# A Comparative Study of Psychophysical Judgment of Color Reproductions on Mobile Displays between Europeans and Asians

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## ABSTRACT

The purpose of this study is to investigate the differences in the psychophysical judgment of mobile display color appearances between Europeans and Asians. A total of 50 participants, comprising 20 Europeans (9 French, 6 Swedish, 3 Norwegians, and 2 Germans) and 30 Asians (30 Koreans) participated in this experiment. A total of 18 display stimuli with different correlated color temperatures were presented, varying from 2,470 to 18,330 K. Each stimulus was viewed under 11 illuminants ranging from 2,530 to 19,760 K, while their illuminance was consistent around 500 lux. The subjects were asked to assess the optimal level of the display stimuli under different illuminants. In general, confirming the previous studies on color reproduction, we found a positive correlation in the correlated color temperatures between the illuminants and optimal displays. However, Europeans preferred a lower color temperature compared to Asians along the entire range of the illuminants. Two regression equations were derived to predict the optimal display color temperature ($y$) under varying illuminants ($x$) as follows: $y = \alpha + \beta * \log(x)$, where $\alpha = -8770.37$ and $\beta = 4279.29$ for European ($R^2 = 0.95$, $p < .05$), and $\alpha = -16076.35$ and $\beta = 6388.41$ for Asian ($R^2 = 0.85$, $p < .05$). The findings provide the theoretical basis from which manufacturers can take a cultural-sensitive approach to enhancing their products' appeal in the global markets.

**Keywords:** cross-cultural, cultural variability, color preference reproduction, chromatic adaptation, white point

## 1. INTRODUCTION

Mobile displays have been developed with much attention being paid to produce accurate colorimetric reproduction of images. Although the problems of color reproduction have been studied intensively, there still remains one problem; the reproduction of color preferred by users[1]. Given that the human visual system is the ultimate receiver of displayed colors, the success of mobile displays depends highly on the perception of end users. Affective image quality has to be seriously taken into account by focusing on the human visual characteristics and psychological perceptions. Research on the effects of color shows that color directly affects user preference[2,3] and hence purchasing behavior[4]. Moreover, an inappropriate choice of color may also lead products to strategic failure. Therefore, the ultimate goal of a display color reproduction might not always be accurately reproducing the same color, rather matching the idealized colors users perceive, known as color preference reproduction[5].

Especially, with the internationalization of markets and growing user demand in the emerging economies, a cultural-specific approach should be adopted when designing the color appearance on the display devices. The users' psychophysical judgment of colors is influenced by several factors such as age, sex, and geographical area of residence[6]. Although there have been numerous studies regarding the effects of age and sex differences, very few have focused on geographical areas, especially from a cross-cultural perspective. The literature in the public domain has a largely Western focus and the notion of color universality is fraught with risk[7]. Gao et al.[8] reported the cross-cultural differences in the affective emotions of color. The recent study by Ou et al.[9] found that color preferences are not identical across countries. A pan-cultural approach has often resulted in cultural faux pas, and herein it is argued that a cross-cultural perspective is imperative for display color reproduction.

Recently, Choi and Suk[10-12] investigated the color reproduction for mobile displays under varying ambient illuminants. One very significant finding in these studies was that the display color temperature has to be adjusted by taking into account the viewer's level of chromatic adaptation. Based on the assessments by Korean subjects, a positive correlation was observed between the illuminant color temperatures and the optimal display color temperatures. A regression equation was

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derived to predict the optimal color temperature adjustment under varying illuminants. However, because the subjects of the study were Koreans, the effect of cultural variability was not taken into account. In this regard, this study aims to derive a color temperature adjustment formula for mobile displays while focusing on the differences in color preferences between Europeans and Asians.

