^2) was presented about 3 sec between trials to avoid the effect of chromatic after image of the preceding test stimulus. Viewing condition and the answer sheet are indicated in Figure 2 and Figure 3, respectively. One test stimulus was presented 6 times throughout the experiment, and 4 sessions were repeated for each observer. Test stimuli were presented in a random order in each session. Normal images and mosaicked images were examined in different sessions.

Twenty observers, 10 males and females in their twenties, with normal color vision participated the experiment using normal images and 7 observers, 6 males and 1 female in their twenties with nomal color vision participated the experiment using mosaicked images.

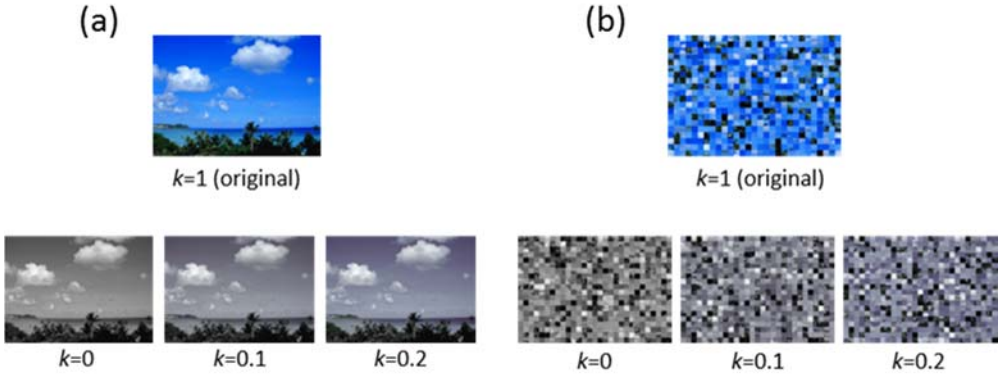

Figure 1 – Example of the test stimuli of “blue”. Normal (a) and Mosaicked (b) images

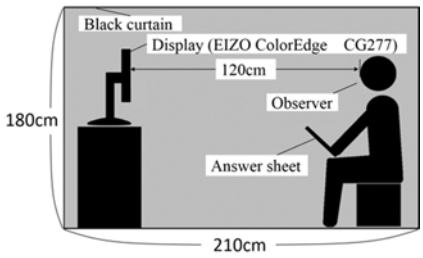

Figure 2 – Viewing condition

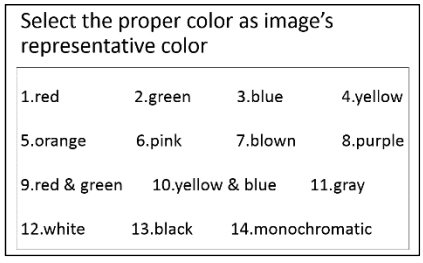

Figure 3 – Answer sheet

3 Results

The number of achromatic responses were counted for each test image. Achromatic responses here mean that observer's choice was one of the following color names, "gray", "white", "black", or "monochromatic" in the answer sheet. Total number of achromatic responses among all observers is plotted against the effective value of C_{ab}^*, which means the ΔC_{ab}^* from the average a^* and b^* of k=0 image as an origin. Results of "blue" and "red-green" images are indicated in Figure 4. Original and some of the test stimuli of "blue" are indicated in Figure 1. As shown in Figure 4, BCACI was obtained as the effective metric chroma C_{ab}^* where 50% of responses were achromatic color names by the fitting using sigmoid function. For both color images of "blue" and "red-green", BCACI of normal image ((a) and (b)) is larger than that of mosaicked image ((c) and (d)).

Figure 5 shows BCACI of all test images for normal and mosaicked images. Results of normal images indicate that BCACIs of various color images are in the same range around $C_{ab}^* = 7$ except "pink" and "purple" of which BCACIs are lower than those of others. Reason is unknown at the present. Results of mosaicked images show consistently lower BCACI than normal images except "purple" image. Average of BCACI for normal and mosaicked images are compared in Figure 6. No statistical difference was found between the two groups at the present, while it differed significantly without "pink" and "purple" with the significance level of 5%.

