

Evaluation of Visual Business Continuity in Office using equal Luminance Virtual Reality Images

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Abstract— Increasing number of natural disaster strongly require us to prepare means of working continuously over periods of emergencies and sustainably when power supply is low or unstable. Moreover, we must know how to keep comfortable office ambient appearance even in uncomfortable situations. In this study, authors evaluated comfortability office appearance in emergencies and of possible business continuity durations.

I. INTRODUCTION

In order to continue to work though times of black out, whether planned or spontaneous, and of low or unstable power supply, we must know a sustainable and comfortable office appearance. In such office two qualities must be met simultaneously: necessary tasks can be performed effortlessly and ambient appearance should be kept even in uncomfortable conditions. Increasing number of natural disasters strongly require us to prepare to work sustainably over periods of emergencies and during recovery of periods.

Task-ambient lighting (tal) is a method used in working environments which maintain people's performance while effectively creating bright ambient appearance using minimum light. When only the working plane is lit, it is most energy efficient however, apparently dark rooms are uncomfortable for workers especially when they spend most of their day in that space. On the other hand, when all areas of the room are lit equally, energy efficiency is low because not all parts of the room must be illuminated at the same bright appearance as the working plane. Effective installation of tal system to work place in emergencies, is an efficient way to allow us to continue to work even though uncomfortable conditions.

In this paper, we present a method to evaluate office appearance and possible business continuity duration. We created a virtual reality system (vrs) and virtual reality office (vro) with equal luminance as real offices with one variations, using only task or only ambient light. Using vrs we performed an evaluation experiment where subjects evaluated the vro on whether they are able to work continuously for certain duration, apparent comfort and performing difficulty of typical visual tasks.

II. VIRTUAL REALITY SYSTEM USED TO EVALUATE POSSIBLE BUSINESS CONTINUITY DURATION

Office appearance in emergencies and possible business continuity duration was evaluated using vrs and vro.

Virtual Reality Display System: The proposed vrs was used to display equal luminance vro (Table.1). The displayed images have the same luminance as the real office when it viewed from the same view point.

Table 1. Virtual reality system device

Device	Use	Specific
Urgod 3D VR Goggle	Head Mounted Display display	103 degrees viewing angle
iPhone XS Max	Head Mounted Display goggle	6.5 inch organic electroluminescent diode display, maximum luminance 625 candela
THETA	virtual reality display application	display virtual reality images

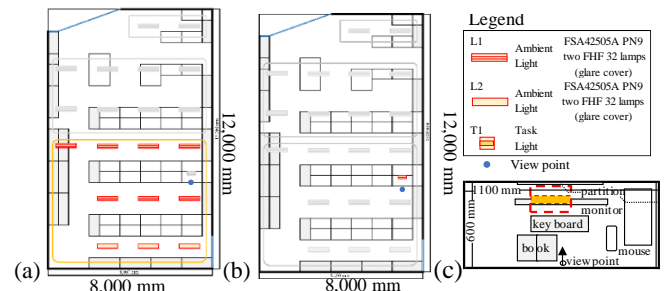


Fig. 1 Office layout and lighting (a) ambient only, (b) task only (c) desk layout

Virtual Reality Office Images: The target room is a real office in Tokyo Institute of Technology, Kanagawa, Japan. Omnidirectional luminance images was taken at the viewpoint and were converted to virtual reality office appearance lit with ambient light (vroa) (Fig. 1(a)) and virtual reality office appearance lit only with task light (vrot) (Fig. 1(b)). The desktop layout of target seat is shown in Figure 2(c). The viewpoint is set in front of the monitor.

Office Appearance Conditions: The working plane illuminance (wpil) and screen luminance (slm) conditions of vroa and vrot were set at: wpil at 5 lx, 15 lx, 30 lx, 75 lx, and 150 lx and slm at 50 cd/m², 100 cd/m², and 200 cd/m².

Office Appearance Evaluation: Each vro conditions were evaluated on possible business continuity duration (pbd) of one day, three days, ten days, and when duration was not clear. (Table. 2) Nine subject aged 20 ~ 30 participated in the experiment (Table. 3). Subjects were given time to memorize the evaluation scale (Fig.5) prior to the experiment. Finally they evaluated vro on: possible business continuity, ambient comfort of room, performing difficulty for two usual visual tasks (paper and computer) orally.

Table 2. Virtual reality office conditions

Working plane illuminance [lx]	5, 15, 30, 75, 150
Monitor screen luminance [candela]	50, 100, 200
Possible business continuity duration	one day, three days, ten days, not clear

Table 3. Subject list

age	Occupation	Sex	subjects number
20 ~ 29	worker	male	1
		female	2
	student	female	4
30	student	female	2
total			9

< Business Continuity >	< Level of Ambient Discomfort >	< Difficulty to perform task (PC & Paper) >
Yes	0. Not uncomfortable	0. Easy
No	-1. Slightly uncomfortable	-1. Little difficult
	-2. Uncomfortable	-2. Difficult
	-3. Unbearably uncomfortable	-3. Just performable
		-4. Impossible

Fig. 3 Office appearance evaluation scale

III. RESULTS AND DISCUSSION

The results are shown in Figures 4 through 6.

