The Influence of Different Lighting Source Positions on the Visual Comfort of Refrigerator Illumination

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Abstract. By adopting the method of user experience, this research studies the influence of the layout of the lighting source for the visual comfort of refrigerator inner illumination. There are three kinds of layout, including the lighting source on the top, at the side wall and at the back of the refrigerator, which are conducted experiments under the environment of nighttime, kitchen, living room, common market and high-end store. The result shows that with the vacancy of the refrigerator, there is few influence of the different layout of light source on the visual comfort under the same environment of external illumination. There is a significant difference on the comfort illumination level on the top light and back light under the nighttime environment. But under other outer illumination environments, there is no significant difference among these three lighting source layout.

Keywords: Lighting source positions · Refrigerator illumination · Visual comfort · User experience

1 Introduction

People get more than 80 % outer information from their vision. The internal illumination of refrigerator is the necessary visual condition for people to check goods and quickly recognize them and take them out. When choosing the appropriate illumination for the internal space of the refrigerator, we should take the visual ergonomics, visual satisfaction degree and effective use of energy into consideration.

On the aspect of internal illumination, the current research mainly focuses on the field of construction, locomotive and airplane. For example, in the construction industry, there are specific technical requirements for outdoor roadway lighting and indoor lighting. Xia [1] from Shanghai Aircraft Design and Research Institute has put forward the assessment method of civil airplane drive cabin illumination. Yao [2], from Fudan University, has made some research about the LED lighting ergonomics of the

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drive cabin and its lighting. However, nowadays there is still no study on the internal lightening visual ergonomics of refrigerator in China.

2 Methods

2.1 Subjects

In all, 40 participants, comprising 21 men and 19 women were recruited, respectively. The mean ages of the participants were 40.13 (±11.14) years. All the participants have normal eyesight, natural or corrected, with no problem of color blindness or weakness. In the process of the experiment, all subjects keep good health and a good attitude.

2.2 Experimental Environment

The experiments were done in dark rooms. According to the mandatory standards GB 50034-2013 "Standard for lighting design of buildings" [3], the lighting standard value of normal supermarkets should be 300 lx and of high range market should be 500 lx. Moreover, the lighting standard values of kitchens and living rooms should be 100 lx and 100 lx–300 lx respectively. Considering that refrigerators may also be used at night without any lighting, hence the night environmental conditions should also be taken into account (Table 1).

Table 1. External environment illumination level

Experimental environment	Illuminance standard value (lx)	Experimental illuminance value (lx)
Nighttime conditions	/	5
Kitchen conditions	100 lx–150 lx	100
Living room conditions	100 lx–300 lx	170
Common supermarket environment	300 lx	300
High-end store environment	500 lx	580

2.3 Experiment Material

This research mainly focuses on three-door refrigerators. The cold storage of refrigerator has adopted the liner materials, with the size 52 cm, height 65 cm and depth 45 cm. And its inner side is vacant. There are three kinds of lighting layouts, including top lights which locate at the central top of the lumen, side lights which locate at the front side of the lumen and back lights which locate at both back sides. All these three layouts are two light bars and adopt cold and white LED point light source installing symmetrically at the relevant places (Fig. 1).

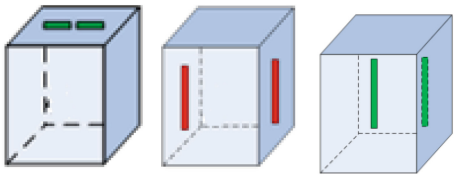

Fig. 1. Different layouts of lighting position

2.4 Experiment Procedure

Before the experiment, we introduce the whole process for the participants. During the experiment, every time when the external lighting is adjusted, the subjects will first make a visual adapt and then start to do the experiment. After the experiment, under the guidance of supervisors, subjects can adjust the inner lights to their most comfortable point. And the values are recorded by supervisors. After the experiment, we make a stationing measurement by the XYI-III shape all-digital portable illuminometer, including the illumination of the left, right and back side of the refrigerator as well as the clapboard of each layer.

3 Result and Discussion

Under the external environment of nighttime, kitchen, living room, common supermarket and high-end store, the comfortable illumination value of top, side and back light can be seen in the following Table 2.

Table 2. Comfortable illumination value of different layouts of lighting

Experimental environment	Environmental illuminance (lx)	Most Comfortable illuminance (lx)	
		Refrigerator inner with items	Empty refrigerator inner
Nighttime conditions	5	50	37
Kitchen conditions	100	69	64
Living room conditions	170	82	84
Common supermarket environment	300	123	122
High-end store environment	580	192	181

From the Table 1 and Fig. 2, we can see the value changes from 5 lx to 580 lx under the above 5 external environment. And the comfortable illumination value of the top, side and back light also increases. As a result, it reflects the objective law between the comfort level of the refrigerator and the external illumination value.

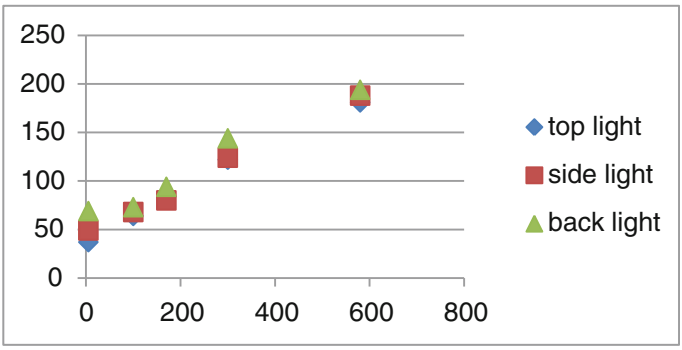

Fig. 2. Comfortable illumination value of different layouts of lighting

We make a difference analysis about the data and conclude that there is little difference under the environment of these five external conditions. In the perspective of statistics, there is no significant difference of the most comfortable illumination level of top and side lights. And only in the nighttime conditions there is a significant difference in top and back lights. No differences in other four conditions. Under these five external environments, the average comfortable illumination value of top lights is lower than that of back lights for 32 lx, 9 lx, 10 lx, 22 lx and 13 lx respectively. For the side and back lights, there is no significant difference of the side and back lights.

4 Conclusions

This research adopts the method of users' subjective experience to study the influence of different illumination layouts on the visual comfort of the inner lighting of refrigerators. The results show that there is no significant difference among these three layouts in other external illumination environment except the top and back lights in the environment of nighttime. Moreover, there is a little influence of inner lighting layout on the visual comfort. We think that the illumination value of visual comfort is equal regarding to top, side and back lights.

Next we can analyze advantages and disadvantages from the perspective of dazzling in different layouts and evenness of inner lighting in order to offer references for people who design the lighting of refrigerators.

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