EFFECT OF LIGHT ENVIRONMENT ON FORGETTING OF LEARNING TASKS: A PRELIMINARY STUDY

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Abstract

Recent studies have reported that light affects human circadian rhythm, attention, and memory. Among them, memory can be said a very significant factor in terms of the effectiveness of learning. This is because if there is a large amount of retention after a certain period of time with having learned a task, the effect of learning can be considered high. In this respect, long-term memory linked to the memory over an extended period Is one of the important subjects to be covered in learning. A series of studies prove that the performance of working memory and long-term memory in learning field may differ depend on the environment of light. In addition, the studies argue that the optimum light environment for working memory and long-term memory is different. Studies involving the light and long-term memory have consistently reported that the long-term memory under the condition of relatively dark 400 Ix is superior. However, the exact causes of why long-term memory is superior in a relatively dark light environment has still not identified. Thus, this study was conducted to research into the reason why long-term memory is superior in a dark environment through the study on how light environment affects the memory forgetting of learning tasks. With this, we will systematically analyze the effect of long-term memory based on light environment, drawing the implication for the composition of the light environment in the educational field.

Keywords: *LED lighting, forgetting, memory, illuminance*

1. INTRODUCTION

Modern people live with the light almost all the time. All activities such as reading a book, eating a meal, using a mobile phone or watching TV is done under the light environment. Education and learning are no exception. People are educated under the lights on the ceiling of the classroom and study under the stands at home. In a sense, light is a very important environmental stimulus in the educational or learning field.

However, there is a relatively perceived shortage of researches on the effect of light in learning. When it comes to learning, studies have been reported that bright light is effective in attention, cognitive performance, and memory etc., but do not always show consistent research result. Besides, there are only few studies on memories closely tied to the learning effect. Memory is a very important cognitive element of learning. If something is learned and yet not remembered, it can't be said to be learned. Also, it is hard to say it has learning effect if it is not remembered for a long time after learning.

According to multi-store model of Atkinson and Shiffrin, memory can be largely divided into sensory memory, short-term memory, and long-term memory. Information coming from the surroundings first goes to sensory storage called sensory memory. Sensory memory has a large capacity but quickly disappears within less than 5 seconds to a few seconds, and only the information paid attention to in sensory memory is transferred to the next stage, short-term memory. Short-term memory storage also called working memory has a limited capacity. In which if the information is left unattended, it will cause disappearance or forgetting for about 20 seconds, and yet the information can be prevented from being disappear through a rehearsal that repeats the information over and over again. The information of short-term memory is transferred to long-term memory through rehearsal or elaboration process. Finally, long-term memory can be said a massive storage that generally stores all available information. The capacity for storing long-term memory is unlimited. It allows information to be returned to short-

term memory through retrieval process, manipulating and using information to perform a given task in short-term memory.

The nature of light has an effect on attention, short-term memory (working memory), and long-term memory. Previous studies have generally reported that attention is excellent when illuminance of light is high. As mentioned earlier, attention plays a key role in the process of transition from sensory memory to short-term memory. Therefore, it can be predicted that excellent attention is effective for short-term memory (working memory). In fact, studies generally report that working memory is excellent at high illuminance.

However, the quantity of studies on light and long-term memory are very small compared to studies on attention or working memory, and the result is different from ones on working memory. For example, in 2017, Jung et al., verified the effect of long-term memory at 400 lx, 700 lx, 1,000 lx through LED lighting, showing long-term memory retrieval is the best at 400 lx, a relatively dark illumination, and the lowest at 1,000 lx. Since then, the studies on light and long-term memory have continued reporting that long-term memory is the best at 400 lx.126 But, it is not enough to draw a conclusion that long-term memory is superior at 400 lx illumination based on these finding.

