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RESEARCH ARTICLE

Effect of Art's Increasing Human Creativity and Motivation When Viewed in An Immersive Environment

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ABSTRACT

This study was conducted on the assumption that art appreciation contributes to improving people's motivation and creativity, and to verify this through psychological experiments. As art, video art created by one of the authors, a media artist, was used. This is an artwork based on natural phenomena, and does not contain much of the artist's own arbitrary decisions, and has general applicability as art. In order to increase the effect of viewing art in a vast space, we constructed a hexagonal experimental environment using a mirror-type display that has both mirror and display functions.

Within this experimental environment, 40 subjects viewed and evaluated the video art. For comparison, we used simple geometric figures and a case where there was no displayed content. As evaluation items, in addition to factors related to impression and relaxation, one of the authors, who is a specialist in psychology and physiology, proposed new evaluation items related to motivation and creativity.

The results of the psychological experiment confirmed that the initial hypothesis was correct, with art content receiving significantly higher ratings than geometric figures and no content at the 1% level for impression, motivation, and creativity factors.

Keywords: Immersive Space, Mirror Display, Psychological Evaluation, Creativity

1 Introduction

Art has the power to enrich people's hearts, heal their minds, and inspire them, and there has been a lot of research done on this topic[1-5]. It is thought that excellent art can immerse people in its world[6,7], and this is why art leads to these effects. The art that has been used in previous research on evaluating art is so-called fine art, such as paintings. New art forms such as video art[8-10] have emerged, but there has been no research into the effects of video art on the human mind.

On the other hand, there is research into virtual reality (VR)[11-14] that gives people a sense of immersion, and although there is a lot of effort being put into research into VR technology, there is not much research into the design and construction of immersive spaces that combine art and VR, or into evaluating them. The authors have started a study to evaluate how art appreciation affects people's minds using video art, and to design and construct an immersive space suitable for art content, as well as to evaluate how people feel when they appreciate art content in that space through psychological experiments.

The art content used was the video art of one of the authors, Tosa Naoko (hereafter "Tosa Art"). Tosa Art is video art that uses technology to extract the beauty hidden in natural phenomena, and its characteristic features are its abstract and organic shapes. Many people who have viewed Tosa Art have commented that it makes them feel as if they are in outer space, or that it improves their creativity. If art appreciation leads to improved creativity, it will lead to new applications of art, so we set out to prove the hypothesis that art appreciation contributes to improved creativity.

First, we decided to create an immersive space surrounded by mirror displays that have both mirror and display functions, as we thought that the characteristics of Tosa art would be expressed when it was viewed in a large space. In this paper, we will first describe the design and construction methods for the immersive space. Next, we conducted a psychological experiment in which we asked participants to view Tosa art in the immersive space and perform a subjective evaluation. The results of the psychological experiment were analyzed to examine the impact of the combination of the immersive space and Tosa art on people's minds. As a result of this, the hypothesis that art appreciation contributes to improving people's creativity was verified. This paper discusses these contents.

2 Related research and activities

2.1 RESEARCH ON THE IMPACT OF ART ON PEOPLE'S PSYCHOLOGICAL STATE

It is well known that art has a significant impact on people's psychology. There have been many studies on the relationship between art that appeals to the senses, such as paintings, and music, and psychology [1]. It has been reported that visiting art museums and viewing paintings can lower blood pressure and reduce stress [2]. It has also been reported that art appreciation is effective in preventing and treating dementia[3]. Using this, there is also a project underway that aims to prevent and reduce dementia by systematically having patients with dementia visit art museums[4]. Furthermore, it has also been reported that not only art appreciation, but also being involved in art production is effective in the treatment of cancer and other illnesses[5].

2.2 RESEARCH ON IMMERSIVE SPACES

The purpose of VR is to create a space different from reality and to give people an immersive feeling as if it were reality.[11-14] VR space can be constructed by projecting images into an actual space using a projector or displaying images on an HMD (Head Mounted Display).[15, 16] In both cases, there is much research on adding the senses of touch, taste, and smell to increase the sense of presence. As these are primitive human senses, however, there is a problem: Research progress takes time.[17-19]

2.3 FUSION OF VR AND ART

Attempts to fuse art and VR occurred with the advent of VR and have continued until now. For example, William Latham[20] of Goldsmiths, University of London, has been actively creating an art-expressed artificial life form called "Mutator VR[21]." In the 1990s, there were many attempts to create an immersive space (CAVE is a typical example of such an immersive space[22, 23]) using projectors, etc., and to display art in the space.

2.4 CONSTRUCTION OF IMMERSIVE SPACE USING MIRRORS

Mirrors are often used in art expression because it is relatively easy to create a seemingly endless space by using mirrors. One well-known example is Yayoi Kusama's "Infinity Mirror Room," in which she installed her art in a mirrored space.[24, 25]

3 Digital Art "Sound of Ikebana"

3.1 CONCEPT OF "SOUND OF IKEBANA"

One of the authors, Naoko Tosa, discovered that by applying sound vibrations to a fluid such as paint and photographing it with a high-speed camera, the fluid creates a shape similar to that of Ikebana (Japanese flower arrangement).[26, 27]

Figure 1 shows a specific fluid art production system. The speaker is placed face up, a thin rubber membrane is stretched over it, and a fluid such as paint is placed on top.

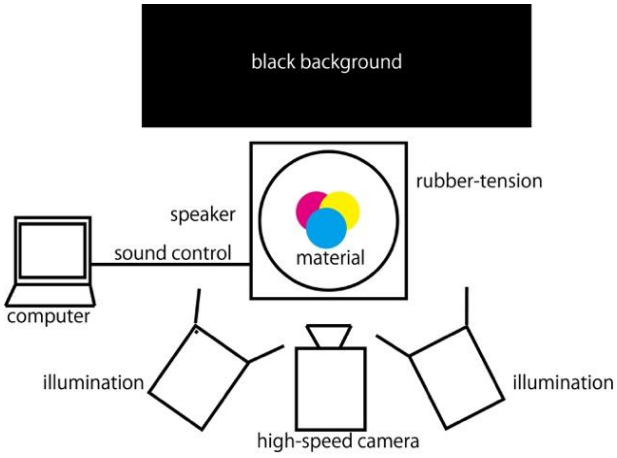

Fig. 1. Fluid art production system

Using this environment, Tosa confirmed that various fluid shapes could be generated by changing the shape of the sound, the frequency of the sound, the type of fluid, and the viscosity of the fluid[28].

