EFFECTS OF LIGHTING COLOR TEMPERATURE ON CUSTOMERS' PREFERENCE FOR CRAFT PRODUCT

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Abstract - This study discusses the influence of the color temperature of LED light source and the craft product type on subject's visual image and preference. The study enrolled 120 subjects in the experiment. Each of them randomly watched 9 experimental conditions containing three color temperatures (2700°K, 3100°K, and 6000°K) matched with three craft products (wooden stationery, jade product, and ceramic cup) and then filled in the visual image and preference questionnaires. The results show that the color temperature of 2700°K is more suitable for wood products, and compared to other color temperatures, it is more likely to give noble, fresh, warm, sensual, elegant, and natural feelings and have a high preference. Moreover, 3100°K is more suitable for ceramic, while 6000°K is more suitable for jade products. The research suggests that products with different craft material should use different color temperatures for lighting in order to make the viewers have a positive feeling and high preference.

Index Terms - Color temperature, visual image, craft product, preference.

I. INTRODUCTION

With better luminous efficiency and energy saving features compared to traditional lights, Light-Emitting Diode (LED) in recent years has gradually replaced incandescent light bulbs and fluorescent lamps and thus become the mainstream of next-generation lighting. In addition to its small size, low power consumption, high efficiency, fast reaction time, long product life, and zero mercury content, LED has a lighting mode different from traditional light sources. Moreover, scholars have engaged in studying the differences in lighting effects between LED and incandescent or fluorescent lights. Many years ago, Kruithof [1] proposed a combination of illumination and color temperature in a human comfort zone. To put simply, in order to create a comfortable lighting environment, as the color temperature increases, the illumination also increases. If a low color temperature-high illumination or a high color temperature-low illumination combination is adopted, then it will make people feel uncomfortable. However, Kruithof's experiments used fluorescent lamps. Viénot, Durand [2] applied the LED light source and referred to the Kruithof comfort curve to conduct the correctness test, visual performance test, performance reading, color choice test, and other operations as well as to assess subjective feelings under 9 lighting conditions combining 3 different illumination intensities (150lx, 300lx, 600lx) and color temperatures (2700°K, 4000°K, 6500°K). The experimental results show that the low color temperature is still judged within the comfort range even under high illumination; under a high illumination, when a high color rendering light source (Ra> 90) is used, there is no evidence showing that the high color temperature will make people feel more comfortable than the low color temperature, which is different from Kruithof's research. It can be seen that with the development of LED, the impacts of various operations are different from the past.

As people's lighting demands are gradually satisfied, lighting effects on exhibition objects now also become critical, such as fruits, vegetables, and fresh meats in supermarkets; pictures and sculptures in museums and art galleries; gold and jewelry in boutiques, and so on. Due to a wide range of exhibition objects, the appropriate light source and lamps should be selected for individual needs to fully demonstrate the characteristics. Chia [3] compared the color difference of 12 LEDs on a gold plate and found that the LED with an average color rendering coefficient of 92.5, a color temperature of 3187°K, and a dominant wavelength of 580nm produced the least color difference; the LED with the average color rendering coefficient of 49.5, a color temperature of 3437°K, and a dominant wavelength of 580nm produced the largest color difference, indicating that the color rendering property will cause color differences on the gold surface. Chang, Chen [4] noted that subjects thought that 6500°K had a better surface color and preferred less the illumination effect below 5000°K. Szabó, Kéri [4] presented three types of LED light sources for fabrics, vegetables, fruits, meat, bread, and other food products respectively and concluded which lighting the subjects preferred through comparisons. The results indicated that the subjects preferred the illumination effect of a light source with a higher color saturation. Shih [6] explored the impacts of light color temperature, illumination, and rendering on consumer choice of fruits. The results showed that in a lighting combination with the highest purchasing willingness, the lighting with a color temperature of 4000°K and an average color rendering index of 70 was better for both fruits, and the illumination of 750lx was better for guava, but a higher illumination of 1500lx should be used to maximize the purchasing willingness of people on apples, while the color rendering of the light source

affected the evaluation of freshness. Based on the above results, it can be seen that for an article's exhibition lighting, sufficient illumination should be selected first. The selection of color temperature should be adjusted according to the characteristics of the article. The most important factor is the color rendering of the light source, which affects the viewer's perception of the article's color and thus affects preferences and satisfaction.

