

# Reflected Light vs. Transmitted Light: Do They Give Different Impressions to Users?

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## ABSTRACT

*The difference in information display between using a projector (reflected light) and a display (transmitted light) is an essential issue. Marshal McLuhan proposed in his book "Laws of Media" the well-known hypothesis that "reflected light makes people analytical and transmitted light makes them emotional." In this study, we matched the display conditions of the projector and display as much as possible. Then we presented the subjects with emotional content (landscape video) and analytical content (three-digit multiplication) and asked them to evaluate their experiences. As a result, we found no statistical difference between the projector and the display evaluations.*

## 1 Introduction

Information display and viewing include two methods. One is displaying information on a screen with a projector (PJ), by which we receive information through the reflected light. Another is displaying information using an LED or liquid crystal display (DP), by which we get information by transmitted light. DP has the characteristic of clearly showing even in the daytime because of its high brightness. On the other hand, PJ can project images not only on a flat surface but also on a curved surface.

Due to these differences in characteristics, PJ and DP are appropriately used depending on each scene. However, as to what kind of effect information displayed by these different methods would give human psychology, there is still little accumulation of essential data.

This psychological experiment aimed to clarify the difference in appearance between PJ and DP through psychological experiments after adjusting various conditions of DP and PJ devices as much as possible.

## 2 Related research

Regarding reflected and transmitted light, Marshall McLuhan made a well-known statement in his book "Laws of Media" that "reflected light makes people logical and transmitted light makes them emotional [1]" based on the experiment by Herbert E. Krugman [2].

This is associated with the common belief that, in the case of finding errors in text, checking on printed paper (reflected light) is easier to find mistakes than checking on

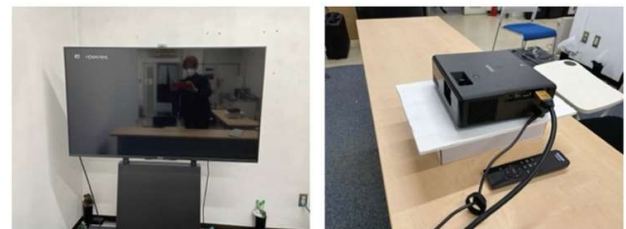
display (transmitted light), and various discussions are being held online (for example [3]). Also, several experiments have been conducted to confirm this [4]. However, no investigations have been undertaken to examine the difference in appearance between PJ (reflected light) and DP (transmitted light) after strictly controlling the conditions.

Based on this, in this study, we carried out psychological experiments after matching the display conditions of PJ and DP as much as possible.

## 3 Environmental conditions

### 3.1 Display device

In this research, we investigated how the difference in devices, such as whether to use reflected light or transmitted light, affects the appearance when conditions such as brightness, contrast, etc. of these devices are adjusted as much as possible. We adopted the device size of 55 inches (screen size: 139.7 cm diagonal x 121.7 cm horizontal x 68.5 cm vertical). We used the following display devices in the experiment.



**Fig. 1. A display and a projector used for the experiment.**

Display device 1: SONY KD-55X8500B (55-inch liquid crystal display) (Fig. 1: left).

Display device 2: Epson EF-11 (Brightness: 1000 lumens, resolution: Full HD, laser light source) (Fig.1: right)

### 3.2 The positional relationship between the display surface and the subject

Generally, the optimum viewing distance is screen height x 3. Since  $68.5 \times 3 = 205.5$  cm, a subject sits 2 m away from the screen and watches the displayed content.

### 3.3 Setting the experimental environment.

Figure 2 shows the settings for the entire experimental environment. The DP was set on the front side of the room. Also, the projector and the screen were placed on the side of the room. When changing the display device, the subjects changed their sitting position to always sit in front of the displayed content.



Fig. 2. Setting of the experiment

### 3.4 Display device condition settings

We have set the conditions for the DP and PJ as similar as possible as follows.