A. Office Appearance and Possible Business Continuity

In vroa, bcd when wpil is 75 lx or over is 10 days. For vroa, over 70 % of the people evaluated that office appearance is sufficient for business for bcd of 10 days when wpil is as low as 15 lx (Fig.4 (a), (b)). However, for vrot, bcd when wpil is 75 lx or over is only 1 day. In addition, for office appearance of vrot when duration is 10 days and wpil is 75 lx, only approximately 80% of the people evaluated that they can continue to work even though everyone can continue to work in vroa with the same wpil.

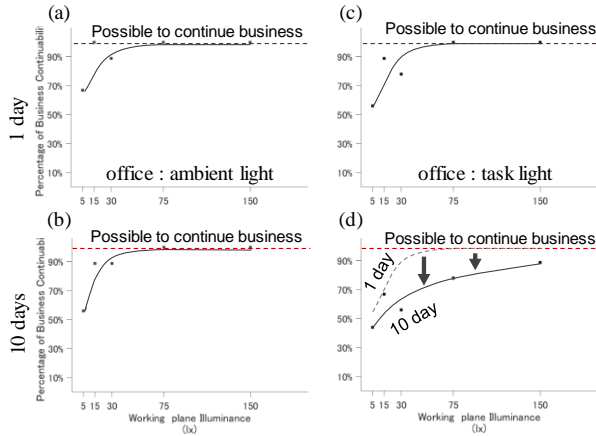


Fig.4 Percentage of business continuity [screen luminance 50 candela]

B. Ambient comfort and office appearance

In vroa, office appearance (oapp) is comfortable when wpil is over 30 lx for duration of 1 day, and over 75 lx for duration of 10 days (Fig.5 (a), (b)). On the other hand, in vrot, oapp is between uncomfortable to slightly uncomfortable when wpil is 30 lx for duration of 1 day (Fig.5 (c)). In vrot oapp is comfortable when wpil is over 75 lx. In vrot, oapp is one level less comfortable when duration period is increases from one day to ten days at the samr wpils, hence oapp of the working plane is the same (Fig.5 (d)). As mentioned before, oapp of vrot is comfortable when wpil is 75 lx and duration is one day because it is comfortable for focusing on individual task for a short period of time. However, to continue working for a longer period of time, oapp created using only task light is ineffective to make the office appear comfortable. Moreover, results showed that ambient light is important for making comfortable office appearance.

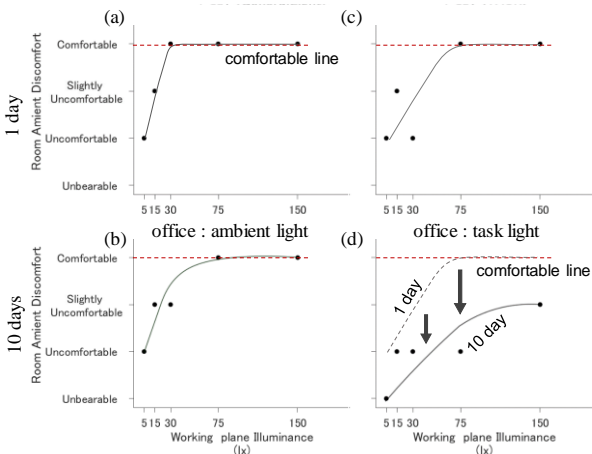


Fig. 5 Ambient comfort of office appearance [screen luminance 50 candela]

C. Task performing difficulty

In vroa paper task is easy to be performed when wpil is over 75 lx while in vrot, task is easy to be performed when wpil is over 150 lx. In vrot wider area on the working plane is lit while in vrot, limited area appear is lit. Moreover, for easy performance of paper tasks, working plane appearance where larger area is uniformly lit and appear bright is more suitable (Fig.6 (a)(b)).

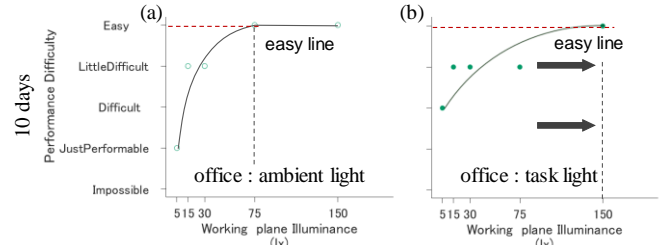


Fig. 6 Paper task performing difficulty and working plane illuminance

IV. CONCLUSION

To evaluate office appearance on possible business continuity and duration period, we constructed a virtual reality system (vrs). We also created virtual reality offices where variations of office appearance (oapp) were created with two different lighting method: task light only and ambient light only. Using virtual reality system and variations of virtual reality office appearances, subjects evaluated office appearance on possible business continuity duration (bcd), ambient comfort and difficulty to perform visual tasks. Possible business continuity duration was longer for virtual reality offices lit with ambient light (vroa) than virtual reality office lit using task light only (vrot). In addition, ambient comfort of office appearance lit with task light only, worsened when duration period increased. Lastly, to perform task easily, greater working plane illuminance (wpil) was required when office was lit with task light only than when ambient light was used.

Analysing these results, we showed that to create office appearance where it is possible to continue business, task ambient light is an effective. In this paper we showed that task light can secure sufficient working plane appearance, however, it may be insufficient to secure ambient comfort and ambient light are more efficient to secure this. In conclusion, in this paper we showed the characteristics of office appearance necessary for business continuity in emergencies. To further our research, we will investigate effective office appearance which increases possible business continuity duration.

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