From the literature over the years, we can see that lighting affects people's cognition, emotion, and behavior. High color rendering, high color temperature, and high illumination help to see an object's details and color clearly, but at the same time the lighting conditions make people nervous and under pressure, resulting in increased blood pressure and sympathetic nerve excitement and other physiological phenomena. Therefore, a balance point should be reached between lighting functionality and emotionality. Different from workplace lighting or living environment lighting, exhibition lighting is both a technology and an art. It not only needs viewers to see the details of the exhibition objects, but also needs the viewers to feel the beauty and texture of the exhibition objects, which makes it a combination of functional and emotional lighting. In addition, the traditional light source and the LED light source produce different effects. Regarding the combination of the illumination light sources that enables the viewer to see details of the object and generate more appropriate emotions, which in turn leads to higher evaluation, this study discusses the influence of the color temperature of LED light source and the product type on viewer's visual image and then summarizes suitable combinations of color temperature and product.

II. METHODS

A. Subjects

One hundred and twenty university students (47 male and 73 female) participated in the experiment. The mean age of male participants was 26.8 (SD = 10.6) years. The mean age of female participants was 23.9 (SD = 6.7) years.

B. Experimental design

The independent variables in this study include the color temperature of light source and craft product type. Table 1 lists the light source specifications, which are common LEDs in the market. The craft product samples used in this study include a wooden stationery, a jade product, and a ceramic cup. Figure 1 shows the conditions of these three samples under three color temperature lighting conditions.

The variable measured in this study is the subjective feeling questionnaire. The basic data in the first part contain gender, age, highest education, etc.; the second part is the opposite adjective group of the visual image, representing two extremely different feelings, including "cheap-noble", "cool-dull", "gorgeous-simple", "warm-cold", "sensible-sensual", "elegant-rough", and "natural-mechanical", and the judgment scale is divided into five levels (1 point indicates that the visual image is the most inclined to the adjective on the left, 3 points mean that the visual image is in the middle, and 5 points mean the visual image is the most inclined to the adjective on the right); the third part includes an inquiry about the preference of the subjects for the lighting color and the samples under this lighting color. The judgment scale ranges from strongly dislike to strongly like and is divided into five levels, 1 point indicating strongly dislike, 3 points indicating normal, and 5 points indicating strongly like.

Table 1. LED light source specifications used in this study

Color temperature (°K)	2700	3100	6000
Brand (or manufacturer)	FEIT	OSRAM	Tai Ming Green Energy Group
Watts (W)	5	4	4
Color rendering (Ra%)	80	80	80
Lumen (lm)	420	200	300

		
Wooden stationery+2700°K	Wooden stationery+3100°K	Wooden stationery+6000°K

 Jadeproducts+2700°K	 Jade products+3100°K	 Jade products+6000°K
 Ceramiccups+2700°K	 Ceramic cups+3100°K	 Ceramic cups+6000°K

Fig. 1.9 experimental conditions in this study

C. Experiment procedure

Before the experiment, the researcher explained the purpose and procedure to the subjects. After that, one of the experimental samples was placed on a black poster and then illuminated with one of experimental LED spotlights. In order to avoid too large a difference of illumination under different color temperatures, the sample illumination was measured by a digital illuminometer (TENMARS LUX/FC LIGHT METER model TM-205) under 2700°K, 3100°K, and 6000°K in the sequence of 420lx, 555lx, and 524lx. The subjects watched the experimental condition 10 seconds and then were asked to fill in the subjective questionnaire. The 9 experimental combinations were randomized for each subject and completed within 15 minutes.