- Screen size: 55 inch
- Brightness: 163cd / m<sup>2</sup>
- Resolution: Full HD
- SRGB (Cover rate is 94% for both PJ and DP, area ratio is PJ / 107%, DP / 96%)
- White color temperature: PJ/7231K, DP/6792K
- Contrast PJ/580, DP/1148
- Frame: To make the appearance of the PJ and DP as similar as possible, a frame was installed using black tape around the screen projected on the wall surface. (Fig. 3).



Fig. 3. A frame is installed on the projection surface of the projector.

### 3.5 Lighting conditions.

Initially, to maintain the minimum illuminance required for work, we planned to secure an illuminance of about 200 lux on the work desk. However, in the projection by a PJ, the illumination is reflected on the projection surface, reducing the actual brightness and contrast, not making an equal comparison with the DP. Therefore, the experiment was carried out without lighting.

## 4 Experimental conditions

### 4.1 Scene

The following two scenes were targeted.

Scene 1: Passively watch the displayed video (landscape video).

Scene 2: Actively watch the displayed image while doing some work (mathematical task).

### 4.2 Subject

In this psychological experiment, we used 34 students of Kyoto University as subjects (Male: 21 and female: 13).

### 4.3 Content

We prepared multiple contents and provided them to the subjects in a well-balanced manner for each condition and subject according to the design of the experiments. Specifically, we used the following contents.

Content 1: 4 types of landscape videos (Resolution: Full HD)

<https://www.youtube.com/watch?v=Q98ACV6SVe8>

<https://www.youtube.com/watch?v=mee3u5jJTts>

<https://www.youtube.com/watch?v=4ijYpgSkxPo>

[https://www.youtube.com/watch?v=E5hZKq\\_broQ](https://www.youtube.com/watch?v=E5hZKq_broQ)

Figure 4 shows the situation in which a subject is watching the landscape video.



Fig. 4. A subject watching a landscape video

Content 2: 3 digits x 3 digits multiplication

Initially, we thought about displaying only the problem on the screen and having the subjects carry out multiplication on the work desk. However, since it was necessary to have them pay close attention to the display screen, we decided for them to perform the multiplication using the keyboard while watching the display screen.

Several multiplication practices were conducted before achieving the actual experiment. Almost all subjects could get used to multiplication using the keyboard and screen by practicing only one problem.

### 4.4 Measurement method

The seven-scale SD method was adopted as the subjective evaluation method.

### 4.5 Experimental procedure

Based on the preliminary experiment, the viewing duration of the landscape image was set to 5 minutes, and multiplication was set to 7 minutes.

### 4.6 Evaluation items

The following items selected from the evaluation items used in the literature [5][6] were used as evaluation items. Also, we have added several evaluation items depending

on our experiment [7]. In addition, for scene 2, the number of multiplications the subjects could answer and the correct answer rate of the task are also evaluated.

1) How did you feel? (Impression)

Comfortable – Uncomfortable, Familiar – Unfamiliar, Beautiful - Not beautiful, Calm – Restless, Interesting – Boring, Warm – Cold, Changeable - Not changeable, Flashy – Plain, Unique – Ordinary, Like - Dislike

2) What kind of effect does it have? (Effect)

Work goes well - Work does not go well, Can relax - Cannot relax, Can be creative – Cannot be creative, Motivated - Not motivated, Can face difficulties - Cannot face difficulties, Can get rid of tiredness - Cannot get rid of tiredness.