## 2. METHOD

For the visual examination, the stimuli were displayed on a smartphone with a 4.8 inch display. The smartphone had a Super AMOLED (active-matrix organic lighting-emitting diode) display, which has become one of the most promising display technologies with its large color gamut. When measured with a spectroradiometer (Konica Minolta CS-2000), the white point of the smartphone was 7,646 K in correlated color temperature. The examination was conducted in a room equipped with a LED luminous ceiling, as shown in Figure 1. A uniform illumination environment was realized in the room, ensuring that the participants fully adapted to the surrounding environment. The correlated color temperature and the illuminance of the ambient illuminant could be controlled by adjusting the *R*, *G*, *B* and *W* (White) input values. The subjects were seated in the center of the room and were instructed to observe the smartphone at a viewing distance about 30 cm (the distance of distinct vision). The experiment was conducted on a gray desk, and the survey sheets were printed on a gray paper. These specifics of the experiment, such as the setup of the room and the methodology in general, were identical to the previous studies conducted by Choi and Suk[10-12].

Figure 1. Room equipped with an LED luminous ceiling (Left: 2,531 K - 503 lux, Right: 19,760 K - 496 lux)

### 2.1 Display Stimuli

It has been acknowledged that one of the key points of the color management system (CMS) is color temperature adjustment, which is determined by the coordinates of the white point[13]. Therefore, this study was focused on the color temperature of white backgrounds under varying illuminant chromaticity. The stimuli were designed in black text against a nuanced white background in order to resemble the reproductions of an e-mail application. As shown in Figure 2, a total of 18 differently nuanced whites were produced, varying from 2,470 to 18,330 K in correlated color temperature, by adjusting the *R*, *G*, *B* values. The black body locus was carefully segmented in micro reciprocal degrees (MK-1) in order to achieve visual uniformity. The colorimetric values of the 18 display stimuli were measured in terms of luminosity (Lv), correlated color temperature (CCT), delta *uv*, and *x* and *y* values using a spectroradiometer, as listed in Table 1.

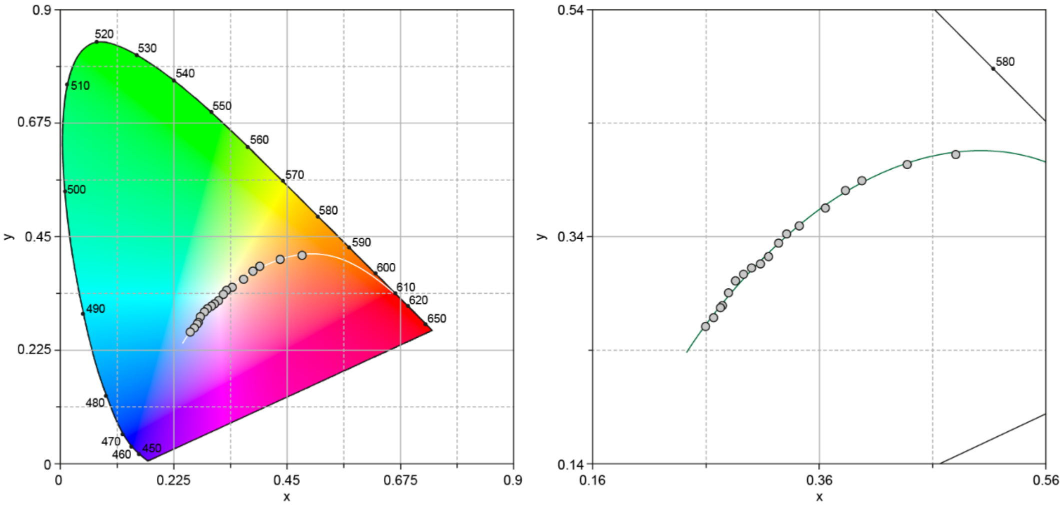


Figure 2. The 18 display stimuli for visual examination, varying from 2,470 to 18,330 K in terms of the correlated color temperature

