

A Comparison between Fluorescent Lamp and LED on the Preference of Indoor Illuminance and Color Temperature: Scale Model Experiments Assuming Living Rooms

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ABSTRACT

Illuminance and color temperature are widely recognized as important factors in interior lighting. Luminance and preferred color temperature are known to be related each other, since Kruithof showed the comfortable illuminance zone related to the color temperature of light sources. Other research papers, such as Nakamura et al. showed the Kruithof's curve is not always useful. In a previous research, we found that the preferred combinations of illuminance and color temperature under RGB (Red, Green and Blue) fluorescent lighting in residential spaces vary according to activities. However, combinations of illuminance and color temperature are expected to be controlled more frequently with RGB LED today.

This paper aims to find the preferred combinations of illuminance and color temperature under RGB LED lighting in living rooms and to compare them with those found in the previous research under RGB fluorescent lighting.

As a result, although the color rendering indices under RGB LED lighting were significantly lower than RGB fluorescent lighting, preferred combinations of illuminance and color temperature found were very similar to those under RGB fluorescent lighting.

Keywords : RGB LED, RGB fluorescent lamp, Preference, Illuminance, Color temperature, Color rendering, Interior lighting

1. INTRODUCTION

Illuminance and color temperature are widely recognized as important factors in interior lighting. Luminance and preferred color temperature are known to be related each

other, since Kruithof¹⁾ showed the comfortable illuminance zone related to the color temperature of light sources. Other research papers, such as Nakamura et al^{2) 3)}, showed the Kruithof's curve is not always useful. In a previous research⁴⁾, we found that the preferred combinations of illuminance and color temperature under RGB (Red, Green and Blue) fluorescent lighting in residential spaces vary according to activities. However, combinations of illuminance and color temperature are expected to be controlled more frequently with RGB LED today.

This paper aims to find the preferred combinations of illuminance and color temperature under RGB LED lighting in living rooms and to compare them with those found in the previous research⁴⁾ under RGB fluorescent lighting.

2. METHODS

2.1 Experimental Conditions

Subjective experiments were carried out using 1:10 scale models (420mm x 420mm x 240mm) illuminated by RGB LEDs from their ceilings with the dimmer (Fig. 1). 20 combinations which consist of 5 illuminances (50lx, 100lx, 200lx, 400lx, 800lx) and 5 color temperatures (3000K, 3500K, 4200K, 5000K, 6500K) were investigated.