Tosa further edited the resulting video to match the colors of the Japanese seasons and created a digital artwork called "Sound of Ikebana." Figure 1 shows a scene from the work. For the details of the art creation process, please refer to:[28-30] Although there has been various research on the visualization of sound, called "Cymatics" (for example:[31]), this is another way of sound visualization.

Fig. 2. A scene from "Sound of Ikebana."

3.2 EFFECTS OF "SOUND OF IKEBANA" ON HUMAN

When Tosa exhibited her digital art around the world with a focus on the "Sound of Ikebana," many overseas art professionals pointed out that "Tosa's digital art, which expresses beauty latent in physical phenomena in an abstract form, expresses beauty previously unnoticed by Westerners, and this is Japan's consciousness and sensitivity."

Since then, "Sound of Ikebana" has taken on challenges in new directions, such as attempting to create new shapes by using the birth cries of newborn babies and the voices of Olympic athletes as sound sources and attempting to create art in the space age by creating works under microgravity.[29] Many people who have viewed Tosa art have commented that they feel their creativity is enhanced. A stimulating new art effect can be found if art appreciation enhances the viewer's creativity. Such effects are apparent in a space with infinite expansion[24]. This also led us to design and construct a space that gives a sense of infinite expansion and have visitors view Tosa art in that space to see if it improves creativity.

4 Design and construction of immersive spaces using mirror displays

4.1 MIRROR DISPLAY

As mentioned in 2.4, using mirrors is appropriate for constructing a system that gives the impression of being in an infinite space[24]. Here, we decided to use a mirror display with the functions of both a mirror and a display.

We used a mirror display developed by AGC Corporation and commercialized under the name "Mirroria[33]". The feature of this display is that it achieves a half-mirror reflectance of approximately 65%, the same level of reflectance as that of an ordinary mirror, by utilizing the company's glass manufacturing technology.

4.2 DESIGN AND CONSTRUCTION OF IMMERSIVE SPACES

Through several psychological experiments, we have confirmed that art content positively affects the human mind.[34, 35] Art content was displayed on large LED and mirror displays in these experiments. To take this further and confirm whether art content is effective in improving people's creativity, placing people in a more immersive environment would be effective.

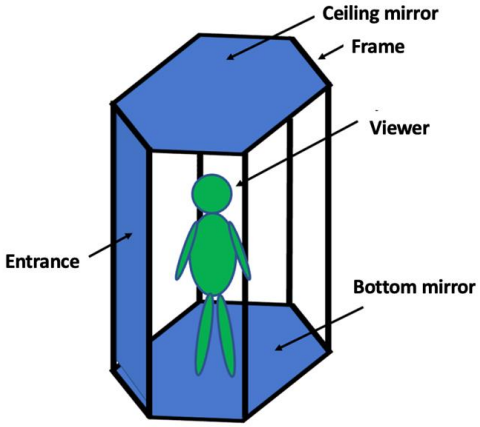

Fig. 3. Conceptual diagram of immersed space.

Therefore, we have constructed an environment in which the space is surrounded by mirrors and part of the mirrors are used as mirror displays to display art contents. First, a hexagonal space surrounded by rectangular mirrors is constructed. The concept is shown in Fig. 3, where the hexagonal space comprises three sets of two mirrors facing each other. It is well known that mirrors create an infinite number of images by mutually reflecting each other.[36] By having three sets of mirrors, the person inside feels as if he/she is surrounded by countless mirror images of himself/herself. Furthermore, by using the ceiling and floor as mirrors, one feels as if one is surrounded by an infinite number of images of oneself, both above and below.

The six mirrors that make up this hexagonal space are mirror displays and can display images. Since the vertical length of the mirrors is longer than the vertical length of the display, the display on which the images are shown forms part of the mirrors. At the same time, the position of the display is variable in the vertical direction (Fig. 4). This makes it possible to shift the position where the six mirrors display the image. Suppose the mirrors facing each other have the same position for displaying the images. In that case, the respective images will interfere with each other, reducing the sense of an endless series of images. Thus, by shifting the position of the image display, it is possible to create the effect of an endless series of images without having each image interfere with the other.

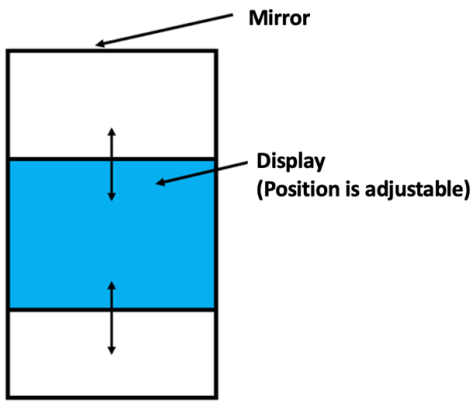

Fig. 4. Configuration of individual mirror displays.

Fig. 5. Exterior view of the immersed space (Left: exterior view, Right: door open).

The appearance of the constructed immersive space is shown in Fig. 5. Inside this device, even simple shapes can generate an environment of beauty by continuing back and forth, left and right, and up and down indefinitely (Fig. 6). Figure 7 shows several scenes where Tosa art is shown as an example of art content.

Fig. 6. Geometric figure (circle) displayed in the immersed space.