Table 1. The luminance (Lv), correlated color temperature (CCT), delta *uv*, and *x* and *y* values of the 18 stimuli

| **No.** | **Lv (cd/m$^2$)** | **CCT (K)** | **delta *uv*** | ***x*** | ***y*** |
|---|---|---|---|---|---|
| 1 | 123.02 | 2,468 | 0.0007 | 0.4784 | 0.4113 |
| 2 | 138.56 | 3,011 | -0.0002 | 0.4357 | 0.4030 |
| 3 | 151.45 | 3,675 | 0.0010 | 0.3969 | 0.3887 |
| 4 | 156.89 | 3,975 | 0.0005 | 0.3819 | 0.3788 |
| 5 | 161.91 | 4,401 | -0.0009 | 0.3639 | 0.3640 |
| 6 | 169.83 | 5,150 | 0.0003 | 0.3410 | 0.3490 |
| 7 | 193.49 | 5,598 | 0.0007 | 0.3303 | 0.3405 |
| 8 | 197.64 | 5,952 | -0.0001 | 0.3230 | 0.3325 |
| 9 | 179.02 | 6,456 | -0.0015 | 0.3145 | 0.3216 |
| 10 | 182.64 | 6,984 | -0.0011 | 0.3069 | 0.3149 |
| 11 | 194.30 | 7,499 | 0.0006 | 0.3002 | 0.3112 |
| 12 | 198.87 | 8,151 | 0.0013 | 0.2933 | 0.3050 |
| 13 | 184.90 | 8,957 | 0.0023 | 0.2862 | 0.2989 |
| 14 | 175.53 | 10,199 | 0.0017 | 0.2789 | 0.2887 |
| 15 | 174.54 | 11,604 | -0.0012 | 0.2745 | 0.2777 |
| 16 | 155.84 | 12,215 | -0.0009 | 0.2722 | 0.2752 |
| 17 | 161.36 | 14,479 | -0.0008 | 0.2664 | 0.2671 |
| 18 | 152.77 | 18,331 | 0.0006 | 0.2596 | 0.2593 |

### 2.2 Ambient Illuminants

The ISO standard ISO 8995-1:2002(E) provides guidance on the illuminance recommended for general indoor areas[14]. It suggests 500 lux for the performance of visual tasks with medium concentration, such as reading, doing regular office work, and viewing computer screens; which is believed to conform to the situation for general usage of mobile devices. Therefore, the 11 ambient illuminants were produced that were chromatically different (2,530 to 19,760 K), while their illuminance was approximately 500 lux in all cases. Moreover, the display stimuli were also examined with the light turned off. In all, 12 illuminants were produced with the LED luminous ceiling. The colorimetric values were measured in terms of illuminance (Ev), correlated color temperature (CCT), delta *uv*, and *x* and *y* values using a chroma meter (Konica Minolta CL-200), as listed in Table 2. Moreover, the spectral distribution of the 11 illuminants (numbered from 1 to 11 in Table 2) was measured using a spectroradiometer (Figure 3).

Table 2. The illuminance (Ev), correlated color temperature (CCT), delta *uv*, and *x* and *y* values of the 12 illuminants

| No. | Ev (lux) | CCT (K) | delta *uv* | *x* | *y* |
|---|---|---|---|---|---|
| 1 | 503 | 2,531 | -0.0010 | 0.4700 | 0.4062 |
| 2 | 496 | 3,001 | 0.0006 | 0.4376 | 0.4056 |
| 3 | 503 | 3,953 | 0.0004 | 0.3829 | 0.3792 |
| 4 | 501 | 4,911 | 0.0010 | 0.3479 | 0.3559 |
| 5 | 505 | 6,037 | 0.0003 | 0.3214 | 0.3316 |
| 6 | 502 | 6,976 | 0.0008 | 0.3065 | 0.3181 |
| 7 | 504 | 8,003 | 0.0001 | 0.2952 | 0.3049 |
| 8 | 504 | 9,068 | 0.0000 | 0.2866 | 0.2950 |
| 9 | 496 | 9,969 | -0.0004 | 0.2813 | 0.2877 |
| 10 | 499 | 15,120 | -0.0007 | 0.2651 | 0.2654 |
| 11 | 496 | 19,760 | -0.0003 | 0.2590 | 0.2561 |
| 12 | 0 | 0 | 0 | 0 | 0 |

