

## A WORLDWIDE SURVEY METHOD FOR MEMORY COLORS

Kenta Kawada, Naokazu Aoki, Shoko Imaizumi and Hiroyuki Kobayashi\*

*Graduate School of Advanced Integration Science, Chiba University, Japan  
1-33 Yayoicho, Inage-ku, Chiba-shi, Chiba 263-8522, Japan*

\*Corresponding author: Hiroyuki Kobayashi, kobahiro@faculty.chiba-u.jp

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### ABSTRACT

This paper presents a novel method for conducting global surveys on memory color that allows the participants to conduct tests without limiting their research area and to make speedy measurements. We studied the preferred reproduction of memory colors using prints and displays, which limit the experimental location. In addition to smartphones, the use of which has been increasing, light-emission type media displays are less affected by ambient light than print materials. Moreover, it is easy to limit certain models. It was found that the difference in color reproduction among the same kinds of smartphones is slight without the use of a special color management. Therefore, we suggest a method for surveying memory color using the Internet and smartphones that is also suitable for global surveys. We also report the survey results after applying the proposed method in Japan and Thailand.

### INTRODUCTION

In color reproduction method, there is preferred color reproduction in addition to true color reproduction to the original. The preferred color is related to the color from the subject's memory, and tends to differ based on culture and environment. The reproduction of flesh color has been studied in the field of color photography. Bartleson used the Munsell color system to investigate memory color and preference judgments on ten types of familiar objects. The subjects' preferred color for complexion had the same chromaticity as the mean memory color for that particular flesh tone [1]. Suzuki studied the racial attributes of the subjects and found that Asians prefer more reddish flesh colors than Caucasians, while Caucasians prefer more yellowish flesh colors than Asians [2]. Nishiura conducted surveys on color preference in Japan and several other countries (USA, Germany, Sweden, Italy, and Brazil) by applying their "systematic arrangement method" and showed there are regional differences in color preference [3].

However, the numbers of subjects and communities used for the surveys have been limited in previous researches because specific displays or prints have been used.

Since high-performance mobile devices such as tablets or smartphones have been widely used in recent years, data can be collected from the general public at any location in the world using this method. Additionally, smartphones, which are of a light-emission type, are less affected by ambient light than prints, and it is easy to specify a particular model. Therefore, we minimized the individual differences in colors using a limited number of smartphone models, and kept the brightness of the smartphones constant, which allowed us to deduce the error range of the individual differences in colors for the same model based on the measurement results.

Accordingly, in this study, we aim to realize surveys on memory colors using perception data collected from an unspecified number of subjects from around the world. Specifically, we suggest a new method for conducting worldwide surveys on memory colors using the Internet and the smartphones of each individual subject, and analyzed the results after applying this method for flesh colors in Japan and Thailand.

## EXPERIMENT

### *Differences in colors among the same model of smartphones*

It is known that there are the differences in color for different smartphones based on the model or degradation. Further, owing to variations in display brightness, differences in user preference have been shown in most smartphones with the same properties. After making the brightness of each smartphone constant, the differences in color between the same models were thus measured, and the errors were estimated.

Smartphones: Seven iPhone4S and twelve iPhone5 models were used (a variety of elapse times and production dates)

Digital values of calibrated colors: white (255, 255, 255), gray (128, 128, 128), flesh (209, 157, 135), red (128, 0, 0), and yellow (128, 128, 0)

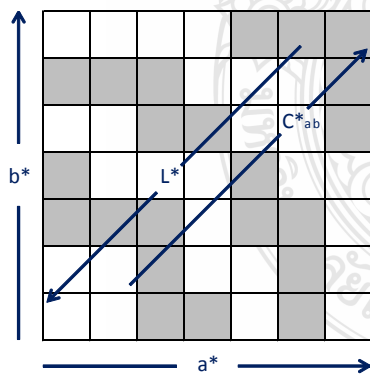
Viewing distance: about 150mm

Display brightness: 160 cd/m<sup>2</sup>

(The brightness sliders on the smartphones were adjusted to the middle position, and thus their relative brightness values were 50% in all ranges without automatic control.)