IV. RESULTS

Table 2 presents the results of descriptive statistics and ANOVA analysis in this study. ANOVA analysis results show that the visual image adjectives that are significantly affected by the color temperature of the light source include "warm-cold", "sensible-sensual", "elegant-rough", and "natural-mechanical" ($p<.05$). "light color preference" and "sample preference" are also significantly affected by the color temperature of the light source ($p<.001$). Furthermore, from the perspective of Duncan grouping results, 2700°K and 3100°K belong to the same group in "warm-cold", "sensible-sensual", and "natural-mechanical", while 6000°K belongs to the other group. It can be known from the matching mean results that compared to 6000°K, 2700°K and 3100°K both give people feelings inclined to "warm", "sensual", and "natural", while 6000°K gives people feelings inclined to "cold", "sensible", and "mechanical". In addition, 2700°K and 6000°K belong to the group with higher scores in "elegant-rough", while 3100°K belongs to the group with lower scores, indicating that the "elegant" feeling produced by 3100°K is higher than that of 2700°K or 6000°K. In the aspects of "light color preference" and "sample preference", 2700°K and 3100°K belongs to the group with the highest score, followed by 6000°K, indicating that the subjects like the lighting condition under 3100°K, enhancing the sample preference.

The craft product type has a significant difference in six adjective groups and two preferences ($p<.001$). Specifically, the feeling of wooden stationery is inclined to "warm", "sensual", and "natural"; the feeling of jade product is inclined to "dull", "simple", "cold", "sensible", and "natural"; the feeling of ceramic cup is inclined to "cool", "cold", and "sensible". Wooden stationery has the highest "preference", followed by jade product and ceramic cup.

The interaction between the color temperature of light source and craft product type has a significant effect on all measurement variables ($p<.001$). In the "cheap-noble" aspect, 6000°K inclines to a cheap feeling in wooden stationery, but a noble feeling in jade product; conversely, 2700°K inclines to a noble feeling in jade product; the feelings of 2700°K are similar to those of 3100°K and incline to a cool feeling in wooden stationery, but a dull feeling in jade product. In the "gorgeous-simple" aspect, 6000°K inclines to a simple feeling in wooden stationery, but a gorgeous feeling in jade products; 2700°K and 3100°K incline to a simple feeling in jade products, but a gorgeous feeling in wooden stationery. In the "warm-cold" aspect, the three products incline to a cold feeling at 6000°K, but a warm feeling at 2700°K and 3100°K. The warm feeling of wooden stationery is especially more intense. The trend of "sensible-sensual" is similar to that of "warm-cold", and the three products incline to a sensible feeling at 6000°K, but a sensual feeling at 2700°K and 3100°K. The sensual feeling of wooden stationery is especially more intense. In the "elegant-rough" aspect, 6000°K inclines to a rough feeling in wooden stationery, but a elegant feeling in jade products; 2700°K and 3100°K incline to a rough feeling in jade products, but an elegant feeling in wooden stationery. In the "natural-mechanical" aspect, 6000°K inclines to a natural feeling in jade products; the feelings of 2700°K are similar to those of 3100°K and incline to a natural feeling in wooden stationery, but a mechanical feeling in jade products. In the "light color preference" and "sample preference" aspects, 6000°K has the highest preference in jade products and the lowest in wooden stationery; the trend of

2700°K is similar to that of 3100°K, but runs contrary to that of 6000°K, and it has the highest preference in wooden stationery and the lowest in jade products.

It is known that the color temperature of 2700°K is more suitable for wooden crafts, is more likely to give noble, fresh, warm, sensual, elegant, and natural feelings compared with other color temperatures, and has a high preference; 3100°K is more suitable for ceramic products, which more easily shapes a noble feeling and enhances the preference versus other color temperatures; and 6000°K is more suitable for jade products, making people feel more noble, fresh, gorgeous, and elegant than any other color temperature and have a higher preference.

Table 2. Descriptive statistics and variance analysis results *p<.05, **p<.01, ***p<.001.a,b,c: Duncan grouping result.Preference: 1 represents strongly dislike, 5 represents strongly like.