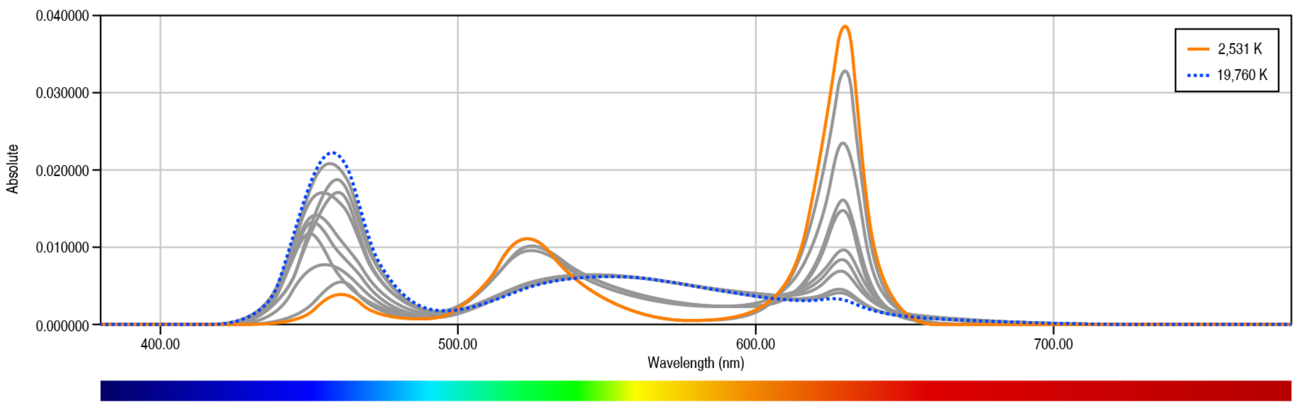


Figure 3. The spectral distribution of the *RGBW* LED lighting in the experiment room

### 2.3 Participants

This study involved a total of 50 participants, consisting of 9 French, 6 Swedish, 3 Norwegians, 2 Germans, and 30 Koreans. Their ages ranged from early to late adulthood, with an average age of 22.81 years with a standard deviation of 2.95 years.

The Korean participants were the only ones who were born and living in their native country. The French, Swedish, Norwegian, and German participants were also born in their native countries, but they have stayed in the Republic of Korea less than six months. All participants were tested for color deficiency using Ishihara's color vision test. No significant color deficiencies were observed.

### 2.4 Procedure

The participants were asked to assess 18 display stimuli under each illuminant in terms of their preferences using a five-point Likert scale ranging from -2 (least optimal) to +2 (most optimal). The visual assessment was based on the mental representation of the ideal white point of each participant, without any physical reference being presented. In total, 216 judgments were made in the experiment: 18 (display stimuli) × 12 (illuminants). The stimuli and illuminants were presented in a random order to eliminate any sequential effect on the subjects' evaluations. In each illuminant, the participants were asked to keep their eyes closed for 10 seconds, spending the other 10 seconds adapting their eyes by freely scanning the room. Participants began a series of 18 stimuli evaluations after the adaptation period. The 12 observing sessions usually lasted for approximately 30 minutes. The auto-brightness function of the smartphone was turned off throughout the experiment.