### *Evaluation based on Systematic Arrangement Method*

As a subjective evaluation method of the image, a paired comparison method and systematic category method are generally used. The newly developed "systematic arrangement method" of our laboratory[4] is suitable for evaluations, such as for preferred colors, in which subjective judgment is required; in addition, it can be evaluated easily by unskilled users, efficient image evaluation of a large number is a presentation method which can be performed. This method is characterized in placing varied systematically L\*a\*b\* three-dimensional to allow list on paper of one piece of two-dimensional. (Fig.1) For this experimental study, evaluation images of 49 (7×7) Mongolian (Japanese) and Caucasian faces were displayed as digital evaluation images on a smartphone. (Fig.2)



**Figure 1. Systematic arrangement method: arranging a\* on horizontal axis, b\* on a vertical axis and L\* on oblique axis in regular intervals**



**Figure 2. Evaluation flesh color "Mongolian (Japanese)" according to systematic arrangement method**

For an easy evaluation by unskilled observers, we used the "systematic arrangement method" when presenting the samples. Two presentation steps were carried out for the evaluation because each image appears reasonably well on a smaller display.

The subjects had to select the one image that they viewed as the most suitable flesh color for the woman shown in the 49 Mongolian (Japanese) and Caucasian images evaluated. The evaluation method is described below.

Observers: 50 Japanese and 49 Thai subjects (males and females in their teen years to their 60s)  
 Evaluation images: Flesh color for "Mongolian (Japanese)" and "Caucasian" faces  
 Content of the evaluation: Select the "image of skin color that I think worthy of this most women" from the nine images of Fig.3 were selected systematically from Fig.2. Next, Select the "image of skin color that I think worthy of this most women" from the nine images vicinity of the image was then selected at that time. The most preferable flesh color of image were determined that the subject selected in the end was the person's memory color.

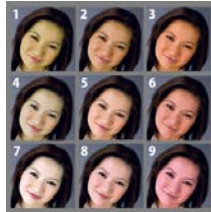


Figure 3. Flesh color evaluation of "Mongolian (Japanese)" face selected systematically from Fig.2 based on the systematic arrangement method

### RESULTS AND DISCUSSION

#### Differences in brightness among different smartphones

Figure 3 shows the results of colors displayed of different smartphones by converting the tristimulus values, X, Y, and Z, into CIE L\*, a\*, and b\* values, respectively. Table 1 shows the standard deviations of each L\*, a\*, and b\* value on an iPhone4S and iPhone5 as determined from Fig.3. From Tab.1, the L\*, a\*, and b\* error range of individual differences in colors for the same model was deduced as the average value of the standard deviation of five colors near the flesh color.

