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**INFLUENCE OF COLOR TEMPERATURE AND INTERIOR
REFLECTANCE ON SPATIAL BRIGHTNESS DEMAND**

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INFLUENCE OF COLOR TEMPERATURE AND INTERIOR REFLECTANCE ON SPATIAL BRIGHTNESS DEMAND

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Abstract

This report shows the results of two experiments on spatial brightness in a space with different color temperature and interior reflectance. Experiment 1 compared the perception of "spatial brightness". Experiment 2 compared the demand of "spatial brightness" for specific use.

The perception of spatial brightness showed the relation $3000K = 4000K \neq 5000K = 6000K$. The higher the color temperature, the higher the perception of spatial brightness tends to be.

And, the spatial brightness demand tended to be higher as the color temperature was lower, regardless of the room usage. And when the interior reflectance is high, there is a tendency that the average luminance of the space that answers "just right brightness" increases.

Keywords: Spatial Brightness, Color Temperature, Interior Reflectance, Room Use

1 Introduction

In recent years, much research on spatial brightness has been done, especially in Japan. These studies explain the spatial brightness by the luminance distribution of the observing scene. And these are targeted for perception of spatial brightness.

However, for design, "how much spatial brightness is required" is more important than "how much spatial brightness perceives". Therefore, it is urgent to investigate the demand for spatial brightness according to space usage.

However, it is doubtful whether the space usage and the required spatial brightness are consistent. For example, some people like the impression of calm for the space for meals, others like gorgeous impression. I do not think they both want the same spatial brightness.

A large amount of light is necessary to make the space composed of the low reflectance interior material and the space formed of the high reflectance interior material identical. But is there really such a space required? If you want to create a space that feels bright, increase the reflectivity of the interior material and lower it if you want to create a quiet impression space. That is, it can be predicted that there is regularity in the relationship between spatial brightness demand and interior reflectance.

Also known as a Kruithof curve¹⁾, preferred illuminance tends to differ depending on color temperature. It is said that low illuminance is accepted at low color temperature and high illuminance is accepted at high color temperature. If the illuminance and the spatial brightness are regarded as almost equivalent, the color temperature is also considered to affect it.

Therefore, in this research, we investigated the influence of interior reflectance and color temperature on the demand of spatial brightness according to the room use.

2 Experiment method

2.1 Experimental space

Experiments were conducted using a scale of 1/6 model. The size is 8 Jo-ma (the size of a general room of a Japanese housing : 3.6m*3.6m*2.4m). A light is installed in the center of the

ceiling. The size is 60 cm * 60 cm. An opening for observation was provided at a position corresponding to a height of 120 cm. Figure 1 shows the dimensions of the model.

The experimental variables are color temperature and interior reflectance.

The color temperature was set to 4 kinds, 3000 K, 4000 K, 5000 K, 6000 K. The LED equipment used for experiment prepared 2 types of 4000K (Panasonic: XL584PFU LT9) and 5000K (Panasonic: XL584PFV LT9). 3000K and 5000K used color temperature change filters (Lee filter: 442, 218). The color temperatures measured in the experimental space were 2858K for 3000K, 3857K for 4000K, 4867K for 5000K, and 5853K for 6000K.

The illuminance was set to 6 levels (32lx, 63lx, 125lx, 250lx, 500lx, 1000lx) with a dimmer. Setting value is equal pitch on logarithmic axis.

There are three types of interior reflectance, N 4.5(11.4%), N 7.5(45.7%) and N 9.5(77.5%). In addition, three reflectance (11.4%, 45.7%, 77.5%) cubes are placed in the evaluation space to make the perception of lightness accurate. Table 1 shows the photographs showing the inside of the experimental space.

Figure 1 – Size of the experiment space : 1/6 scale model

Table 1– State inside the evaluation space

		Color Temperature			
		3000K (2858K)	4000K (3857K)	5000K (4867K)	6000K (5853K)
Interior Reflectance	N4.5 (11.4%)
	N7.5 (45.6%)
	N9.5 (77.5%)
Illuminance		32lx 63lx	125lx 250lx	500lx 1000lx	

2.2 Method for evaluation

Two types of experiments were conducted. The first is to evaluate the perception of spatial brightness, as in previous studies. The other is to evaluate the spatial brightness required for use in each room.

2.2.1 Experiment on perception of spatial brightness (Experiment 1)

This evaluation was done with the magnitude estimation method. In the reference space, the floor surface is N4, the wall surface is N7.5, and the ceiling surface is N9, the color temperature is 5000 K, and the illuminance is set to 300 lx at the center of the room. An overview of the reference space is shown in Table 3.