Furthermore, current studies on light and long-term memory have not succeeded to find the reason why long-term memory is superior at 400 lx illumination. This is because not only is it not easy to identify mechanisms due to the nature of long-term memory, an abstract concept, but also there are many limitations to study brains on long-term memory. For instance, a widely-used (f)MRI hardly perform memory task, and it makes difficult for (f)MRI to apply an experiment with humans because retrieval also should be measured after relatively long period of time due to the nature of long-term memory. Thus, in the current research environment, it is evitable to reply on indirect reasoning when it comes to the searching for the cause of the light's effect on long-term memory.

Accordingly, this study aims to explore the effect of light illumination on memory, focusing on forgetting. We intent to find out why long-term memory is excellent at 400 lx and how light illumination affects learning effect, verifying how learning under the condition of bright light and dark light affect forgetting over time.

2. METHODS

2.1. Participants

The experiment was conducted with 11 adults with no impairment in cognitive function. Their average age was 22.3 years and consisted of 3 males and 8 females. Prior to the experiment, an orientation was conducted to explain the experimental procedure, method, and prohibited matters. In addition, in order to prevent sleep deprivation that may affect the experiment, the experiment was not conducted if sufficient sleep was not achieved.

2.2. Lighting Environment

The light condition was treated at 400 lx and 1,000 lx, and color temperature was all set at 5,000 k for this experiment. The lightning for the experiment is a light sensor-based automatic LED lightning device made by the author, with an illuminance sensor and a color temperature sensor to maintain a constant light environment. The input power of the lightning device is 25VDC, and the light source is high power LED.

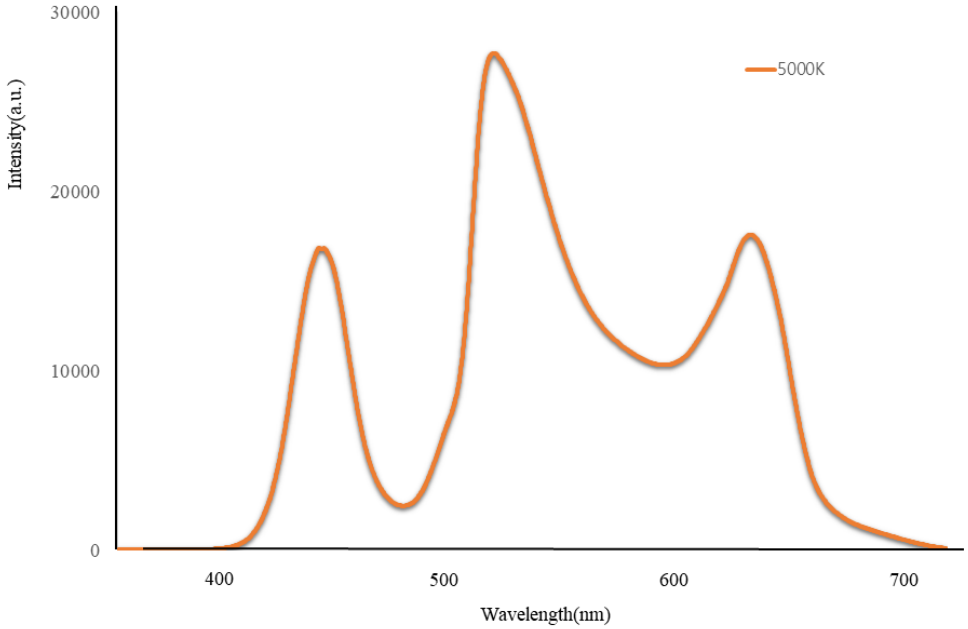


Fig. 1. Spectral power distribution

2.3. Experimental Design

This experiment is designed with a with-in subject design, and has four experimental conditions. Participants were assigned to all four experimental conditions, having measured the retention at 5 and 30 minutes after learning the memory task.

2.4. Measure Instrument

The memory measurement used for this experimental is the Word Fragment Completion (WFC) Task. The WFC is a task of completing words by filling in missing letters based on the learned information, being usually used for indirect measurement of long-term memory. The WFC task is usually used to measure implicit memory. Because the WFC task itself does not have the property of implicit memory, but is often used as a method of memory retrieval through priming effect after unconsciously memorizing it. If an attempt is made to consciously remember items of task, the WFC task can also be used to verify external memory. In this experiment, the WFC task used meaningless spelling consisting of 7 consonants, and there were 3 missing letters to be filled by participants. The total number of tasks learned was 20, and 10 items were presented at 5 and 30 minutes after learning the task, and the memory retention was measured as the ratio of items that completed words out of 10.

