

A Study on the Divergence between Psychological Evaluation and Physiological Indices during Art Viewing in Immersive Art Spaces

Ryohei Nakatsu¹, Naoko Tosa¹, Yasuyuki Uraoka², Akane Kitagawa², Koichi Murata², Tatsuya Munaka², Yoshiyuki Ueda¹, Masafumi Furuta², Michio Nomura¹

Nakatsu.ryohei@gmail.com

¹Kyoto University, Sakyo-ku, Kyoto, 606-8501 Japan

²Shimadzu Corporation, Seika-cho, Soraku-gun, Kyoto, 619-0237 Japan

Keywords: Immersive space, Art viewing, Psychological evaluation, ECG data analysis.

ABSTRACT

This study explores the divergence between psychological and physiological responses to art. Two immersive environments were used: one with mirror displays and another with large LED panels. While psychological evaluations showed no significant differences, ECG data indicated that the latter promoted higher parasympathetic activity and lower sympathetic arousal, suggesting a dual-layered structure of art experience involving both subjective perception and bodily response.

1 Introduction

Art is widely recognized for its power to inspire, soothe, and provoke deep reflection. While not essential for physical survival, it plays a vital role in enhancing mental well-being and creativity. Immersive art experiences have been shown to strengthen these effects by providing spatial contexts that foster deeper engagement.

Previous studies have reported that art appreciation can reduce stress and enhance emotional states by activating physiological responses such as reduced cortisol and increased heart rate variability [1]. However, most have examined either subjective reports or physiological data in isolation. Few have addressed the potential divergence between conscious psychological evaluation and unconscious bodily responses, particularly in immersive environments.

To explore this gap, we investigated how two contrasting immersive spaces affect both psychological and physiological responses to art. Two immersive spaces were constructed and participants viewed identical digital artworks in each space while psychological evaluations and ECG data were recorded.

This study aims to reveal the layered nature of aesthetic experience by highlighting discrepancies between subjective impressions and physiological states.

2 Immersive Space for Art Appreciation

2.1 Immersive Space 1

Immersive Space 1 was designed using mirror displays to create a strong sense of spatial infinity, based on the psychological premise that immersion enhances the impact of art appreciation [2][3]. We adopted a mirror display, to achieve this effect (Fig. 1).

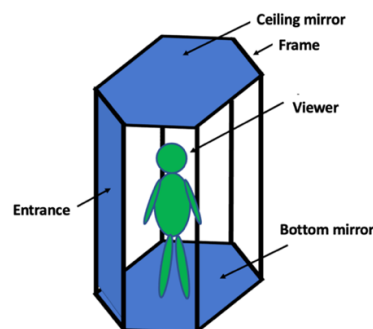


Fig. 1. Conceptual diagram of Immersive Space 1

Immersive Space 1 consists of a hexagonal enclosure with three pairs of opposing mirror displays, forming a space where images are infinitely reflected. The floor and ceiling are also mirrored, allowing participants to experience the sensation of being surrounded above and below. Art content is displayed on six of these mirror displays. This design creates a perceptual experience in which viewers see countless images of themselves and the artwork, contributing to a complex visual and emotional effect.

2.2 Immersive Space 2

Immersive Space 1 has the disadvantage that using mirrors results in an endless series of mirror images of the viewers. Immersive Space 2 is a closed space surrounded by four-sided displays. A 77-inch organic LED panel is used as the display. A conceptual diagram of the Immersive Space 2 is shown in Fig. 2.

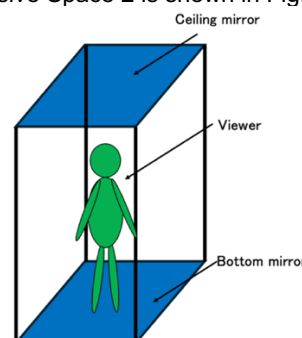


Fig. 2. Conceptual diagram of Immersive Space 2

3 Comparative Experiment of the Two Immersive Spaces Based on Psychological Evaluation and Physiological Data

3.1 Concept of the evaluation experiment

This experiment aimed to examine whether differences in immersive spatial environments influence viewers' psychological and physiological responses to art, and whether a divergence exists between them.

Two immersive spaces with contrasting characteristics were used: Immersive Space 1 (mirror-based) and Immersive Space 2 (LED-based). Identical video artwork and geometric control content were presented in both environments. Participants' psychological evaluations and physiological responses (ECG) were recorded at specific stages.

By integrating both subjective and objective data within a unified protocol, the experiment enables direct comparison of perceived experience and bodily reaction, offering a structured framework for analyzing divergence in art appreciation.

3.2 Test subjects

Different subjects evaluated Immersive Spaces 1 and 2. Immersive Space 1 was evaluated by 40 Kyoto University students (32 males, 8 females), and Immersive Space 2 by 52 Kyoto University students (28 males and 24 females).