## 5 Experimental Result

### 5.1 Comparison of average values

Figure 5 compares the DP and PJ when targeting landscape images,

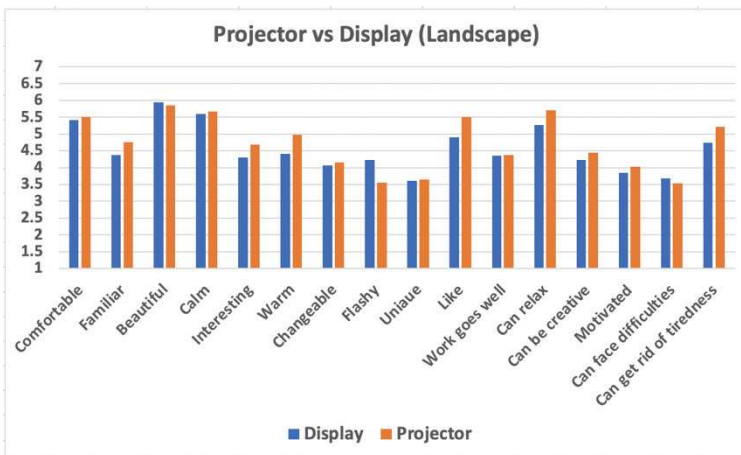


Fig. 5. Comparison of display and projector for landscape video

In addition, Fig. 6 compares the DP and PJ regarding the number of answers in multiplication (the average number of multiplications performed in time). Figure 7 shows the comparison between the DP and PJ regarding the correct answer rate (the average percentage of correct answers among the obtained answers).

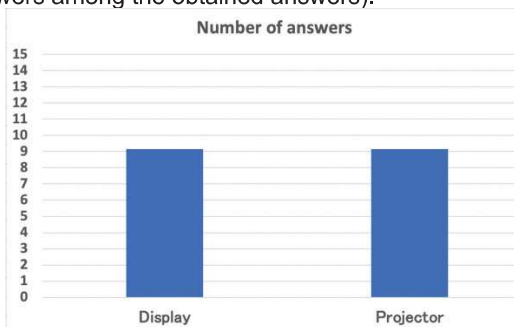


Fig. 6 Display-projector comparison for the number of obtained answers in multiplication.

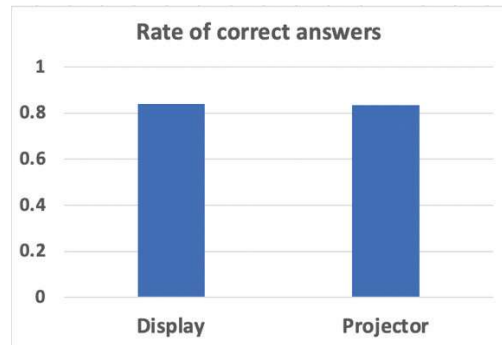


Fig. 7. Display-projector comparison for correct answer rate in multiplication.

### 5.2 Consideration1

(1) Comparison of DP and PJ for landscape images

According to Fig. 5, when compared with the intermediate value of 4, evaluation values of 4 or more are obtained in many cases. Regarding the relationship between the evaluation values for each evaluation item, the same tendency was observed that if one was high, the other was also high. More detailed analysis is given in 5.3 and 5.4.

(2) Comparison of DP and PJ for multiplication

Regarding the number of answers and the rate of correct answers, the results showed almost no difference between the display and the projector.

From these results, when multiplication is targeted, in other words, when logical processing is performed, there is almost no difference between DP and the PJ. This indicates that transmitted and reflected light has almost no effect on humans when performing logical processing.

Therefore, in the following, the difference between DP and PJ will be analyzed in more detail regarding the impact on human non-logical processing.

### 5.3 Factor analysis

A similar tendency is obtained for the averaged evaluation values in Fig. 14. But it is unclear whether there is a difference due to many evaluation items. Therefore, we conducted a factor analysis on ten evaluation items related to "How did you feel (impression)?"

First, an exploratory factor analysis (Maximum Likelihood method, Promax Rotation) was performed on the ten evaluation items. Based on the results, three factors were considered based on the attenuation pattern of the eigenvalues (3.806, 2.084, 1.124, ...). Next, factor analysis (Maximum Likelihood method, Promax Rotation) was performed with three factors. The results are shown in Table 1.