## 3. RESULT & DATA ANALYSIS

For analysis, the total scores of the 18 stimuli were averaged for each of the illuminants. The display stimuli with the highest average score for each illuminant were considered as the most optimal display color temperatures. The correlation coefficients were obtained from comparisons between each participant group. The results showed a reasonably high agreement among the French, Swedish, Norwegian, and German participant groups, with correlation coefficients ranging from 0.78 to 0.93 ($p < .05$). The responses obtained from the four groups were combined into one group (called "European") as they showed a close agreement in the responses, whereas the Korean participants were labeled as the "Asian" group. The intention of combining the four groups into one group was to create a dataset with higher reliability of scale values due to the larger number of participants involved. In all, a total of 20 Europeans and 30 Asians datasets were created for a comparative study of psychophysical judgment. It was found that the assessments under every illuminant fit a normal distribution in each cultural group (Kolmogorov-Smirnov test, $p > .05$). This indicates that the central tendency of judging optimal white had a peak that showed a high agreement in both groups.

### 3.1 European Participants

The average scores of the 20 European participants were calculated for each of the 11 illuminants, as listed in Table 3. The 11 illuminants had different color temperatures, while their illuminance was approximately 500 lux in all cases. The display color temperatures with the highest score for each illuminant are underlined, and were extracted as the most optimal display color temperature. As seen in Table 3, the color temperature of the illuminant varied from 2,530 to 19,760 K, while the display color temperatures perceived as the most optimal were fixed in range from 6,460 to 12,220 K. Within these bounds, the optimal display color temperature increased as the illuminant color temperature rose. In addition, the display color temperatures ranging from 5,950 to 10,200 K were generally preferred; these received positive scores across entire illuminants. Based on the optimal combination between the color temperature of the display and that of the illuminants, a regression analysis was performed. The derived formula predicts the optimal display color temperature ($T_d$) using the illuminant color temperatures ($T_i$) as the independent variables:

$$T_d = 4279.29 \log (T_i) - 8770.37 \quad (R^2 = 0.95,\ p < .05) \qquad (1)$$

Table 3. The accumulation of European participants' assessment of the optimal level for the 18 stimuli under the 11 illuminants (N = 20). The display color temperatures with the highest score for each illuminant are underlined.

| Display CCT (K) | Illuminant CCT (K) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2,531 | 3,001 | 3,953 | 4,911 | 6,037 | 6,976 | 8,003 | 9,068 | 9,969 | 15,120 | 19,760 |
| 2,468 | -1.65 | -1.75 | -1.85 | -1.80 | -1.80 | -1.95 | -1.85 | -1.70 | -1.85 | -1.90 | -1.70 |
| 3,011 | -0.90 | -1.55 | -1.35 | -1.40 | -1.75 | -1.65 | -1.65 | -1.75 | -1.65 | -1.55 | -1.75 |
| 3,675 | -0.65 | -1.00 | -1.10 | -1.15 | -1.40 | -1.40 | -1.40 | -1.45 | -1.45 | -1.40 | -1.60 |
| 3,975 | -0.40 | -0.60 | -0.65 | -0.80 | -1.10 | -1.10 | -1.20 | -1.20 | -1.20 | -1.00 | -1.00 |
| 4,401 | 0.00 | -0.40 | -0.20 | -0.45 | -0.55 | -0.60 | -0.85 | -1.00 | -0.60 | -0.75 | -0.65 |
| 5,150 | 0.45 | 0.10 | 0.25 | -0.10 | -0.25 | -0.35 | -0.85 | -0.65 | -0.75 | -0.55 | -0.65 |
| 5,598 | 0.80 | 0.50 | 0.45 | 0.15 | -0.10 | -0.10 | -0.50 | -0.35 | -0.25 | -0.05 | -0.45 |
| 5,952 | 1.55 | 0.90 | 0.75 | 0.85 | 0.80 | 0.30 | 0.20 | 0.20 | 0.60 | 0.40 | 0.40 |
| 6,456 | 1.35 | 1.45 | 1.45 | 1.00 | 1.10 | 1.00 | 0.80 | 0.80 | 0.65 | 0.90 | 0.40 |
| 6,984 | 1.20 | 1.10 | 1.20 | 1.35 | 1.20 | 1.20 | 1.30 | 1.30 | 0.90 | 0.75 | 0.25 |
| 7,499 | 0.85 | 1.15 | 1.10 | 1.25 | 1.40 | 1.40 | 1.40 | 1.30 | 1.20 | 0.75 | 0.65 |
| 8,151 | 0.95 | 1.00 | 1.05 | 0.50 | 0.75 | 1.00 | 0.80 | 1.45 | 1.30 | 1.00 | 0.60 |
| 8,957 | 0.65 | 0.75 | 0.55 | 0.45 | 0.40 | 0.95 | 0.95 | 1.35 | 0.85 | 1.30 | 0.80 |
| 10,199 | -0.05 | 0.45 | 0.05 | 0.00 | 0.30 | 0.20 | 0.20 | 0.50 | 0.75 | 0.55 | 1.10 |
| 11,604 | 0.45 | 0.15 | 0.15 | -0.35 | -0.05 | 0.85 | 0.20 | 0.95 | 0.30 | 0.75 | 0.55 |
| 12,215 | 0.55 | 0.30 | 0.00 | -0.15 | 0.20 | 0.55 | 0.35 | 0.80 | 0.95 | 0.95 | 0.85 |
| 14,479 | -0.55 | -0.35 | -0.55 | -0.45 | -0.10 | 0.00 | -0.40 | -0.05 | 0.70 | 0.55 | 0.35 |
| 18,331 | -0.65 | -0.60 | -0.75 | -0.90 | -0.55 | 0.25 | -0.10 | -0.20 | -0.40 | -0.05 | 0.05 |