2.5. Experimental procedures

Participants performed the first dark adaptation for 2 minutes, followed by a light adaptation of 2 minutes. And then, they learned 20 tasks over 10 minutes, and performed an interference task to prevent rehearsal for 5 minutes. Right after completing an interference task, the amount of the first memory retention was measured through the WFC task. 10 of the 20 tasks learned were presented in the first WFC task and started to be retrieved exactly 5 minutes after learning task. After 20 minutes of interval, the second memory retention was measured for 5 minutes. And retrieval began exactly 30 minutes after learning.

Participants were randomly assigned to one illumination per day and the experiment had been conducted over two days at the same time of day, considering the circadian rhythm.

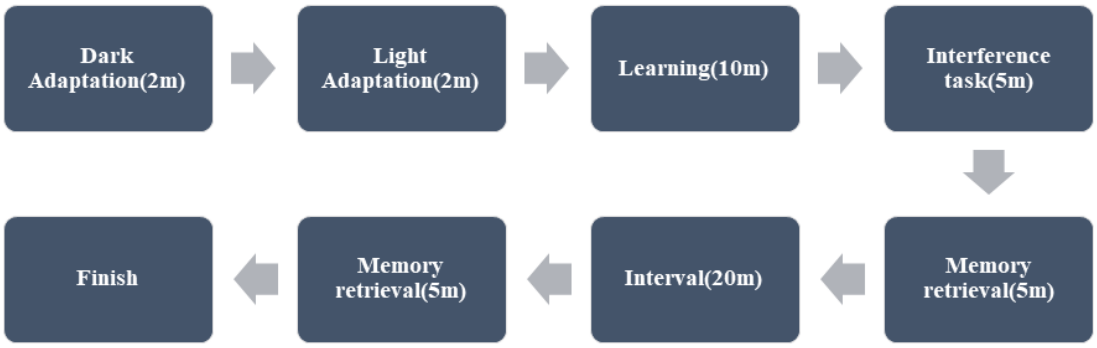


Fig. 2. Experimental Procedures

3. RESULTS

The descriptive statistical analysis of this experiment is shown in Table 1.

	memory after 5 minutes	**memory after 30 minutes**	**N**
	Mean (SD)	**Mean (SD)**	
400 lx	50% (27.2)	20% (23.7)	11
1000 lx	48.18% (18.88)	12.73% (14.21)	11

Table 1. Result of Descriptive statistical analysis

The descriptive statistical analysis indicates that memory retention is 50% at 400 lx, higher than 48.18% at 1,000 lx after 5 minutes, and 20 % at 400 lx, higher than 12.73% at 1,000 lx after 30 minutes. Thereafter, there was an analysis of variance (ANOVA) to verify the difference in each condition. The result of it is as below Table 2.

	Sum of Square	**df**	**Mean of Square**	**F**	***P***
Memory Retention	12090.90	3	4030.30	9.259	.000**

**p<.05 **P<.01*

Table 2. Results of variance analysis of memory retention

The ANOVA says that the 4 conditions have p=.000 at the 95% confidence level with a significant difference. A post-hoc test was conducted to verify the detailed differences for each condition. The result is shown in Table 3.

Illuminance(Time)	Mean Difference	Standard Error	Sig
400 lx(5min) vs. 400 lx(30min)	30.0**	8.09	.004
400 lx(5min) vs. 1000 lx(5min)	1.82	9.13	.846
400 lx(5min) vs. 1000 lx(30min)	37.27**	9.73	.003
400 lx(30min) vs. 1000 lx(30min)	7.27	8.10	.390
1000 lx(5min) vs. 1000 lx(30min)	35.46**	7.43	.023
1000 lx(5min) vs. 400 lx(30min)	28.18*	10.52	.023

**p<.05 **P<.01*

Table 3. Results of post-hoc test

The analysis shows that there are statistically significant differences between 400 lx (5 min) and 400 lx (30 min), 1000 lx (5min) and 1000 lx (30 min), 1000 lx (5 min) and 400 lx (30 min). However, there is no significant difference between 400 lx (5 min) and 1000 lx (5min), 400 lx (30 min) and 1000 lx (30 min).

