The Application of Lighting Factors in Information Transfer: a case study of external hard disk

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ABSTRACT

Objective: The aim of this study is to explore the interaction between human visual perception and lighting factors in information transfer. **Background:** Visualization through lighting helps effectively deliver information to people. Although lighting can be controlled with various factors, only a few factors have been used to transfer information. Therefore, we wondered how various factors of lighting are related to the visual perception of information. Six factors of lighting were identified based on the literature study: Intensity, Color, Area, Movement, Texture and Distribution. **Method:** In order to reveal the interaction between the lighting factors and the perception of information, an experiment was designed and 10 participants were recruited. Based on representative three scenarios of an external hard disk storage space usage (in case of being full, half full and empty), the participants were asked to set the most appropriate lighting of each scenario by controlling each factor of lighting according to given scenarios. **Results:** The results indicated that there was no significant difference in the pattern of setting lighting factors between the participants for each scenario. However, the pattern of setting lighting factors was distinct among scenarios. **Conclusion:** The conclusion was drawn that lighting factors influence the human perception in information transfer depending on use cases. **Application:** In information transfer, lighting can be more effectively utilized by understanding the interaction between lighting factors and the visual perception of human.

Keywords: Lighting, Information transfer, Visual perception, External hard disk, Visualization

1. Introduction

Vision plays a dominant role in human perception among human senses such as hearing, touch, taste, and smell. More than 50% of the brain is related to vision directly or indirectly (Elizabeth, 1996). And also visualization is the most effective way to transfer information (Smiciklas, 2012). Visual stimulus begins when it comes into eyes with reflected lights from an object. Humans have been constantly trying to get and handle the light, because it plays an essential role in visual perception.

The light has been applied for certain purposes in human lives and this use of light is defined as lighting (Cho et al., 2010). The lighting has been used for a variety of purposes in addition to simply illuminating the space we are living. The four definitions of the roles of lighting were defined in our previous study (Jun et al., 2014) and the conceptual framework of the roles of lighting in the human-lighting interaction was made: Visibility, Visual aesthetic enhancement, Emotion induction, and Information Transfer (Figure 1).
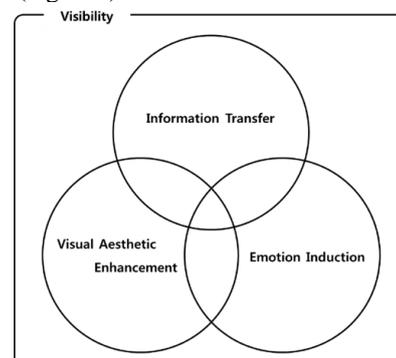

Figure 1. The conceptual framework of the roles of lighting in human-lighting interaction

Especially, the ways of transferring information have been diversified thanks to the advent of LED and its development,

because LED lighting is digitally controllable and much smaller than earlier types of lamp (Hoonhout et al., 2011). For example, the lighting is used to indicate the state of battery charging or the status of network connection as shown in Figure 2.

Figure 2. Examples of information transfer using LED lighting

Although factors consisting of LED lighting can be controlled, turning on/off and the color of LED are only used to transfer information in products. There are various factors of lighting defined in other studies. Theatre studies identified seven factors of lighting: intensity, color, direction, distribution, texture, shape, and movement (Essig et al., 2005). Another study presents four factors of lighting: distribution, intensity, movement, and color (Gillette, 2012). According to Chang (2010), lighting interaction can be also described as factors of lighting as the number of lighting, intensity, the amount of light, type of light, color, reaction scheme and light changes. These studies showed that the factors of lighting have been already controlled in several fields to provide diverse visual perception to human.

Our assumption is that LED lighting can deliver better user experiences by providing the user rich information with manipulating the controllable factors. Therefore, this study aims to find out the interaction between human visual perception and the controllable factors of LED lighting in the context of information transfer.

2. Method

In order to identify what factors of lighting and how they can be related to information transfer, an experiment was designed.

2.1 Determining the factors of lighting and its levels

Based on the literature review, six factors of lighting were defined in this study: intensity, color, area, movement, texture and distribution. Intensity is related to brightness of light. Area means the illumination area and texture is the degree of light scattering. Movement refers to blinking light

and distribution is the effect of lighting direction (e.g. direct or indirect). The controllable levels in this experiment of each factor of lighting were composed of as shown in the Table 1.

Table 1. Controlling conditions of each lighting factor

Factors of Lighting	Controlling Level			
	1	2	3	4
Intensity	Middle	Strong	Weakness	
Color	White	Red	Green	Blue
Area	Middle	Wide	Narrow	
Movement	No Blinking	Rapidly Blinking	Slowly Blinking	
Texture	Middle	Strong	Weakness	
Distribution	Direct Lighting	Indirect Lighting		

2.2 Product selection and scenario development

It came to an important criterion to choose a product with which people have never experienced in information transfer rather than on/off state before. Another important criterion was to avoid the bias resulting from prior-experience, such as the battery charger that has already used lighting to show the state. Therefore, we selected an external hard disk, which was placed next to the PC for backing up data purpose. The current external hard disks showed the state of their remaining storage with numerical information on the computer screen. We supposed that LED lighting could deliver more information than the numbers. Therefore, three scenarios were made with regard to the state of storage: 'The storage is full', 'The half of storage is filled', and 'The storage is almost empty'.

