

A Study on the Serial Position Effect of Memory according to Illumination of LED Light

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Abstract. The purpose of this study was to verify the forms of the effect of serial position effects of memory according to the illuminance of light. This study was conducted as an experimental method, and 21 adults without cognitive impairment participated in the study. The illuminance condition was designed with high illuminance condition of 1,000 lx and low illuminance condition of 300 lx. The memory task used word list of 20 items consisting of a series of pointless spellings. After memorizing the word list for 10 minutes, the participant performed a retention task 24 hours later. The memory retention task consisted of filling the empty part of the learned word and completing the word. The analysis was performed by dividing the word items into three conditions: primacy, middle, and recency. Primacy used the first item in the word list, Middle used the 10th item in the middle of the word list, and finally Recency used the last item in the word list for analysis. The result was $F = 4.16$ ($p = .02$), and showed that there was a statistically significant difference in memory retention of primacy, middle, and recency at 95% confidence level in dim condition.

1 Introduction

Recent studies have demonstrated that light affects memory [1], [2]. Especially, brightness of light is considered as a factor affecting memory recognition and memory recall [3]. Previous studies have reported that bright light with high illuminance is effective for working memory (short-term memory) such as attention or word processing, but light with relatively low illuminance is effective for long-term memory [3]-[5].

However, it is somewhat unreasonable to think that the relationship between illuminance and memory is a firm result. This is because unmatched research results still exist. For example, Kretschmer et al. reported that the correct response of the working memory task was excellent at a high illuminance of 3,000 lx, but reported false response was not affected by illumination [6]. On the other hand, Jung et al. argued that long-term memory is superior at relatively low illuminance of about 400 lx to high illuminance [3]. Therefore, more systematic and repeated verification of the relationship between light and memory is needed.

In order to systematically verify the effect of light on memory, there is a need to examine serial position effects of memory on light. Serial Position Effects mean that the retrieval of first and last item is better in a memory task involving a set of word lists. Excellent retrieval of an initial item is called Primacy Effect, and excellent retrieval of a last item is called Recency Effect. Generally, Primacy Effect and Recency Effect in memory retrieval are in the form of U-shaped performance curves [7][8][9]. Rundus (1971) argued that tasks in the first part of the list

are more likely to be stored in long-term memories by making more rehearsals, whereas words in the last list are still short-term memories, leading to increased retrieval, and explained that this is why Serial Position Effects occur. Although this argument remains controversial, a variety of clinical studies have proven that there is a distinction between Primacy Effect and Recency Effect. As a representative example, Recency Effects of dementia patients are similar to ordinary person, but Primacy Effects are different from ordinary person [10]-[14].

Looking at Serial Position Effects, depending on the illuminance of light, we can roughly see how the overall memory retrieval pattern, including the Primacy Effect and Recency Effect. And this understanding can provide important information for exploring how differences in illuminance create differences in memory retrieval and performance. This study was conducted to investigate the characteristics of memory retrieval according to illuminance through analysis of Serial Position Effects in bright and dim conditions using LED illumination.

2 Method

2.1. Participants

This experiment was performed in adults 21 people with no cognitive impairment. The participants were 8 males and 13 females, and the mean age was 23.5 years. In addition, prior to the experiment, participants were fully

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informed about the problems that could affect the experiment, such as alcohol or drugs, that could affect cognitive abilities.

2.2 Lighting Environment

The LED lighting used was the GM10743 model lighting manufactured by Ningbo Golemore Industrial Co., Ltd. This product has a diameter of 9 cm and 5 small LED bulbs are inserted. For this experiment, several lightings were used to construct illuminance conditions. In this study, the illuminance condition was designed with high illuminance condition of 1,000 lx and low illuminance condition of 300 lx. The color temperature was 5,500k and the spectral power distribution was the same as the figure.



Fig. 1. LED lighting(GM10743).

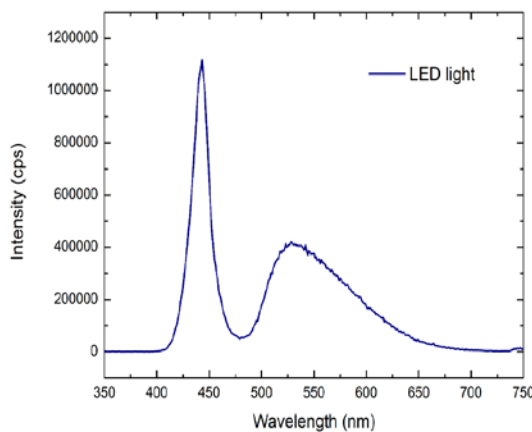


Fig. 2. Spectral power distribution.

2.3 Memory Task

The memory task used word list of 20 items consisting of a series of pointless spellings. After memorizing the word list for 10 minutes, the participant performed a retention task 24 hours later. The memory retention task consisted of filling the empty part of the learned word and completing the word.

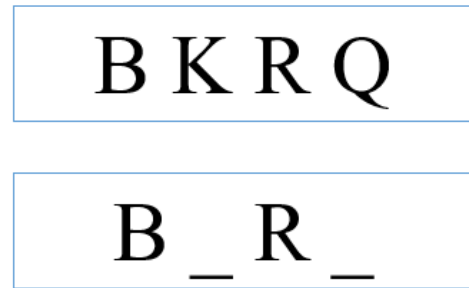


Fig. 3. Example of memory task.