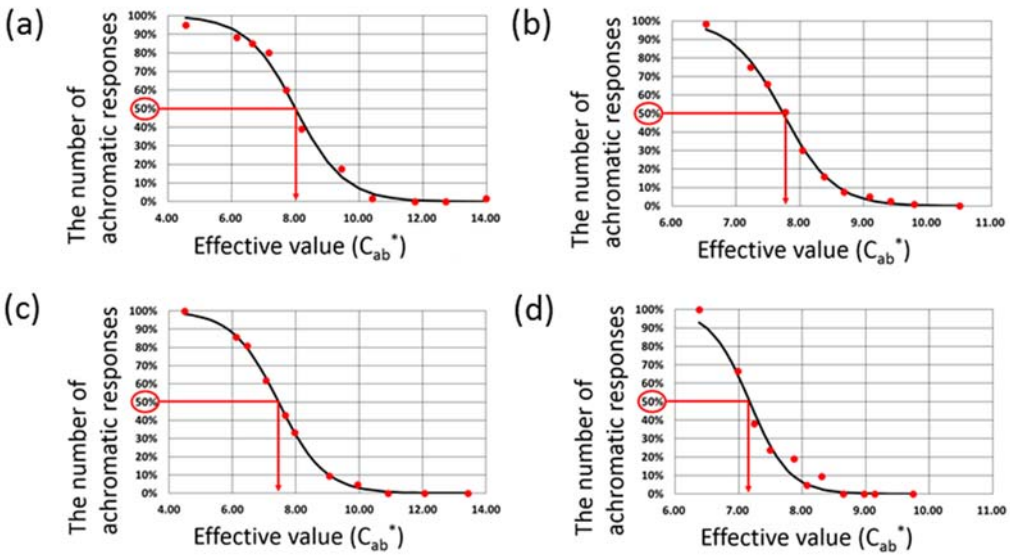

Figure 4 – Example of the achromatic responses and the curve fittings. Upper figures ((a) and (b)) are the results of "blue" and "red and green" for normal image, and lower figures ((c) and (d)) are the results of the same color images for mosaicked image.

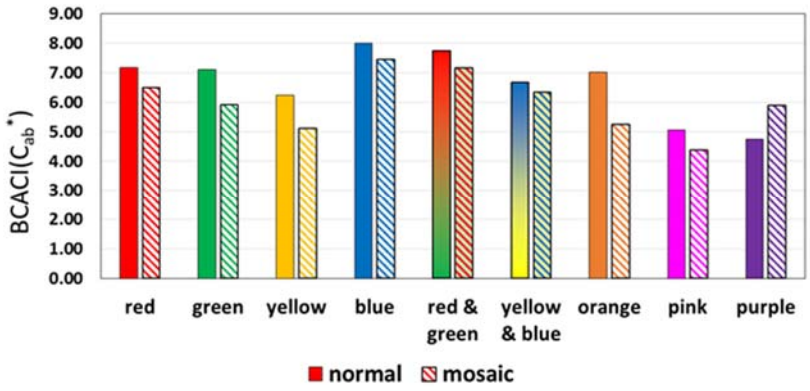

Figure 5 – Average BCACI of normal and mosaicked images for all test stimuli

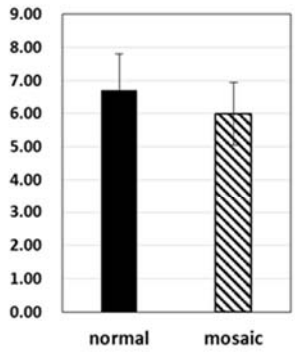

Figure 6 – Comparison of the BCACIs for normal and mosaicked images

4 Conclusion

In order to gather basic data in a research on psychological effect of saturation increase in digital images, BCACI, Border Chroma between Achromatic and Chromatic Impression, was measured for natural images (normal) and their shuffled-mosaic images (mosaicked). Threshold degree of chroma for various color images that gives observers “chromatic impression” was obtained. Our results of normal images indicate that when the metric chroma C_{ab}^* exceeds 7, observer’s perception of the whole image turns from achromatic to chromatic, except “pink” and “purple” images. BCACI of shuffled-mosaic images is lower than that of normal images. In mosaicked images, objects are dispersed and meaningless, although parts of contents are still visible. This lack of meaning and closeness to uniform color image might be the cause of lower BCACIs in mosaicked images. In the next step, relation between various KANSEI evaluation words and metric chroma is to be investigated.

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