Fig. 1. Interior view of the scale model



Fig. 2. View of the RGB LED system



Fig. 3. View of LED units

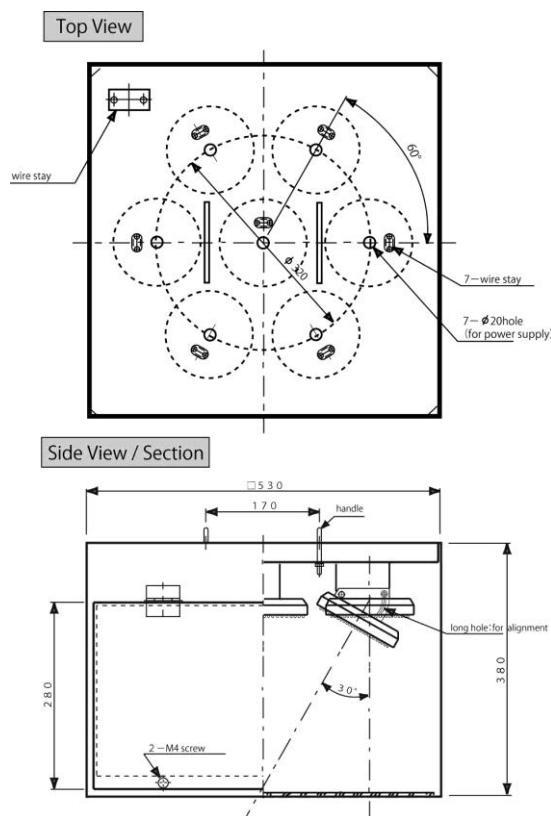


Fig. 4. Top/side views and section of LED box

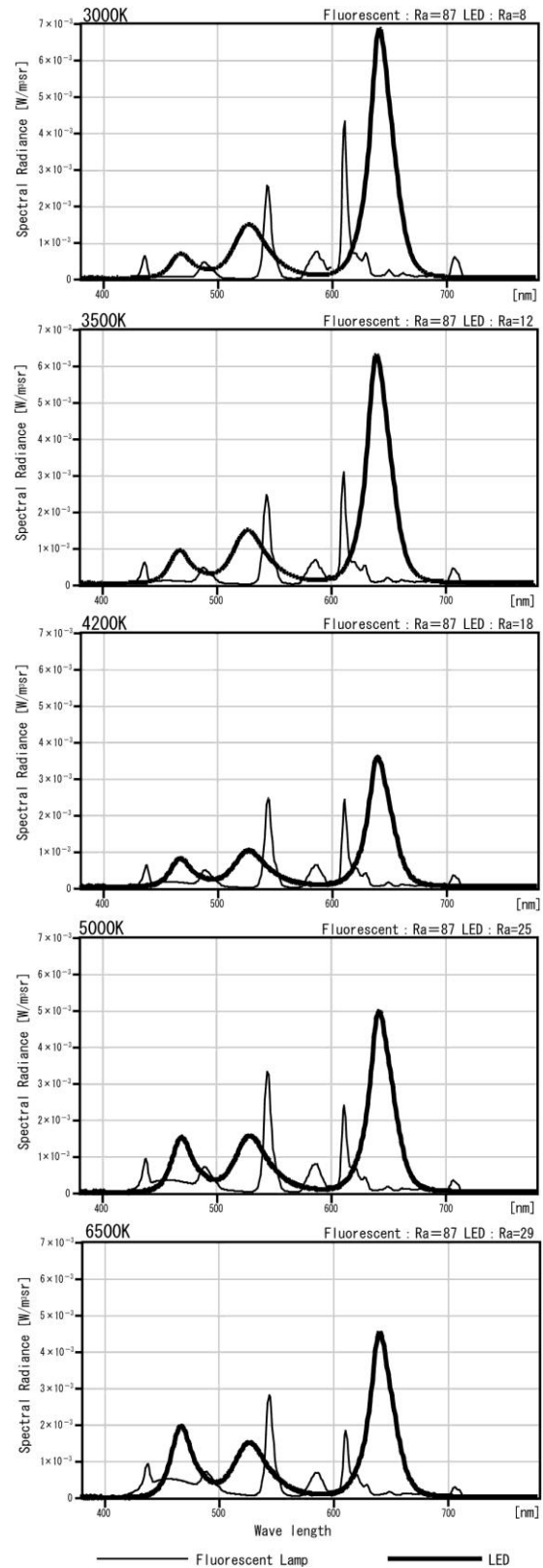


Fig. 5. Spectral Radiance of Lamps
(Illuminance at the floor of the scale model: 200lx)

A general view of RGB LED system and its LED units are shown in Fig. 2, Fig. 3 and Fig.4. LED units used are widely on sale in

Japan (distributed by Panasonic Electric Works Co.).

Since the color rendering of the RGB LED system is unknown when controlled to various color temperature, spectral distributions of each illuminance / color temperature conditions are measured with both fluorescent lamp system and LED system before the subjective experiment.

Although, the RGB LED system used in this research can realize various combinations, the color rendering under all conditions are quite poor compared to those realized with fluorescent lamp system (Fig. 5). These characteristics are exaggerated in lower color temperature. As the colors of RGB LEDs are designed to materialize wide color range, the peak wave length of red LEDs seems too long for general lighting.

2.2 Evaluation Methods

Evaluation methods are practically the same as those of the previous research⁴⁾ for comparing each other. "Preference" and "Brightness" were evaluated by 15 subjects (age 20 to 50) with 7 grades SD scales under the scenes of "Relaxing" and "Getting together".

The procedure of evaluation is as follows:

- 1) A subject observes the standard interior model for adapting to the standard condition (4200K, 200lx) for 30 seconds.
- 2) He / she observes the interior under one of the experimental conditions for 10 seconds.
- 3) He /she marks the SD scales.
- 4) Back to the first procedure.

3. RESULTS AND DISCUSSION

3.1 Average values of evaluation marks

Average values of preference for each condition are shown as diameters of circles in Fig.5 and 6.