2.4 Experimental Procedure

The experiment was designed with a dim condition of 300 lx and a bright condition of 1,000 lx. For the experiment, the participants first underwent dark adaptation for 2 minutes. After 2 minutes of light adaptation, the participants memorized 20 words items over 10 minutes. After 24 hours from the completion of the memory task, the memory retention was measured through the retention task.

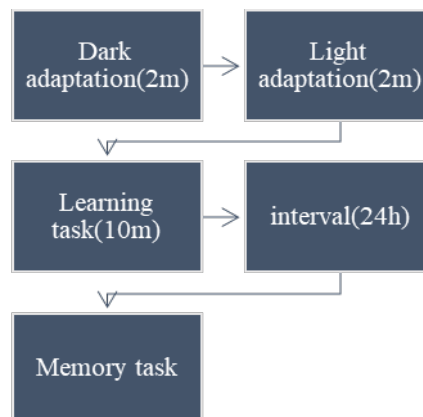


Fig. 4. Experimental procedure.

3 Result

The analysis was performed by dividing the word items into three conditions: primacy, middle, and recency. Primacy used the first item in the word list, Middle used the 10th item in the middle of the word list, and finally Recency used the last item in the word list for analysis. Memory retention was measured as 1 if the memorized word was correctly completed, and 0 otherwise.

The results of descriptive statistics were as follows.

Table 1. Descriptive statistics.

	dim condition(300lx)		bright condition(1000lx)		N
	Mean	SD	Mean	SD	
primacy	.76	.44	.71	.46	21
middle	.38	.50	.52	.33	

recency	.71	.46	.43	.51	
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Then, the variance analysis was performed to verify whether serial position effect appears in the dim condition. The result was $F = 4.16$ ($p = .02$), and showed that there was a statistically significant difference in memory retention of primacy, middle, and recency at 95% confidence level.

Table 2. Result of mean difference (dim condition).

(I)	(J)	Mean difference (I-J)	.sig
primacy	middle	.38*	.028
primacy	recency	.05	.941
recency	middle	.33	.061

* $p < .05$, ** $p < .01$

As a result of the post hoc test, the retention mean difference between primacy and middle items is .38, indicating a statistically significant difference at the 95% confidence level. However, no significant difference was found between primacy and recency, middle and recency. In dim conditions, U-shape curve shape, which is a general aspect of serial position effect, appeared.

However, no statistically significant difference was found between primacy and middle, primacy and recency, middle and recency in bright conditions. In addition, the U-shape curve due to serial position effect was not shown in general, and the retention decreased as the session progressed.

Table 3. Result of t-test (bright condition).

	dim condition	bright condition	.sig
primacy	.76	.71	.733
middle	.38	.52	.279
recency	.71	.49	.064

* $p < .05$, ** $p < .01$

Additionally, the difference verification between primacy, middle, and recency according to illuminance conditions was performed. As a result, there was no significant difference between the dim condition and the bright condition. However, although not statistically significant, the pattern of serial position effects showed a different pattern. Especially in bright condition, recency effect was very low compared with dim condition.

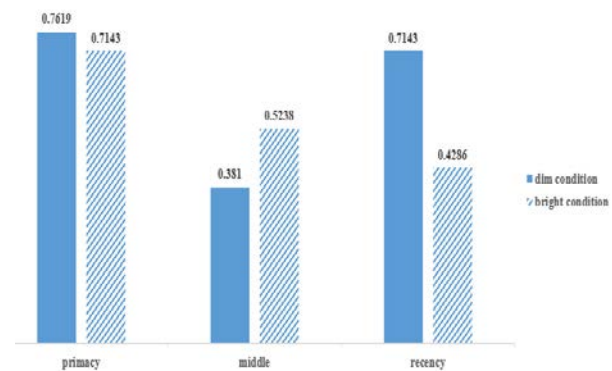


Fig. 5. Aspect of serial position effects by light condition.

4 Conclusion and Discussion

The purpose of this study was to verify the forms of the effect of serial position effects of memory according to the illuminance of light. The study verified that primacy effect appears in both bright and dim conditions where the brightness of light is relatively dark. And the results of this study showed that the difference between primacy and middle items was statistically significant in relatively dim conditions. These results show that the primacy effect is strong in the dim condition, and the retrieval is low in the middle item. The recency effect was also good in the dim condition, but it was low in the relatively bright condition.

One of the possibilities that the recency effect does not appear well under bright light conditions may be due to the depletion of attentiveness over time due to the increased use of attention in bright light conditions compared with dim conditions. Previous studies have consistently shown that attention is high in bright light conditions rather than in dark light conditions. Therefore, in order to verify this aspect of recency effect, it is necessary to consider both the attention aspect and fatigue in light conditions. This is a research topic to be covered in future research.

Despite the contribution of research, this study has limitations in that primacy, middle, and recency were measured only as one item and the difficulty of item was not taken into consideration. These limitations may be helpful for a more systematic understanding of the effects of light on memory if supplemented by further studies.

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