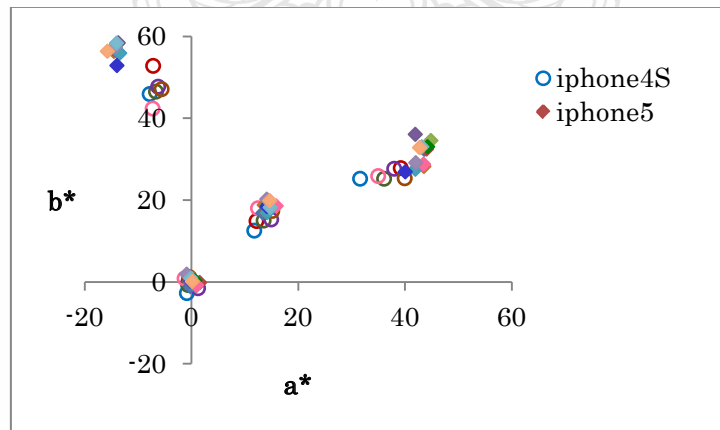


Figure 3. Measurements of the colors displayed on a smartphone

Table 1. Standard deviation of L\*, a\*, and b\* on an iPhone4S and iPhone5

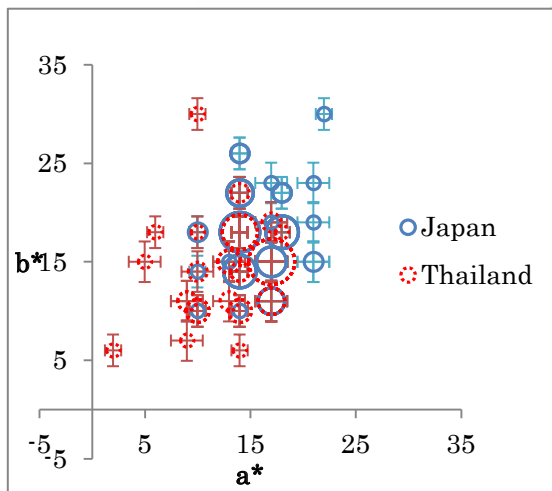
	iphone4S			iphone5		
Color	L*	a*	b*	L*	a*	b*
White	1.81	1.95	2.40	0.95	1.24	1.60
Gray	2.03	1.00	1.63	0.86	0.66	0.84
Flesh	1.71	1.39	1.83	0.89	0.64	1.06
Red	1.54	2.84	1.71	0.60	1.31	2.99
Yellow	2.10	0.80	3.09	0.83	0.57	1.78
Average	1.84	1.51	2.06	0.80	0.80	1.67

**Memory color of Mongolian (Japanese) flesh color**

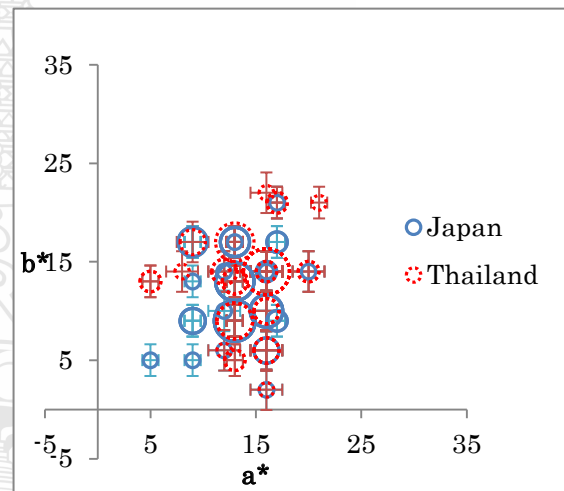
In consideration of and the color difference models and error range of individual differences of colors for the same model as based on the measurement results showed Memory color of Mongolian (Japanese) flesh color in Fig.4. The average flesh color was selected the most in both Japan and Thailand, while the flesh colors selected in Thailand tended to be lower in saturation than those selected in Japan. Although the previous study suggested that it tend to prefer the fair flesh color in Japan compared with USA, Germany, Sweden, Italy, Brazil, it tend to be prefer the fair flesh color in Thailand than ever in those country.

**Memory color of Caucasian flesh color**

Figure 5 shows the average flesh color that was selected the most in both Japan and Thailand. However, in contrast to the earlier, the flesh colors selected in Thailand tended to be higher in saturation than in Japan.



**Figure 4. Memory color of Mongolian (Japanese) flesh color**



**Figure 5. Memory color of Caucasian flesh color**

**SUMMARY**

We suggested a new method for conducting worldwide surveys on memory colors using the Internet and individual smartphones. Furthermore, we conducted actual surveys in Japan and Thailand using the proposed method, and found that the preferred flesh colors between Thailand and Japan tend to differ. It is believed that if we minutely examine the color data of small mobile devices such as smartphones, the proposed method can be effectively used for detailed analyses worldwide.

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