### 3.2 Asian Participants

The average scores of the 30 Asian participants were calculated, as listed in Table 4. The result indicates that the optimal color temperatures of a display ranged from 6,460 to 12,220 K, while the illuminant color temperatures varied from 2,530 to 19,760 K. Within this boundary, a positive correlation is observed; the optimal display color temperature increases as the illuminant color temperature increases. Furthermore, the display color temperatures ranging from 6,460 to 12,220 K generally received positive scores for every illuminant. A regression equation was derived to predict the optimal display color temperature ($T_d$) under varying illuminants ($T_i$) as follows:

$$T_d = 6388.41 \log (T_i) - 16076.35 \quad (R^2 = 0.85, p < .05) \qquad (2)$$

Table 4. The accumulation of Asian participants' assessment of the optimal level for the 18 stimuli under the 11 illuminants (N = 30). The display color temperatures with the highest score for each illuminant are underlined.

| Display CCT (K) | Illuminant CCT (K) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2,531** | **3,001** | **3,953** | **4,911** | **6,037** | **6,976** | **8,003** | **9,068** | **9,969** | **15,120** | **19,760** |
| 2,468 | -1.33 | -1.20 | -1.63 | -1.87 | -1.63 | -1.80 | -1.87 | -1.93 | -1.80 | -1.90 | -1.83 |
| 3,011 | -0.67 | -0.67 | -1.07 | -1.47 | -1.33 | -1.43 | -1.60 | -1.53 | -1.73 | -1.57 | -1.60 |
| 3,675 | -0.40 | -0.47 | -0.70 | -0.77 | -1.17 | -1.33 | -1.40 | -1.33 | -1.43 | -1.37 | -1.33 |
| 3,975 | -0.33 | -0.10 | -0.53 | -0.87 | -0.73 | -0.87 | -0.93 | -1.07 | -0.97 | -0.93 | -0.90 |
| 4,401 | -0.03 | 0.20 | 0.13 | -0.37 | -0.47 | -0.63 | -0.90 | -1.07 | -0.93 | -0.93 | -0.63 |
| 5,150 | 0.23 | 0.27 | 0.23 | -0.27 | -0.23 | -0.33 | -0.63 | -0.80 | -0.67 | -0.77 | -0.50 |
| 5,598 | 0.33 | 0.47 | 0.17 | 0.07 | 0.07 | -0.13 | -0.47 | -0.43 | -0.37 | -0.50 | -0.23 |
| 5,952 | 0.87 | 0.63 | 0.70 | 1.03 | 0.67 | 0.03 | 0.00 | -0.20 | -0.13 | -0.23 | -0.17 |
| 6,456 | 1.33 | 1.13 | 1.23 | 1.10 | 0.80 | 0.90 | 0.90 | 0.40 | 0.53 | 0.67 | 0.57 |
| 6,984 | 1.17 | 1.40 | 1.47 | 1.33 | 1.07 | 0.97 | 0.97 | 0.63 | 0.77 | 0.43 | 0.57 |
| 7,499 | 1.13 | 1.23 | 1.23 | 1.13 | 1.30 | 1.33 | 1.07 | 1.10 | 0.77 | 0.73 | 0.80 |