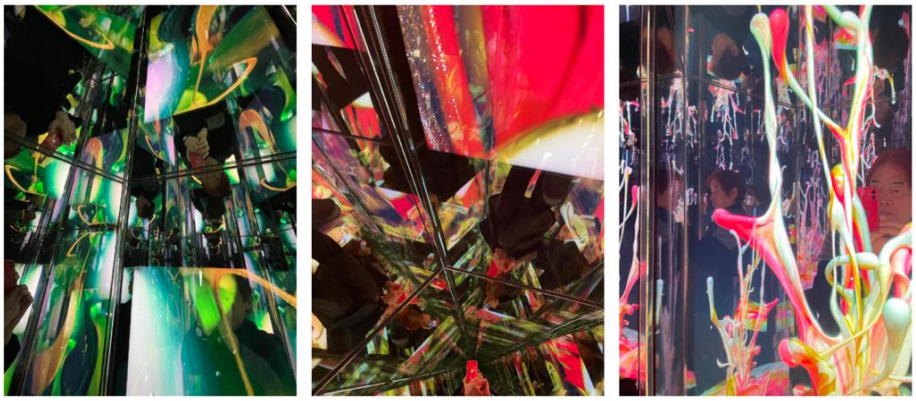

Fig. 7. Example of displaying Tosa Art in the immersive space.

In this immersive space, we have conducted preliminary experiments in which people viewed Tosa Art. Interestingly many of them have commented that they felt their creativity increased. Then, we have set the following hypothesis.

Hypothesis: The combination of the immersive space and Tosa Art increases human creativity. Next, we conducted psychological experiments to check this hypothesis.

5 Evaluation of immersive space by psychological experiments

5.1 EVALUATION CONCEPT

We evaluated the constructed immersive space. This immersive space gives people inside it the feeling of being in an infinitely expanding space. To evaluate this immersive space, we conducted a psychological experiment to compare and evaluate the impression subjects receive when art content and comparison content are displayed.

As for the art content, we decided to use Tosa Art. The reasons for this are as follows.

Art encompasses a wide range of genres, including painting, sculpture, and video art, such as the one used in this study, and there are an extremely large number of works. When evaluating art, it is necessary to select a small number of artworks for evaluation, and it is important to consider how to make the evaluation as general as possible. It is difficult to determine what kind of art is general, but we believe that the following types of art can be used as indicators of generalness

(1) Artworks that do not include the artist's subjectivity have general appeal: Artworks such as paintings created with a paintbrush are thought to show the artist's subjectivity more clearly. In order to have general appeal, artworks that do not include the artist's subjectivity are preferable.

(2) Abstract art is more general than figurative art: Because figurative art is art that depicts a concrete object, the viewer pays attention to what is being depicted, and this may bias the evaluation results. There is research that shows that figurative art is more highly evaluated in evaluation experiments comparing figurative art and abstract art with ordinary people as the target.[39] This is thought to be the result of such bias. In contrast, when it comes to abstract art, the viewer is not focused on what is being expressed, but is able to purely evaluate the impression given by the artwork.

As mentioned earlier, "Sound of Ikebana" is art created by applying sound vibrations to a fluid, and is art that is close to physical and natural phenomena. In that sense, it fulfills condition (1). In addition, by using a high-speed camera to film it, it is not just a familiar splattering of fluid, but an abstract shape. In that sense, it fulfills condition (2). Of course, this alone does not mean that "Sound of Ikebana" represents all art, but it is thought to be art with a certain degree of generality.

5.2 CONTENTS USED IN THE EXPERIMENTS

(1) Art Content

For the reasons stated above, we decided to use Tosa Art. Specifically, we used a 3-minute video with the "Sound of Ikebana" as its primary content.

(2) Comparative Content

When conducting evaluation experiments using art content, preparing comparison content is essential. As there are examples of research using geometric figures as comparison stimuli in artworks (e.g.: [40]), it is thought that using geometric shapes as comparison stimuli is appropriate.

We used simple geometric figures such as circles and squares as comparison contents. We conducted a preliminary experiment and evaluated several geometric figures through psychological experiments to determine the geometric figures to be compared with the art contents. The following three types of geometric figures were used in the preliminary experiment.

Geometric Figure 1: The shape is a circle and only the color changes with time.
Geometric Figure 2: The shapes change to circles and squares in sequence along with the colors.
Geometric Figure 3: The shape is a square, and the square rotates. The colors change with time, as in Geometric Figures 1 and 2.

Here, the colors were set to be the same as the representative color of the art content, in synchronization with the time variation of the color of the art content, to create a similar impression as the art content. Preliminary experiments showed no significant differences among the three types of geometric shapes. As the degree of change for Geometric Figure 2 is in the middle among the three types, we decided to use Geometric Figure 2 (hereafter referred to as "Figure") for comparison with the art content. The details of the preliminary experiments are described in the literature[30] and can be found there.

5.3 EVALUATION ITEMS

Regarding the evaluation items, first, an evaluation item, "Impression factor," was established to determine what impression the subjects had. This has been used in several psychological experiments such as:[14-16] and used by us for art evaluation.

In addition, since one of the purposes of this evaluation is to assess whether the combination of "immersive space + art content" arouses people's creativity, we decided to add an evaluation item regarding how it affects people's minds. As a result of discussions led by one of the authors, Michio Nomura, who specializes in psychology, we decided to evaluate the content in terms of whether it relaxes people's minds ("Relaxation factor"), whether it inspires people's minds ("Motivation factor"), and whether it arouses people's creativity ("Creativity factor"). Specific evaluation items are shown in Table 1 below. Overall, there are 24 evaluation items, which is done on a 7-point scale. The difference in meaning between "immersed," one in the Motivation factor, and "immersive," one in the Creative factor, is subtle, but "immersed" corresponds to logical brain processing, such as "immersed oneself in studying." In contrast, "immersive" corresponds to sensory brain processing, such as "listening to music makes me immersive."