Factor 1 includes four items: "interesting," "unique," "changeable," and "flashy." As these are considered to mean a sense of dynamism, they are grouped into a

variable called a “dynamism factor.” Factor 2 includes four items, “beautiful,” “comfortable,” “calm,” and “liking,” which can be summarized as a composite variable named “serenity factor.” Factor 3 consists of two items, “warm” and “familiar,” which can be combined into a composite variable called “familiarity factor.”

**Table 1. Results of factor analysis of 3 factors on "impression."**

Item	Factor1	Factor2	Factor3	Synthesized factor
Interesting	.830	-.031	.076	Dynamism factor
Unique	.794	.043	-.065	
Changeable	.769	-.137	.183	
Flashy	.592	.092	-.308	
Beautiful	.087	.933	-.246	Serenity factor
Comfortable	-.009	.716	.097	
Calm	-.258	.680	.282	
Liking	.339	.432	.325	
Warm	.023	-.040	.808	Familiarity factor
Familiar	-.025	.045	.403	
$\alpha$ coefficient	.822	.825	.490	

Next, we conducted a factor analysis on the six items in "What kind of effect does it have (effect)." First, an exploratory factor analysis (Principal Factor method, Promax Rotation) was performed on the six evaluation items. Based on the results, two factors were considered based on the attenuation pattern of the eigenvalues (3.079, 1.234, ...). Next, factor analysis (Principal Factor method, Promax Rotation) was performed with two factors. The results are shown in Table 2.

Factor 1 includes four items: “motivated,” “can face difficulties,” “can be creative,” and “work goes well.” These are summarized as a composite variable named the “motivation factor.” Factor 2 includes two items, “I can relax” and “I can get rid of tiredness”, which are combined into a composite variable named “relaxation factor.”

**Table 2. Results of factor analysis of two factors on "effect."**

Item	Factor1	Factor2	Synthesized factor
Motivated	.946	-.050	Motivation factor
Can face difficulties	.727	-.083	
Can be creative	.652	.093	
Work goes well	.599	.130	
Can relax	-.073	.934	Relaxation factor
Can get rid of tiredness	.118	.673	
$\alpha$ coefficient	.826	.776	

#### 5.4 ANOVA

Regarding "impression," the ten evaluation items were combined into three composite variables. A two-way ANOVA was performed on these three synthetic variables. The constituent elements are two factors: two levels of display methods (DP, PJ) and three levels of impressions (dynamism, serenity, and familiarity) using synthetic variables. The result shows that there is no difference since the main effect for the display method is not significant ( $F(1, 33)=2.16, p=.151$ ). This result indicates no

significant difference between PJ and DP.

Next, regarding "effects," the six evaluation items were combined into two synthetic variables, and a two-way ANOVA was performed on these two synthetic variables. The constituent elements are two factors: two levels of display methods (display, projector) and two levels of effects (motivation, relaxation) using synthetic variables. The result show that the main effect of the display method is not significant ( $F(1, 33)=1.89, p=.178$ ), indicating that there is no significant difference between the two display methods of PJ and DP.

#### 5.5 Consideration2

The results of the ANOVA, when viewing a landscape image, showed no significant main effect between DP and PJ both for the evaluation items regarding “impression” and “effect.” This indicates that there is no significant difference between DP and PJ while performing activities that appeal to the senses and emotions, such as viewing a landscape image.

In addition, in performing multiplication, which involves performing logical processing while looking at the screen, it was found that there was no significant difference between DP and PJ in terms of the number of multiplications and the accuracy. This indicates that there is no significant difference between DP and PJ when performing the logical activity of multiplication.

#### 6. Conclusion

It is well known that Marshall McLuhan proposed a hypothesis in his book "Laws of Media" that "reflected light makes people logical and transmitted light makes people emotional." However, our experiments did not support the hypothesis proposed by him. However, regarding the validity of this hypothesis, it is necessary to further examine its validity using more highly valid experimental tasks, which is our future.

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