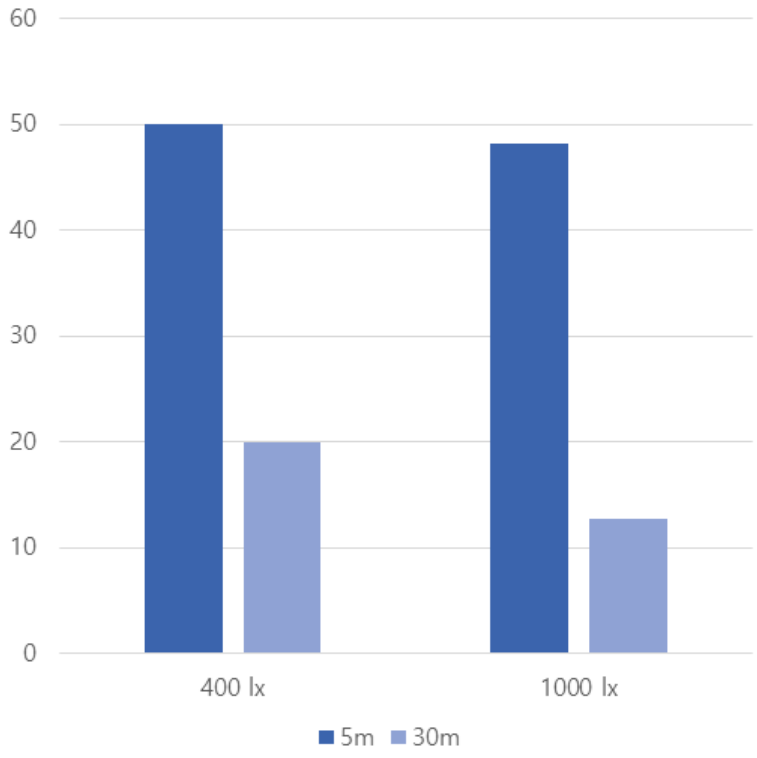


Fig. 3. Memory retention according to illuminance and time

4. DISCUSSION

This study was conducted with experiments to give preliminary look into the effect of the light environment on the forgetting of learning tasks. And based on the results of this study, we tried to

indirectly infer the reason through forgetting why the capacity of long-term memory depends on the characteristics of light. The study has found that the light environment of 400 lx shows a higher memory retention rate than the condition of 1000 lx regardless of time, which means that forgetting at 400 lx occurs more slowly than at 1000 lx. These results are consistent with the existing studies on the superior of long-term memory at 400 lx, but it does not well show to support the existing studies as no statistical significance was found in this preliminary study.

Moreover, it was confirmed with this experiment that half of the memories were quicky forgotten between 5 and 30 minutes after leaning.

5. CONCLUSIONS

Light is the principal environment of everyday life and one of the factors that influence human memory. Some studies have argued that attention and working memory are superior in bright light, others have reported that long-term memory is more superior at an illuminance of 400 lx. Therefore, this study conducted an experiment on the subject of forgetting to explore the cause of why long-term memory is superior at 400 lx. The results reveal, although it is not statistically significant, that long-term memory at 400 lx is superior than at 1,000 lx and forgetting at 400 lx is relatively slower than at 1000 lx. It is not enough to conclude from this preliminary study, but it is likely that forgetting at 400 lx is relatively slower than at bright light. These results show that the light environment can affect the memory of the learning task in the educational field, and that the creation of a light environment suitable for the learning task can produce meaningful learning effects.

ACKNOWLEDGMENTS

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