Table 1. Evaluation Items

1. Impression factor (9 items)	**3. Motivation factor (5 items)**
Comfortable - Uncomfortable	Enthusiastic – Not enthusiastic
Friendly - unfriendly	Immersed – Not immersed
Beautiful **-** Not beautiful	Curious – Not curious
Calm **-** Restless	Motivated – Not motivated
Interesting **-** Boring	Aroused – Not aroused
Warm **-** Cold	**4. Creativity factor (5 items)**
Changeable - Not changeable	Associate – Do not associate
Luxury **-** Sober	Immersive – Not immersive
Individual **–** Ordinary	Activated – Not activated
2. Relaxation factor (5 items)	Inspired – Not inspired
At ease – Not at ease	In the zone – Not in the zone
Secure – Not secure	
Pleasant – Not pleasant	
Relaxed – Not relaxed	
Healed – Not healed	

5.4 PARTICIPANTS

Forty students (thirty-two males and eight females) in their first through fourth year at Kyoto University participated in the experiment. They were recruited through the website of Kyoto University Co-op.

As there are no art-related faculties or departments at Kyoto University, these students did not receive any art education. However, when recruiting students, we used a statement asking for students with an interest in art to participate. Therefore, students with no interest in art were not included in the subjects.

5.5 EXPERIMENTAL PROCEDURE

Below is the process of the experiment. Also, the process is visualized in Fig. 8.

1) First, after briefly explaining the purpose and content of the experiment, the participant signed a consent form.
2) The participant moved into the immersive space.
3) Then, the participant performed an initial evaluation before viewing Content 1 ("No content" condition). The participant brought his/her smartphone into the space, and the evaluation was done using Google Forms.

4) Before Content 1 was displayed, a resting period (3 minutes) was taken to reset the participant's psychological state. During this time, the display was kept black.
5) Contents 1 (Art or Figure) was displayed (3 minutes).
6) After viewing Content 1, the participant was asked to complete a second evaluation ("Art" or "Figure" condition).
7) Before Content 2 was displayed, a resting period (3 minutes) was taken to reset the participant's psychological state. During this time, the display was kept black.
8) Contents 2 (Art or Figure) was displayed (3 minutes).
9) After viewing Content 2, the participant was asked to complete a third evaluation ("Art" or "Figure").
10) Then, the participant exited the immersive space.

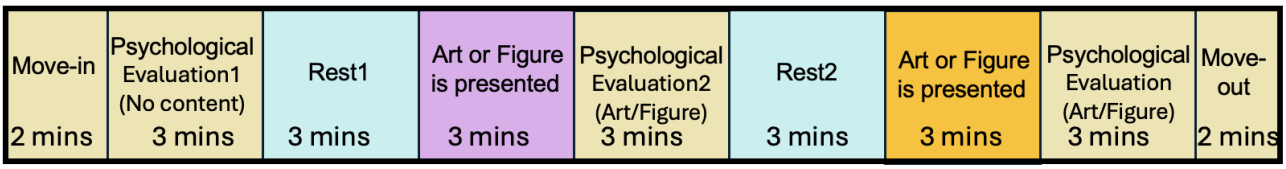

Fig. 8. Procedure of the experiment.

Regarding the order of presentation of art and geometric figures, to ensure that order effects did not affect the results, the order was controlled for each participant so that the total order of Art → Geometric figures and Geometric figures → Art was 20, respectively.

The obtained data was analyzed using HAD, a free software program created by psychologist Hiroshi Shimizu.[41]

6 Evaluation results

6.1 RESULTS FOR EACH EVALUATION FACTOR

The averaged evaluation scores of 40 subjects for each Impression, Relaxation, Motivation, and Creativity factor are shown in Figs. 9, 10, 11, and 12, respectively. In these figures, the graphs show the differences in the evaluation scores for three different contents: while the display was kept black ("No content"), after viewing the geometric figures ("Figure"), and after viewing the art content ("Art"). Also, the results of the analysis of variance (ANOVA), which will be described later, are overlapped on these figures.

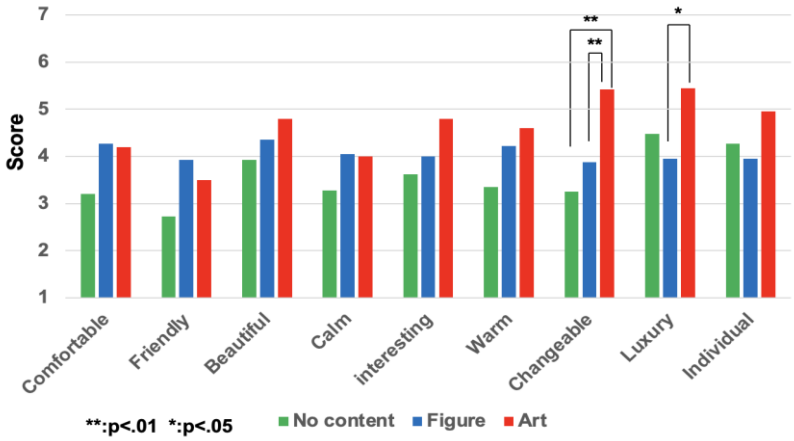

Fig. 9. Evaluation results for Impression factor.

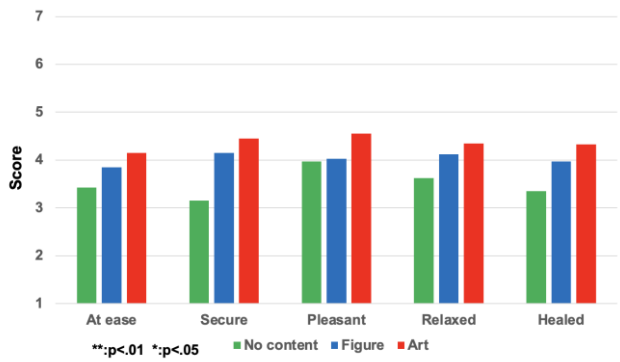

Fig. 10. Evaluation results for Relaxation factor.

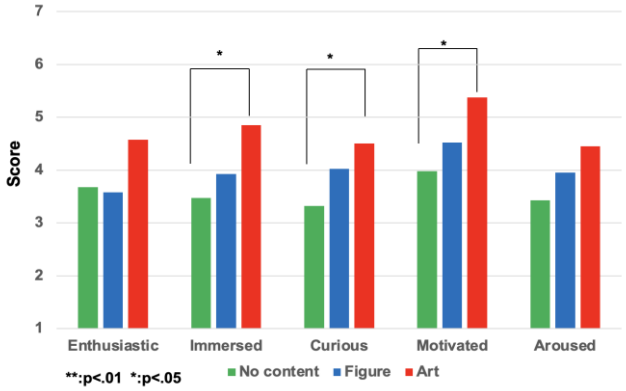

Fig. 11. Evaluation results for Motivation factor.