2.3 Materials

The external hard disk was manufactured as shown in Figure 3. The exterior case of hard disk was printed out from a 3D printer. The shape of the exterior took a simple rectangular form to help concentration on the manipulation of the lighting factors. Arduino was used and the LED used was Adafruit's 40 RGB LED Pixel.
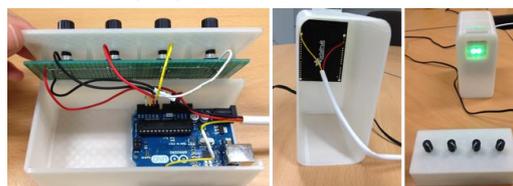

Figure 3. Completed external hard disk

2.4 Sample

10 participants were recruited in this experiment. Five people were men and five people were females. The average age of participants was 23.7 years old.

2.5 Experimental procedure

Figure 4. Experimental set-up

The experiment was carried out on the computer desk (Figure 4). The experimental environment was composed of an actual place where we usually use an external hard disk.

Participants sat in front of the computer desk, and were given a brief introduction of the experiment. Then, they had time to get familiar with the device in order to learn how to use it for a while. We explained three scenarios to the participants and they adjusted factors of LED lighting so that it can represent well in the given scenario information. Next, participants ranked the factors depending on the importance in setting in the given scenario. After the experiment a retrospective interview was conducted in order to understand the reasons of what they had done.

3. Results

3.1 The factors of lighting to influence information transfer

To analyze experiment results, we focused on the responses that had been identically answered by more than 60% of the participants. The reasons they had chosen factors of LED lighting and particular levels of them were identified through a retrospective interview. The results are shown at the table 2 and the blank columns mean that there is no particular tendency.

Table 2. The results of response rate according to scenarios

Factors	Scenario 1: The storage is full	Scenario 2: The half of storage is filled	Scenario 3: The storage is empty

Intensity	Strong	Middle	
Color	Red		White
Area	Wide	Middle	
Movement	Rapidly blinking	No blinking	No blinking
Texture		Middle	Strong
Distribution	Direct	Direct	Direct

■ 90%, ▨ 80%, ☐ 70%, ☐ 60%

Participants preferred the strong intensity of LED lighting when the storage space was full, while the middle intensity was preferred in the situation that the half of storage was filled. Most of the participants chose the red color when the hard disk was in the state of being filled up. However, many of them chose the white color in the case of the empty storage space. The area of LED lighting was proportional to the amount of filled storage space. Regarding movement, the blinking light was chosen only as the storage was full. It was revealed in the interview that the rapidly blinking lighting attracted their attention in a way to warn them. On the other hand, most of the participants preferred no blinking to avoid being distracted unless it was full. It seems that the texture of LED lighting is proportional to the remaining storage space. In terms of distribution, they selected the direct lighting in all the scenarios, because they thought the dimension was important to quickly perceive information. This may imply that direct distribution is essential in information transfer by means of lighting. It seems obvious that the lighting was used in a way to let the participants easily aware of the information in case it is important. However, the lighting was not considered as necessary when the information is not urgent to be perceived. The way of transferring information should be in case of the importance of information.

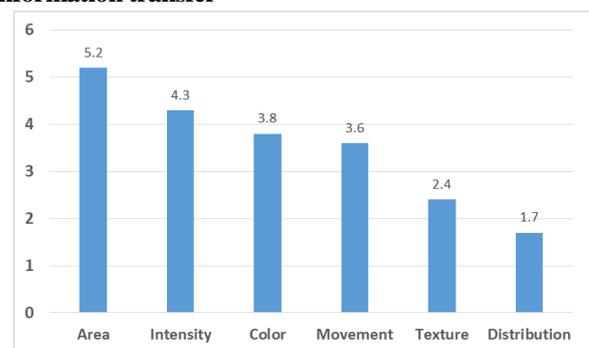## 3.2 The dominant factors of LED lighting in information transfer

Figure 5. The results of ranking the factors in terms of importance

After the experiment, participants determined the rank of factors of LED lighting based on how well each factor represents the information of the state of storage. This was done on the six-point scale: the most important factor got six points and the least important factor got one point. As a result, a factor of area had the highest point in the information of the storage (Figure 5). Participants said in the interview that both storage and the area factor were similarly quantitative concepts. Therefore, more than half participants determined the area factor as the most influential factor and so they changed the area step by step according to scenarios.

4. Conclusion

Visualization is one of effective methods to deliver information to the user with products. Although the various factors of lighting can be controlled, only a few factors have been used to transfer information. We considered that it is possible to deliver richer information by controlling factors of LED lighting. To confirm this hypothesis, we designed the experiment and composed with scenarios of external hard disk usage. Then, we found some common points through experiment with 10 people. When the information of hard disk was visually expressed in the lighting, there were tendencies between people. The factor of area was important to present information in the scenario of storage space. We found that people take cognition and awareness into account when they choose the factors of LED lighting. They used strong color, rapidly blinking and direct lighting in case of filled-up storage in order to get alarmed. On the other hand, any alarming visual information was not important in case the hard disk is almost empty.

Through this study, a conclusion can be drawn that information could become richer by controlling the factors of LED lighting. Information from products cannot only indicate their state, but it also confers a wisdom that informs the user of what to do for suitable usage (Jacobson et al., 2000). Information needs to let the user understand the context of that information and guide behaviors to take next. Visual information utilized by lighting can be more effectively understanding the interaction between human and product. Nonetheless, this study had limitations such as the number of participants and scenarios. To get more findings in the human-lighting interaction, a follow-up study should be done.

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