EVALUATION OF THE EFFECT OF DAYLIGHT ON ROOM BRIGHTNESS

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Keywords: Brightness, Daylight, Window, Reference Matching Method

ABSTRACT

The purpose of present study is to investigate effects of daylight on room brightness using a reference matching method. Participants observed two scale models simulating a room. One was a test room with a window through which artificial daylight entered and the other was a reference room without a window. Participants made brightness match by adjusting illuminance of the reference room with various illuminance levels (from ceiling luminaires) of the test room and window sizes. The results showed that, at the illuminance levels below 300 lx, the illuminance adjusted by participants was low even if the daylight increased the total illumiance of the test room. However, the adjusted illuminance increased efficiently with the daylight at the 1000 lx illuminance level. These results suggest that effects of daylight on brightness change with illumiance levels. The results were also discussed in terms of those of previous study using a magnitude estimation method.

INTRODUCTION

Recent development of lighting design and technology has enabled us to create various visual environments easily. Consequently, however, many designers and researchers have been faced with problems, not usually considered in previous studies. For example, although illuminance is used as an index of room brightness, a low illuminance room sometimes appears brighter than a high illuminace one. This fact not only indicates that illuminance does not always reflect room brightness accurately, but it also leads researchers to investigate factors which causes discrepancies between illuminance and brightness. One of such factors is daylight coming from windows. A few studies examined effects of daylight on room brightness [1] and found that increases in illumiannce by daylight did not sufficiently enhance room brightness, as compared with that by a ceiling light, particularly in the low illumianance room condition. In the present study, we further investigated the effects of daylight on room brightness by using a reference matching method. In this method, participants were asked to adjust illuminance of the reference room with various illuminance levels (from ceiling luminaires) of the test room and window sizes.

EXPERIMENTAL METHOD

In the present study, two 1/8 scale models simulating an office room were used (width; 800 mm, length; 1,200 mm, height; 340 mm). Figures 1 and 2 illustrate experimental apparatus and interior appearance. One room had no window and served as a reference room. Another room had a window and served as a test room. In both rooms, achromatic furniture and interior were arranged. To simulate daylight, we used 8 fluorescent lamps attached outside the test room. By changing the number of lamps turning on, the intensity of simulated daylight was manipulated: High (8 lights), Middle (4 lights), Low (2 lights), and Very Low (1 light). The illuminance of test room from ceiling luminaires and the window size were also manipulated. The Illuminance of the test room was either 100, 300 or 1000 lx. The window size was either full-window, 1/2, 1/4 or 1/8. The

participant's task was to compare the brightness of the two models and to made brightness match by adjusting the illuminance of the reference room. Participants were able to repeatedly view each room and adjust the illuminance of the reference room.

In addition to the daylight conditions, we conducted a no daylight condition (control condition) in which participants viewed the test room with no daylight. The task was identical to that in the daylight conditions. There were 8 blocks of 16 trials. The order of conditions was randomized across participants. Before an experimental session, participants practiced the task for several times until they familiarized with the task. Four participants participated in the present experiment. All of them had experience of brightness experiments before.

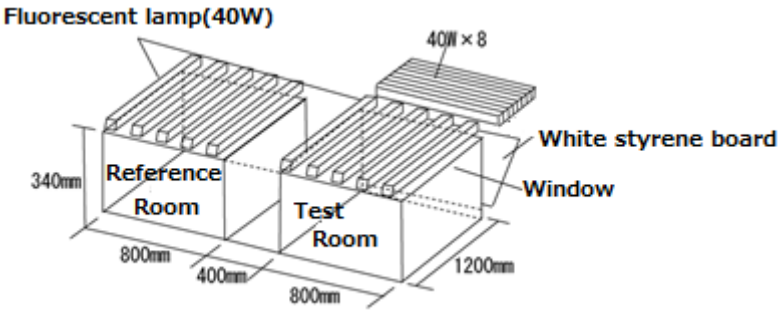

Figure 1. Experimental apparatuses

Figure 2. Interior appearance

RESULTS

Figure 3 shows the mean illuminance of reference room adjusted by participants. Note that horizontal axis represents the total illuminance from the ceiling luminaires and daylight. The white markers indicate the mean illuminance set by participants in the High, Middle, Low and Very Low conditions (in order from right to left). The black markers indicate the mean illuminance set by participants in a no daylight condition. As shown in the figure, the white markers shifted to upper right from the black markers as the illuminance of test room increased by daylight coming. The adjusted illuminance of test room also rose with the test room illuminance. The results indicated that the adjusted illuminance tended to increase as illuminance of test room increased. From the results of 100lx and 300lx conditions, it is obvious that white markers were located below the dotted line. From the result of 1000lx condition, most white markers were located on it.

DISCUSSION

From the results of 100lx and 300lx conditions in Figure 3, compared with the illuminance of test room, the adjusted illuminance of reference room was low. This means both test room illuminance and room brightness increased by daylight coming, but the increase in the brightness was lower than that induced by ceiling luminaire. From the results of condition 1000lx of Figure 3, daylight had almost the same effects as those of ceiling luminaire when interior brightness was enough.