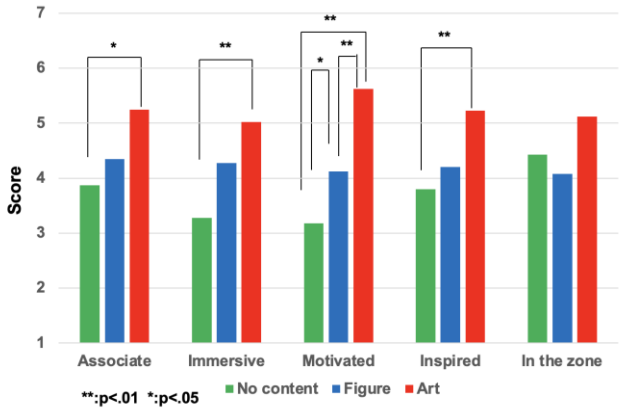

Fig. 12. Evaluation results for Creativity factor.

6.2 DISCUSSION FOR THE RESULTS OF 6.1

(1) Averaged evaluation results

In the individual evaluation results, for many of the evaluation items, the results were higher in the order of "No content < Figure < Art," indicating the effectiveness of the "immersive space + Tosa art" approach.

(2) Individual evaluation items results

For the nine items on the Impression factor, for the item "Changeable," there were significant differences between "No content" and "Art," and "Figure" and "Art" at the 1% level. For the item "Luxury," there was a significant difference between "Figure" and "Art" at the 5% level.

There were no significant differences among "No content," "Figure," and "Art" on any of the five items of the Relaxation factor.

There was a significant difference for three of the five items on the Motivation factor. For the items "Immersed," "Curious," and "Motivated," there were significant differences between "No content" and "Art" at the 5% level.

There were significant differences for four items on the Creativity factor. For the item "Motivated," there were significant differences between "No content" and "Art" and between "Figure" and "Art" at the 1% level. Also, there was a significant difference between "No content" and "Figure" at the 5% level. For the items "Immersive" and "Inspired," there were significant differences between "No content" and "Art" at the 1% level. Also, for the item "Associate," there was a significant difference between "No content" and "Art" at the 5% level.

6.3 RESULTS OF ANOVA REGARDING THREE TYPES OF CONTENT

In order to verify the significance of the differences in evaluation scores between each content in 6.1, we calculated the averaging score of each Impression, Relaxation, Motivation, and Creativity factors for each participant, and conducted a one-way analysis of variance (ANOVA). The results are shown in Fig. 13 (Impression factor), Fig. 14 (Relaxation factor), Fig. 15 (Motivational factor), and Fig. 16 (Creativity factor).

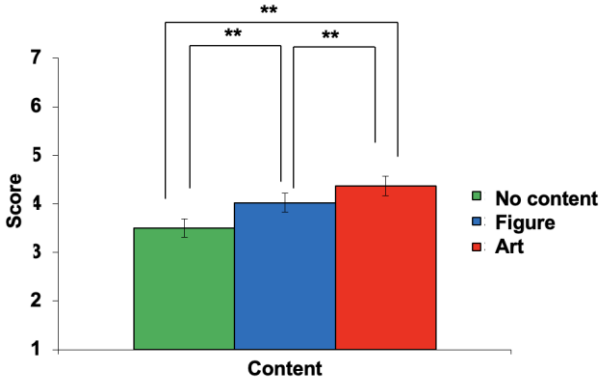

Fig. 13. ANOVA results for the overall Impression factor.

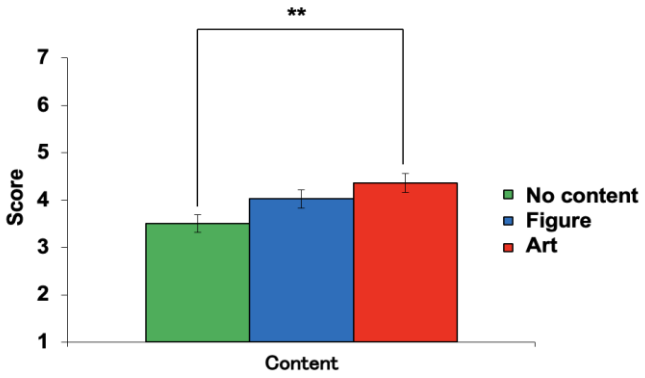

Fig. 14. ANOVA results for the overall Relaxation factor.

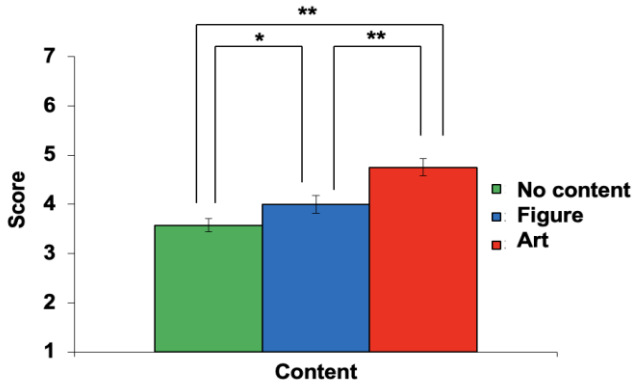

Fig. 15. ANOVA results for the overall Motivation factor.