| 8,151 | 0.97 | 0.90 | 0.97 | 0.53 | 0.63 | 1.10 | 1.37 | 1.17 | 0.73 | 0.80 | 0.80 |
| 8,957 | 0.67 | 0.73 | 0.63 | 0.73 | 0.67 | 1.03 | 1.17 | 1.43 | 1.30 | 0.90 | 0.97 |
| 10,199 | 0.23 | 0.50 | -0.33 | 0.43 | 0.47 | 1.00 | 1.00 | 0.80 | 1.03 | 1.13 | 0.73 |
| 11,604 | 0.40 | 0.43 | 0.07 | 0.00 | 0.50 | 0.77 | 0.90 | 0.87 | 1.00 | 1.37 | 1.27 |
| 12,215 | 0.50 | 0.30 | -0.07 | 0.10 | 0.47 | 0.73 | 0.93 | 0.87 | 0.93 | 1.27 | 1.37 |
| 14,479 | -0.17 | -0.10 | -0.83 | -0.50 | 0.03 | 0.00 | 0.30 | 0.20 | 0.47 | 0.80 | 0.83 |
| 18,331 | -0.63 | -0.67 | -1.17 | -0.83 | -0.33 | -0.17 | -0.07 | 0.27 | -0.03 | 0.43 | 0.67 |

### 3.3 Comparison of the Color Preference

In both cultural groups, it was found that the illuminant color temperature and the optimal display color temperature are positively correlated, which is in good agreement with previous studies[10-12]. However, when the light was turned off (0 lux), the optimal display color temperatures were 5,950 K in the European group and 7,500 K in the Asian group. It is interesting to note that the Europeans preferred a lower color temperature compared to the common standard white point D65 (6,550 K, $x$ = 0.313, $y$ = 0.329), while the Asians preferred a higher color temperature. In Figure 4, two different color adjustment formulas (1) and (2), which could predict the optimal display color temperatures under an illuminant with 500 lux illuminance, are plotted against each other. Equation (1) was derived from the European participants' data, while Equation (2) was derived from the Asian participants' responses. The regression curve fitted for the Europeans lay below the curve fitted for the Asians. An independent samples t-test was performed between each of the coefficient values in order to verify if the errors between the two equations were significantly different. As listed in Table 5, the Europeans preferred a lower color temperature compared to the Asians along the entire range of the illuminants.

Table 5. Independent Samples t-test between equations (1) and (2)

| Coefficients | Equation (1) | Equation (2) | Significance |
|---|---|---|---|
| log ($T_i$) | 5930.73 | 4051.19 | $t(20) = 2.23, p < .05$ |
| constant | -14398.55 | -7926.53 | $t(20) = 2.01, p < .05$ |