		LED Color temperature			Craft product		
		2700°K	3100°K	6000°K	Wooden stationery	Jade product	Ceramic cup
Visual image adjectives (score)	Cheap (1)-noble(5)	3.13	3.24	3.08	**3.24^{b}**	**3.14^{ab}**	**3.06^{a}**
	Cool (1)-dull (5)	2.93	2.86	2.93	**2.89^{ab}**	**3.03^{b}**	**2.80^{a}**
	Gorgeous (1)-simple (5)	3.26	3.14	3.14	3.21	3.16	3.16
	Warm (1)-cold (5)	**2.68^{a}**	**2.81^{a}**	**3.88^{b}**	**2.81^{a}**	**3.32^{b}**	**3.24^{b}**
	Sensible (1)-sensual (5)	**3.28^{b}**	**3.19^{b}**	**2.33^{a}**	**3.13^{b}**	**2.78^{a}**	**2.89^{a}**
	Elegant (1)-rough(5)	**2.80^{b}**	**2.65^{a}**	**2.84^{b}**	**2.65^{a}**	**2.80^{b}**	**2.84^{b}**
	Natural (1)-mechanical (5)	**2.68^{a}**	**2.69^{a}**	**3.34^{b}**	**2.71^{a}**	**2.94^{b}**	**3.06^{b}**
Preference	Light color	**3.14^{b}**	**3.24^{b}**	**2.85^{a}**	**3.22^{b}**	**3.03^{a}**	**2.98^{a}**
	Sample	**3.16^{b}**	**3.26^{b}**	**2.91^{a}**	**3.26^{b}**	**3.03^{a}**	**3.03^{a}**

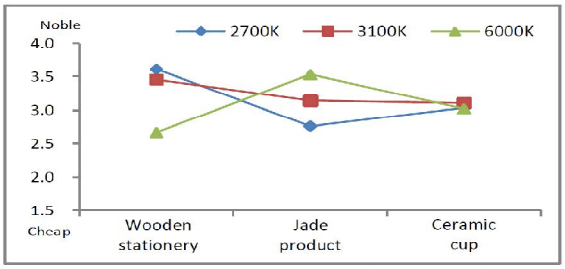


Fig. 2. The interaction between color temperature and craft product on the "cheap-noble"

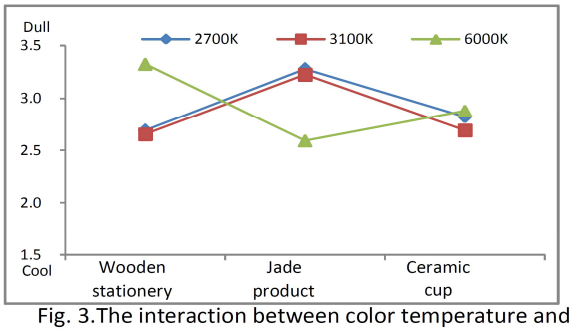


Fig. 3.The interaction between color temperature and craft product on the "cool-dull"

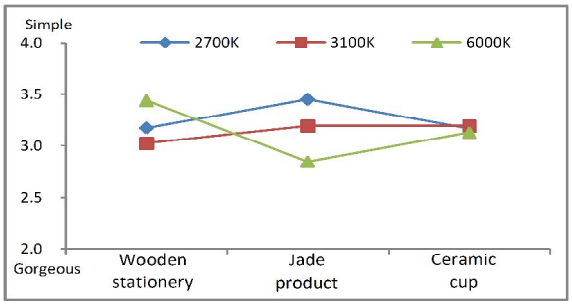


Fig. 4.The interaction between color temperature and craft product on the "gorgeous-simple"

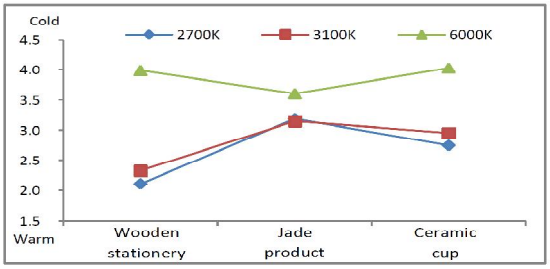


Fig. 5. The interaction between color temperature and craft product on the "warm-cold"