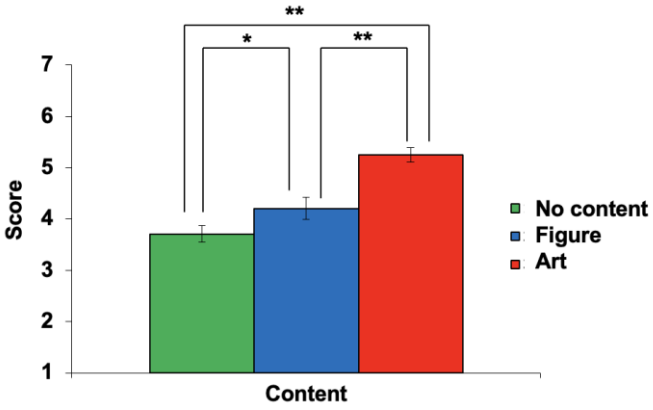

Fig. 16. Analysis of variance results for the overall Creativity factor.

6.4 DISCUSSION FOR THE RESULTS OF 6.3

A one-way ANOVA was conducted on the overall Impression, Relaxation, Motivation, and Creativity factors. The results showed that, except for the Relaxation factor, there were significant differences among "No content," "Figure," and "Art" (Figs. 13 through 16). Specifically, for the Impression factor, there was a significant difference at the 1% level among each combination of "No content," "Figure," and "Art" (Fig. 13). As for the Motivation and Creativity factors, there was a significant difference at the 1% level between "No content" and "Art" and between "Figure" and "Art." Also, there was a significant difference between "No content" and "Figure" at the 5% level (Figs. 15 and 16).

For the Relaxation factor, we found a significant difference at the 1% level between "No content" and "Art" but no significant difference for the other combinations (Fig. 14).

6.5 OVERALL RESULT

The results shown and discussed through 6.1 ~ 6.4 indicate that Tosa art effectively motivates people and improves their creativity. Therefore, the hypothesis set at the beginning of this psychological experiment was supported.

7 Analysis of sequential effects

The order of presentation of the art and geometric figure contents differed among the participants: Order 1 (Figure, then Art) was 20 participants, and Order 2 (Art, then Figure) was 20 subjects. Determining whether this difference in presentation order affects the evaluation results is crucial.

Therefore, an analysis of variance was conducted. This evaluation experiment consisted of two factors: order (Order 1/Order 2) and content (Figure/Art). In addition, the participants are different in Order 1 and Order 2.

Therefore, a two-factor ANOVA (between-participant factor x within-participant factor) was conducted for each evaluation factor. The results are shown in Figs 17 (Impression factor), 18 (Relaxation factor), 19 (Motivation factor), and 20 (Creativity factor).

Each case had no significant difference concerning the main effect on order. This indicates that the evaluation results are the same concerning the order of viewing geometric figures first or art first.

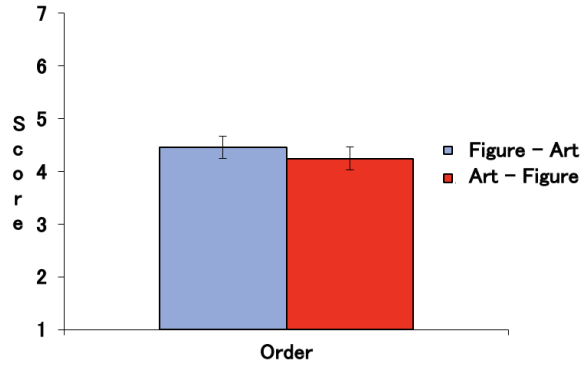

Fig. 17. ANOVA results for Impression factor.

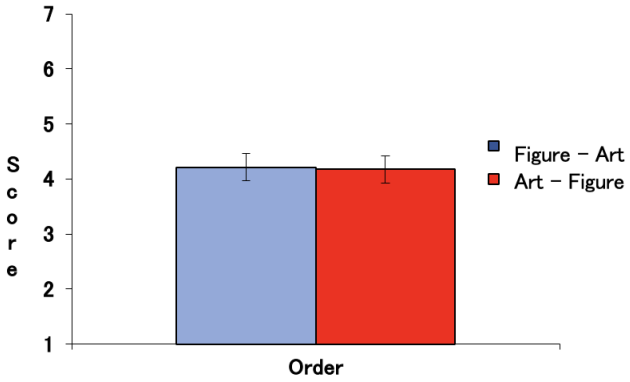

Fig. 18. ANOVA results for Relaxation factor.

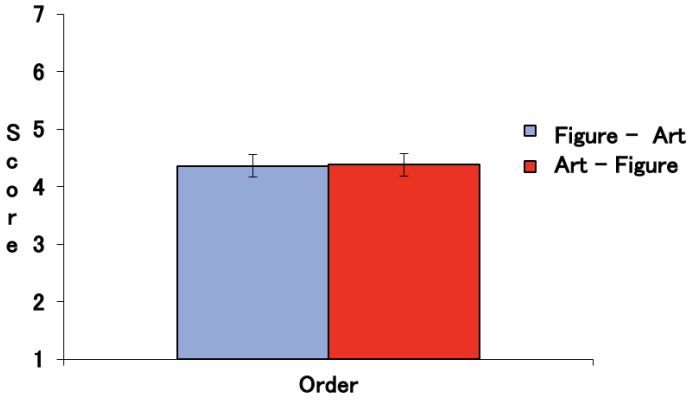

Fig. 19. ANOVA results for Motivating factors.

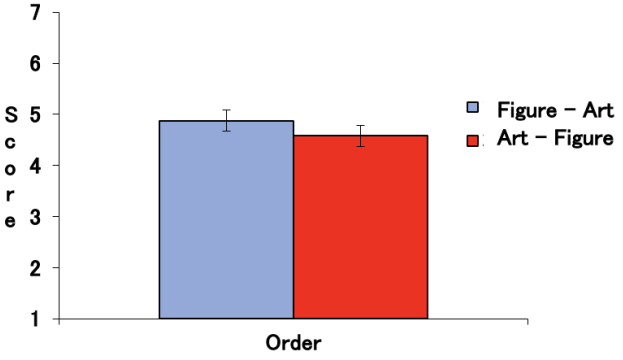

Fig. 20. ANOVA results for Creativity factor.