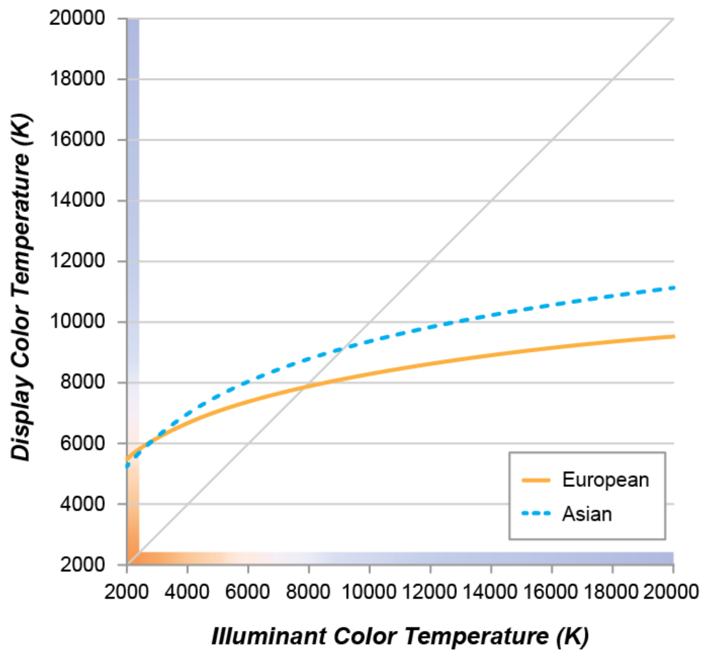


Figure 4. The optimal display color temperatures plotted against the illuminant color temperatures for the Europeans (solid line) and the Asians (dashed line)

## 4. GENERAL DISCUSSION

The differences in the psychophysical judgment of mobile display color appearances between Europeans and Asians were investigated in this study. The study reveals that the display color temperature perceived to be ideal increases as the illuminant color temperature rises; however, the Europeans preferred a lower color temperature compared to the Asians under entire range of the illuminants. Moreover, the optimal display color temperatures were 5,950 K in the European group and 7,500 K in the Asian group when the light was turned off, so there was no effect of illuminant chromaticity. It is interesting to note that the optimal display color temperature for the Europeans is slightly shifted towards a lower color temperature compared to the common standard white point D65, while the Asians preferred a higher color temperature.

A number of white point standards have been defined depending on the industries and countries[15]. The U.S. broadcasting standard (NTSC), the European Broadcasting Union (EBU) primaries, and the international standard for digital high-definition television (ITU-R BT.709) use white point D65 (6500 K) as the reference[16]. On the other hand, D93 (9300 K) is the broadcast standard color temperature for video in Japan, Korea, China, and other Asian countries[17]. This is significantly above the D65 standard for North and South America and Europe. The study observed such differences in color preferences between Europeans and Asians; however, the responses obtained from the French, Swedish, Norwegian, and German participants were combined into one group, and the Asian group was comprised of only Korean participants due to practical limitations. As such, more in-depth studies would be worthwhile to investigate the effect of geographical areas in more detail, especially from a cross-cultural perspective.

## 5. CONCLUSION

With the internationalization of markets and growing user demand in the emerging economies, a cultural-specific approach should be adopted when designing the color appearance on the display devices. A pan-cultural approach has often resulted in cultural faux pas, and herein it is argued that a cross-cultural perspective is imperative for display color reproduction.

Therefore, this research was aimed to investigate the differences in display color preferences among Europeans and Asians. Based on evaluations by 20 Europeans and 30 Asians under 11 illuminants, two color temperature adjustment formulas were derived that could predict the optimal display color temperatures under varying illuminant chromaticity: $y = \alpha + \beta*\log(x)$, where $\alpha$ = -8770.37 and $\beta$ = 4279.29 for European ($R^2$ = 0.95, $p < .05$), and $\alpha$ = -16076.35 and $\beta$ = 6388.41 for Asian ($R^2$ = 0.85, p < .05). Although further research should be conducted to increase the validity of these experimental results, it would not hurt for designers and manufacturers to take these findings into consideration when designing a color strategy for mobile display devices. A culture-sensitive approach in display color reproduction and its strategic use will enhance product value and develop a competitive advantage in the emerging markets.

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