Next, we will discuss the results of the present study in terms of those of the previous study. Figure 4 shows the results of subject RT in the previous study. Note that horizontal axis represents the total illuminance from the ceiling luminaires and daylight, and vertical axis represents brightness values that participants responded. Conditions were the same as the present study. Similar tendency was seen in the most results. However, in some conditions the results showed different tendency from those in the present study. From condition 100lx and 1000lx, the increase was seen, similar to the present study, but from condition 300lx, most white markers were located above the dotted line.

CONCLUSION

Although the illuminance increased by daylight coming, room brightness did not always increase effectively as expected from the illumiance increases by the illuminaires. However, such effects of daylight on brightness changed with illumiance levels. Under the conditions as the illuminance level was low, interior brightness increased as daylight came, but it was lower than before daylight came. Room brightness raised as the illuminance increased, but such effects of daylight became weak. Furthermore, some results differed from the findings measured by using a different method. Therefore, we need to investigate this point in future study.

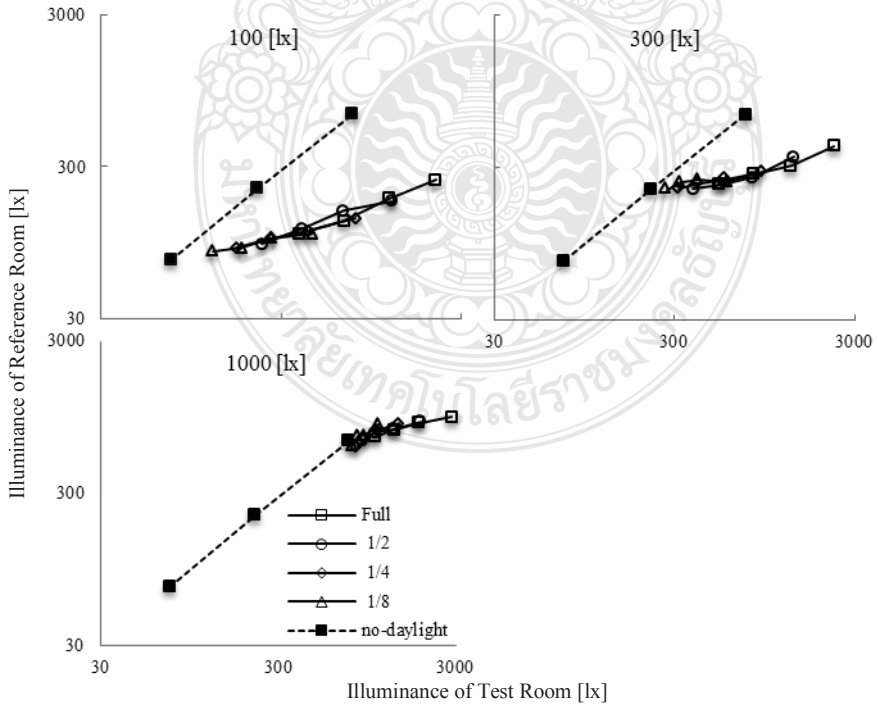

Figure 3. Brightness matching (Average)

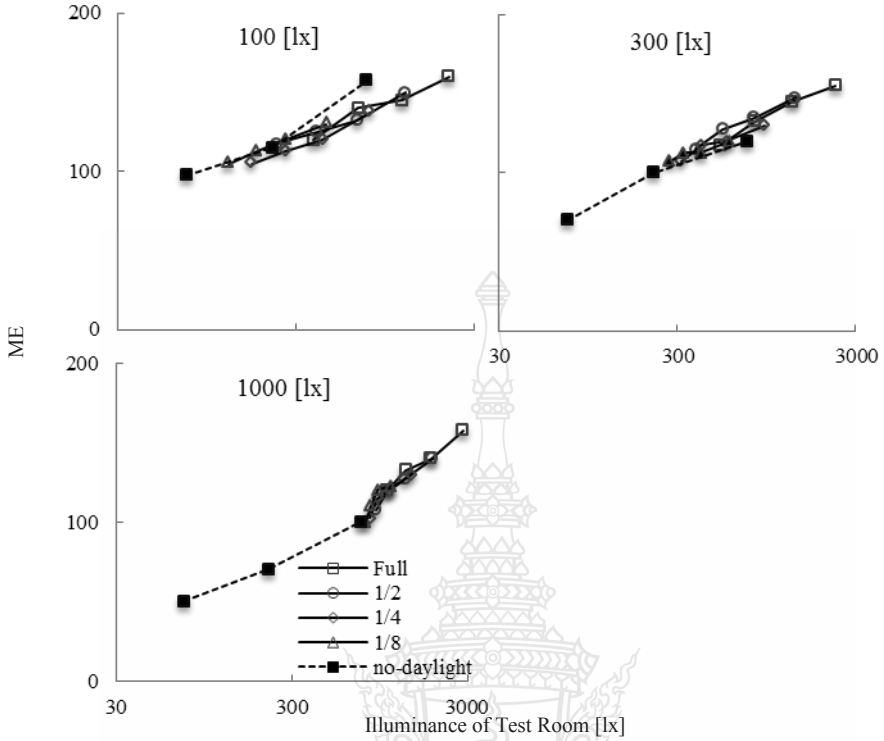

Figure 4. Previous results (RT)

1. T. Maruyama, H. Yamaguchi, H. Shinoda. (2011). *i-PERCEPTION: Space brightness evaluation for a daylit room*. 2(4), 371