8 Factor analysis

8.1 PURPOSE OF FACTOR ANALYSIS

The construction of the immersive space and its evaluation through psychological experiments were motivated by the desire to confirm whether combining the immersive space and art content (Tosa Art) would arouse people's creativity. For this reason, in addition to the nine evaluation items for impressions (Impression factor) that had been used in the past to evaluate the impressions received by the participants, three additional evaluation items were added: "Relaxation factor," "Motivation factor," and "Creativity factor."

The "Relaxation factor" and "Motivation Factor" are based on the authors' belief that art has a calming and inspiring effect on the human mind. Based on this idea, the authors established simple evaluation items for the "Relaxation Factor" and the "Motivation Factor" and conducted psychological experiments using these evaluation items to confirm that such effects exist.[12] In the present study, we decided to revise the content and add an evaluation item on creativity.

As for the specific evaluation items for each factor, we used five items, each related to the "Relaxation factor," "Motivation factor," and "Creativity factor," as suggested by Nomura, one of the authors who specializes in psychology. The specific evaluation items are shown in Table 1.

Whether or not the three groups of evaluation items proposed by Nomura, including the items related to the creativity factor, are reasonable is an important question concerning the validity of this psychological experiment and its results, and there is a great need to evaluate them. As one method, we decided to check the validity of the evaluation items by conducting a factor analysis.

8.2 CONTENTS AND RESULTS OF FACTOR ANALYSIS

A factor analysis was conducted to compare the above groupings of evaluation items with actual data. The results of the factor analysis for the evaluation of art content are shown in Table 2.

Table 2. Results of factor analysis of art content

Item	Factor1	Factor2	Factor3	Communarity
At ease	.961	.085	-.057	.964
Relaxed	.873	.016	.041	.779
Healed	.790	.249	.020	.795
Pleasant	.693	-.015	.121	.509
Secure	.690	-.500	-.025	.543
Curious	-.007	.816	-.271	.702
Enthusiastic	.343	.726	-.143	.770
Immersive	.089	.707	.104	.565
Aroused	-.266	.667	.192	.468
Immersed	.041	.634	.234	.497
Motivated	.069	.098	.780	.649
Inspired	-.047	.007	.775	.595
Activated	-.128	.038	.770	.591
In the zone	.271	-.198	.622	.489
Associate	.093	.204	.429	.266

Table 2 shows the factor analysis results using the maximum likelihood Promax method with three factors since the scree plot indicated that three factors were appropriate. The grouping of the three factors corresponds to the "Relaxation Factor," "Motivation Factor," and "Creativity Factor," each of which consists of the five items described above. In some cases, "more motivated" in the "Motivation Factor" and "immersed" in the "Creativity Factor" are interchanged, but this is considered reasonable. Therefore, it was shown that the three factors (Relaxation Factor, Motivation Factor, and Creativity Factor) and the evaluation items that make up each factor are almost confirmed for the actual data. When conducting similar psychological experiments in the future, it would be appropriate to use the following evaluation items, replacing "motivated" in the "Motivation Factor" and "immersed" in the "Creativity Factor."

Relaxation Factor: at ease, secure, pleasant, relaxed, healed Motivator Factor: enthusiastic, immersed, curious, immersive, aroused
Creativity Factor: associate, motivated, activated, inspired, in the zone

9 Conclusion

Previous studies have shown that art has a calming and inspirational effect on the human mind.[1,2] Through several psychological experiments, we have also found that art

has a relaxing and inspiring effect on the human mind.[12,13] In addition to this, we hypothesize that art has the effect of increasing a person's creativity. This is because when we exhibited video art created by Naoko Tosa, one of the authors, in various places of the world, many people commented that "We felt Japanese beauty." In addition, many others said "We felt a sense of levitation" and "Our creativity was aroused." If art appreciation increases people's creativity, then a new benefit of art can be found. This study was conducted to confirm this through a psychological experiment.

In this paper, we first described designing and constructing an "immersive art space" suitable for art appreciation. The fact that projection mapping using art images is used in many situations means that displaying art in a vast space increases the sense of immersion. In this study, we proposed and constructed a hexagonal immersive space using a mirror display those functions as both a mirror and a display to create a sense of being in a vast space. In this space, three sets of mirrors facing each other create the impression of an infinite space. By displaying art images in the mirrors, it is possible to give people the feeling of being in an infinite space surrounded by art images.

In the latter half of this paper, we described the results of an experiment to confirm whether displaying art in the constructed space enhances creativity through psychological evaluation. The art used for the evaluation was the video art by Naoko Tosa. Geometric figures were used as the content to be compared with the art content. Based on the results of an experiment to compare multiple types of geometric figures with different shapes and movements,[13] one of them was selected and used in this study.

We asked 40 participants to rate on a 7-point scale how they felt when viewing the three types of content, "No content," "Figure," and "Art," using 24 evaluation items in four groups related to "Impression," "Relaxation," "Motivation," and "Creativity." The results revealed the following.

First, a two-way ANOVA was used to test whether there were statistically significant differences between the ratings of the three types of content for the four groups of "Impression," "Relaxation," "Motivation," and "Creativity." The results showed that the main effects of content were significant in "Impression," "Motivation," and "Creativity," indicating that there were differences among "No Content," "Figure," and "Art." For "Relaxation," the main effect of content was significant only between "No content" and "Art."

The analysis on each evaluation item showed significant differences between the contents for two of the nine "Impression" items. Regarding "Motivation," three out of five items showed significant differences among the contents. In addition, significant differences were found in 4 out of 5 items for "Creativity." Among the "Creativity" items, significant differences were found for "Motivated" in all combinations of "No content," "Figure," and "Art" among the contents. These results confirm our hypothesis that "combining immersive art space and Tosa art contributes to creativity."

In addition, to confirm whether the order in which figures and art were presented affected the results, an ANOVA was conducted to determine whether there was a difference in results between participants with "Figure to Art" order and those with "Art to Figure" order. The results showed no significant differences between these two orders. In addition, a factor analysis was conducted to determine whether the evaluation items used in the Relaxation, Motivation, and Creativity factors were reasonable. As a result, the 15 evaluation items were correctly classified into the three factors except for one item, and it was confirmed that the proposed evaluation items were reasonable.