In the space for relaxing (Fig.6), the combination of low color temperature and middle illuminance (3000K, 200/400 lx) are most preferred. Under low color temperature (3000K, 3500K), relatively low illuminance (50lx, 100lx) are also preferred, though low illuminance are not preferred over 4000K. The combinations of high illuminance and high color temperature (5000K, 800lx; 6500K, 400/800lx) are not preferred, even within

Kruithof's comfortable zone. These tendencies are clearly recognized both from LED (dotted circle) and fluorescent lamp (solid circle).

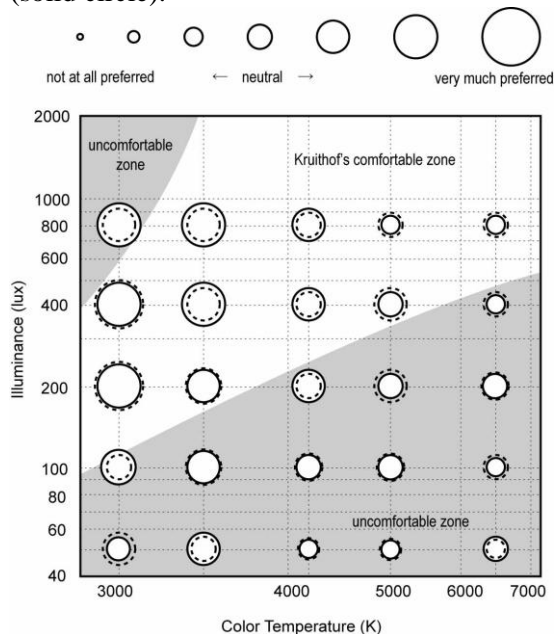


Fig. 6. Preference in relaxing space (solid circle: Fluorescent Lamp, dotted circle: LED)

In the space for family gathering (Fig. 6), preferred conditions are relatively similar to the Kruithof's comfortable zone, though higher illuminances (400/800lx) are preferred regardless of color temperature. These tendencies are almost the same in LED (dotted circle) and fluorescent lamp (solid circle).

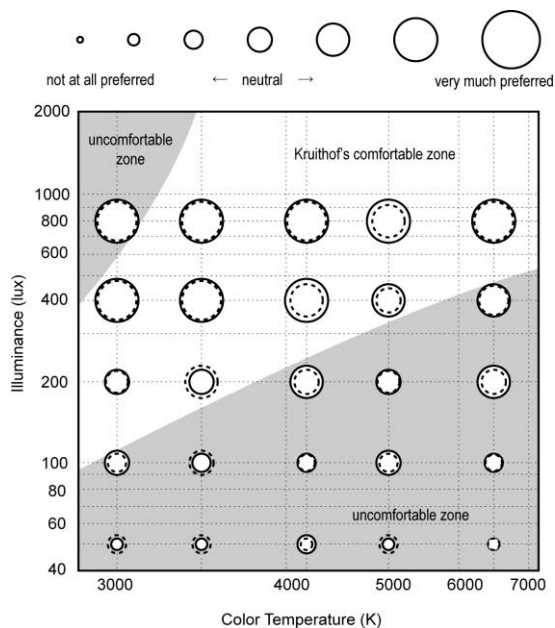


Fig. 7. Preference in gathering space (solid circle: Fluorescent Lamp, dotted circle: LED)

This could be the result of the preference of brighter conditions for the demand of visibility of other people. These results are also similar to Nakamura's result³⁾ generally.

4. CONCLUSIONS

Under RGB LED lighting, the preferred combinations of illuminance and color temperature for relaxing space and family gathering space are almost similar to those under RGB fluorescent lamp. These results suggest that preferred combinations of illuminance and color temperature depend on the living activities and are not influenced much from the sort or spectral radiance of light source. Under the conditions in this paper, color rendering is not affected to the preference as well, though this could only apply to the achromatic interior.

Again, the preferred combinations are vary depend on the living activities, and Kruithof's comfort zone seems not always useful at least in Japan.

In short, in relaxing space, relatively low color temperature is preferred and under higher color temperature limited illuminance range is acceptable. Kruithof's comfort zone is not appropriate for lighting under relaxed situation.

5. ACKNOWLEDGEMENTS

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