The evaluation space of this experiment is the condition of four color temperatures and an interior reflectance of N4.5 and N9.5. There are six levels of illuminance shown in Table 1.

The experimental procedure is described. First, observe the reference space for 20 seconds and store an impression. After that, an evaluation space is observed for 20 seconds to evaluate the spatial brightness. The brightness of the reference space is 100, and the brightness of the evaluation space is answered with a positive integer. What is evaluated in this experiment is how bright it is perceived relative to the reference space. The presentation order of evaluation space is random.

The number of subjects is 19 males and 1 female in their twenties.

Table 2 – Outline of the reference space

Interior Reflectance	Color Temperature	Illuminance	State inside the model
Floor N4(10.5%)	5000K (4867K)	300lx
Wall N7.5(45.7%)			
Ceiling N9(83.9%)			

2.2.2 Experiments for the demand of spatial brightness (Experiment 2)

Five purposes of using the evaluation space were set, "talk while relaxing at home", "relaxing alone", "studying", "reading books", "watching TV". The subject observes the evaluation space and evaluates whether the spatial brightness is appropriate or not, assuming the specified use.

The evaluation scale is seven stages shown below.

For example, if the spatial brightness of the evaluation space is considered appropriate for space use, the subject selects 0.

Subject is the same as Experiment 1 and all Japanese. The acclimation time is the same as in Experiment 1 and is 20 seconds. The presentation order of evaluation space is random.

3 Experimental result and consideration

3.1 Result of Experiment 1

Figure 2 shows the relationship between the spatial brightness evaluation value and the mean luminance for each color temperature. There is no difference between the N4.5 and N9.5 trends in any color temperature, and the interior reflectance has no effect on the perception of spatial brightness.

Figure 3 is a graph in which the approximation formula for each color temperature shown in Figure 2 is superimposed on one graph. Looking at this graph, 3000K and 4000K are almost equal, and 5000K and 6000K are almost equal. And the latter seems to feel brighter. There have been reports in the past that the higher the color temperature, the higher the perception of brightness.

Figure 2 – Influence of interior reflectance (for each color temperature)

Figure 3 – Color temperature comparison

3.2 Result of Experiment 2

The following shows how to find the mean luminance where the spatial brightness is "just good brightness".

Figure 4 shows an example of the relationship between the mean of seven evaluation values and the mean luminance of the evaluation space. First, find an approximate expression for each interior reflectance (See the green letters in Figure 4). Next, find the y value when the x axis value is 0 (See the red arrow in Figure 4).

Figure 5 shows the mean luminance obtained by the above procedure. First of all, looking at the influence of color temperature, regardless of the specified use, the higher the color

temperature, the lower the mean luminance, which feels "brightness is just right". However, the trend is different for 6000K. It is a result different from the tendency shown by Kruithof.

Next, the influence of interior reflectance is compared. The overall trend is that the higher the interior reflectance, such as N4.5, N7.5, N9.5, the higher the mean luminance. According to the result of Experiment 1, if the average luminance is the same, even if the interior reflectance is different, it is perceived as the same brightness. Based on this, it is considered that the higher the interior reflectance, the higher the spatial brightness is required.

Figure 4 – How to find the mean luminance corresponding to “just good brightness”

Figure 5 – Mean luminance to feel as “just good brightness”

4 Conclusions

From the above results, it became clear that the color temperature and interior reflectance affected the spatial brightness demand. This result means that even if the use is the same, given the same spatial brightness (or mean luminance) does not necessarily lead to the same satisfaction.

According to existing standards, the mean luminance and illuminance of ceilings and walls according to the use of the room are determined, but a target value according to room situation

will be required. The placement of lighting fixtures may also affect it, so experiment will be continued.

As mentioned above, the result of this report is the experiment of the subjects living in Japan. How much space brightness is required is likely to be influenced by the light environment experienced so far. If the functions of the eyes are the same, the amount of light necessary for visual work is the same, but the spatial brightness needs to take into account the influence of cultural background. These may be one reason why the results are different from Kruithof's tendency.

In the future, it may be necessary to consider not only the design criteria based on perception but also the viewpoint that requirements (preferences) are satisfied.

Reference

1. Kruithof, A. A., Tubular Luminescence Lamps for General Illumination, *Philips Technical Review* 6, 65-96 (1941)