There are several possible directions for future research. One is to see if the results of this study are generalizable by using art other than Tosa art as content. Another is to reveal what happens in our body and mind during the art appreciation by measuring physiological indices during the evaluation.

References

1. Winner, E. How Art Works: A Psychological Exploration. *Oxford University Press*. 2018.
2. Mastandrea, S., et al. (2018): Visits to figurative art museums may lower blood pressure and stress. *An International Journal for Research, Policy and Practice*. 2018; 11(2):123-132.
3. Beard, R. L. Art therapies and dementia care: A systematic review. *Dementia*. 2012; 11:633-656.
4. Schall, A., et al. Art museum-based intervention to promote emotional well-being and improve quality of life in people with dementia: The ARTEMIS project. *Dementia*. 2018;17(6):728-743.
5. Monti, D., et al. A randomized, controlled trial of mindfulness-based art therapy (MBAT) for women with cancer. *Journal of the Psychological, Social and Behavioral Dimension of Cancer* (online journal). 2005.
6. Grau, O. Virtual Art: From Illusion to Immersion. The MIT Press. 2004.
7. Chapman, SN. Arts Immersion: Using the arts as a language across the primary school curriculum. Australian Journal of Teacher Education. 2015;40(9):85-101.
8. London, B. Video/Art: The First Fifty Years. *Phaidon Press*. 2021.
9. Rush, M. Video Art. *Thames & Hudson*. 2003.
10. Meigh-Andrews, C. A History of Video Art. Bloomsbury Academic. 2013.
11. Greengard S. Virtual Reality. *The MIT Press*. 2019.
12. LaValle, SM. Virtual Reality. *Cambridge University Press*. 2024.
13. Emmal, S. Virtual Reality. *Blurb*. 2024.
14. Bowman DA, McMahan RP. Virtual Reality: How Much Immersion is Enough. *Computer*. 2007;40(7):36–43.
15. Magnor, M, Sorkine-Hornung, A. Real VR – Immersive Digital Reality: How to Import the Real World into Head-Mounted Immersive Displays. *Springer*. 2020.
16. Blokdyk, G. Head-Mounted Displays HMDs. 5STARCooks. 2018.
17. Jones L. Haptics. *The MIT Press*. 2018.
18. Grunwald, M. Human Haptic Perception: Basics and Applications. *Springer*. 2008.
19. Ziat, M. Haptics for Human Computer Interaction: From the Skin to the Brain. *Now Publishers*. 2023.
20. Latham, W. SPACE: 1999 Odysseus Wept. *Powys Media*. 2023.
21. Latham W. *https://en.wikipedia.org/wiki/William_Latham_(computer_scientist)*
22. Cave automatic virtual environment.
https://ja.wikipedia.org/wiki/Cave_automatic_virtual_environment
23. Kenyon, RV. The CAVE Automatic Virtual Environment: Characteristics and Applications. Proceedings of a workshop sponsored by NASA. 1995;149-168.
24. Kusama Y. Infinity Mirror Rooms. *https://www.tate.org.uk/whats-on/tate-modern/yayoi-kusama-infinity-mirror-rooms*
25. Gilberti, F. Yayoi Kusama Covered Everything in Dots and Wasn't Sorry. Phaidon Press. 2020.
26. Sato, S., Yoshimura, K. Ikebana: The Art of Arranging Flowers. Tuttle Publishing. 2013.
27. Ueno, Y. Ikebana: The Zen Way of Flowers. *Tuttle Publishing*. 2023.
28. Pang Y, Zhao L, Nakatsu R, Tosa N. A Study of Variable Control of Sound Vibration Form (SVF) for Media Art Creation. *2017 International Conference on Culture and Computing*. 2017.
29. Tosa N, Yamada A, Pang Y, Toba S, Ito A, Suzuki T, Nakatsu R. Creation of Fluid Art 'Sound of Ikebana' under Microgravity Using Parabolic Flight. Leonard, MIT Press. 2022;56(4):359-366.
30. Nakatsu R, Tosa N, Niiyama S, Munaka T, Furuta M, Ueda Y, Nomura M. Development of Immersive Art Space Using Mirror Display and Its Preliminary Evaluation. *WMSCI 2023*. 2023.
31. Misseroni D, Colquitt DJ, Movchan AB, Movchan NV, Jones IS. Cymatics for the cloaking of flexural vibrations in a structured plate. *Scientific reports*, 2016;6(23929).
32. Tosa N, Yamada A, Pang Y, Toba S, Ito A, Suzuki T, Nakatsu R. Creation of Fluid Art 'Sound of Ikebana' under Microgravity Using Parabolic Flight. Leonard, MIT Press. 2022;56(4):359-366.
33. Mirroria. https://www.asahiglassplaza.net/products/mirroria/
34. Nakatsu R, Tosa N, Niiyama S, Kusumi T. Evaluation of the Effect of Art Content on Human Psychology Using Mirror Display with AR Function. *Nicograph International 2021*. 2021;54–61.
35. Nakatsu R, Tosa N, Takada H, Kusumi T. Psychological Evaluation of Image and Video Display by Large-Screen LED Display and Projection. *Transactions of the Society for Art and Science*. 2021;20(1):45–54.
36. Infinity mirror. https://en.wikipedia.org/wiki/Infinity_mirror
37. Batchelor, GK. An Introduction to Fluid Dynamics. *Cambridge University Press*. 2000.
38. Versteeg, H. An Introduction to Computational Fluid Dynamics. *Pearson*. 2007.
39. Jacobsen, T., Schubotz, R. I., Höfel, L., Cramon, D. Y. Brain correlates of aesthetic judgment of beauty. *NeuroImage*. 2006; 29: 276–285.
40. Okada, M., Inoue, J. A psychological analysis about the elements of artistic evaluation on viewing paintings. *The Educational Sciences of Yokohama National University*. 1991; 31:45-66.
41. Mizuno, K, Shimizu, H. Measuring social value orientation by model-based scoring. *Behaviormetrika*. 2023.