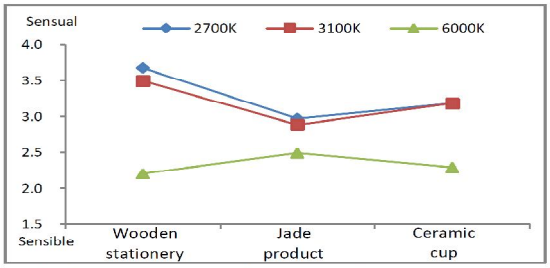


Fig. 6. The interaction between color temperature and craft product on the "sensible-sensual"

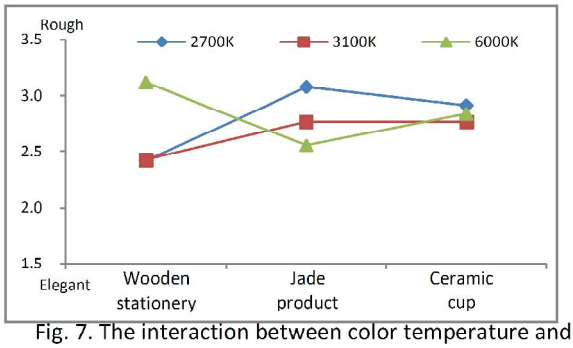


Fig. 7. The interaction between color temperature and craft product on the "elegant-rough"

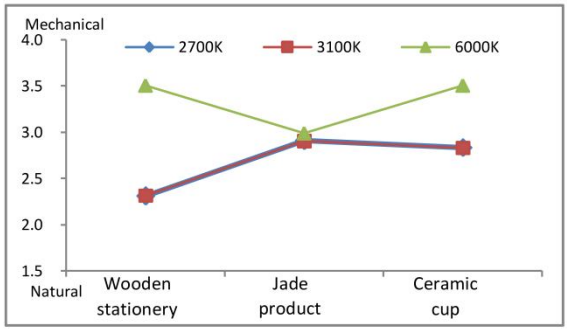


Fig. 8. The interaction between color temperature and craft product on the "natural-mechanical"

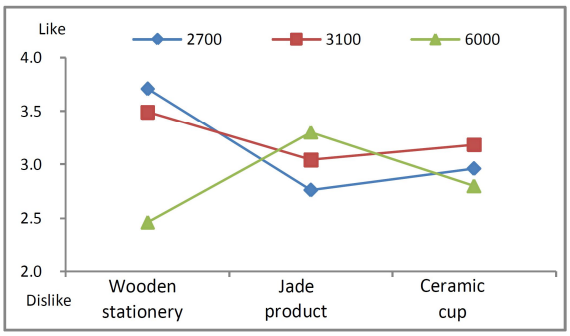


Fig. 9. The interaction between color temperature and craft product on the "light color preference"

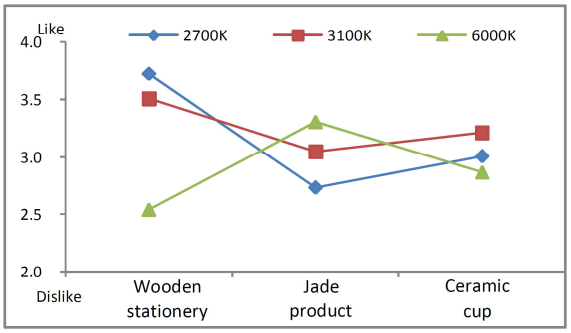


Fig. 10. The interaction between color temperature and craft product on the "sample preference"

CONCLUSION

This study used three different materials as samples to investigate the effects of three light color temperatures on the visual images and preference of viewers. The results show that, the visual image adjectives that are significantly affected by thecolor temperature of the light source include "warm-cold", "sensible-sensual", "elegant-rough", and "natural-mechanical", "light color preference" and "sample preference". Except for the "gorgeous-simple" item that is not significantly different, the remaining items are significantly affected by the product category and the interaction between color temperature of light source and product type has a significant impact on all the items. This study suggests that products of different materials should be used with different color temperature lighting in order to give the viewer a positive emotional experience and high preference.

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