3.3 Experimental procedure

The content is shown twice. Art content and comparative geometric figure content, each lasting three minutes, are displayed in turn ("Art" or "Figure" hereafter), and their order differs randomly depending on each subject.

Psychological evaluation is conducted three times, after a subject enters the immersive space ("No content" hereafter), after viewing Content 1 ("Art" or "Figure" hereafter depending on the content), and after viewing Content 2 ("Art" or "Figure" hereafter depending on the content).

Before displaying Content 1 and 2, a resting period of 3 minutes is taken to reset the subject's state. During this, the display is kept black, and physiological data measurement is conducted ("Rest 1" and "Rest 2" hereafter). Also, when displaying Contents 1 and 2, the physiological data measurement is conducted ("Art" or "Figure" hereafter, depending on the content).

Although two types of physiological data, Rest 1 and Rest 2, are obtained, Rest 2 is strongly affected by the content viewed just before. This research focused only on Rest 1 ("Rest" hereafter).

By incorporating the psychological evaluation experiment and physiological data measurement into a series of these experimental processes, it is possible to measure and evaluate the effects of the same art appreciation experience on subjects' physiology and psychology.

3.4 Psychological evaluation

Twenty-four evaluation items, grouped into four factors of Impression, Relaxation, Motivation, and Creativity, were prepared [2]. The evaluation was conducted using the 7-point SD method.

3.5 Physiological data measurement

This research was conducted in collaboration with Kyoto University and Shimadzu Corporation. We used a device called HuME (Human Metrics Explorer) [4] from Shimadzu to measure physiological data. HuME is a physiological measurement system that integrates various wearable devices. In this study, we measured electrocardiography (ECG) using the HuME device, electroencephalography (EEG) using a commercial device, and skin electrical activity. This paper focuses on the ECG data and its analysis.

4 Contents Used for the Experiments

4.1 Art content

The art content used in this experiment was "Sound of Ikebana," a video artwork created by one of the authors, Naoko Tosa ("Tosa Art" hereafter). This piece was created by capturing the form of jumping-up fluid generated by sound vibrations using a high-speed camera, producing organic and dynamic visual patterns reminiscent of Japanese flower arrangements [5].

Previous studies have used the artwork to evaluate psychological and physiological responses to art in immersive environments [2][3]. It is considered suitable for such experiments due to its rich visual dynamics derived from physical phenomena and its capacity for parameter variation.

In this study, the same video content was presented in both immersive spaces to control for content variability and focus solely on the effects of spatial structure. Figure 3 shows a scene from the artwork.



Fig. 3. A scene from "Sound of Ikebana"

4.2 Comparative Content

We used a geometric animation of circles and squares alternating in shape and color as a control stimulus for comparison with the art content. This content was selected based on preliminary experiments in which several geometric variations were evaluated; the chosen version exhibited minimal emotional impact, making it suitable as a neutral baseline.

5 Comparison of Immersive Spaces 1 and 2 based on Psychological Evaluation Results

The subjects in the psychological experiments in Immersive Spaces 1 and 2 differed. Therefore, the two-way analysis of variance method (ANOVA) of the between-participant factor x within-participant factor in statistical analysis was applied. The results for Impression factor, Relaxation factor, Motivation factor, and Creativity factor are shown in Figs. 7 through 10.

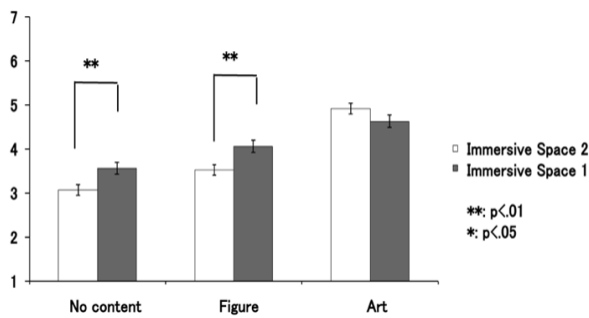


Fig. 7. Multiple comparison results for environment (Impression factor)

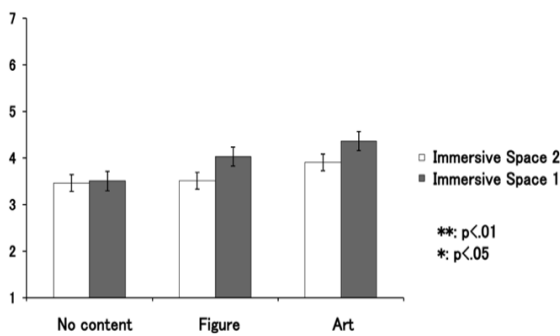


Fig. 8. Multiple comparison results for environment (Relaxation factor)

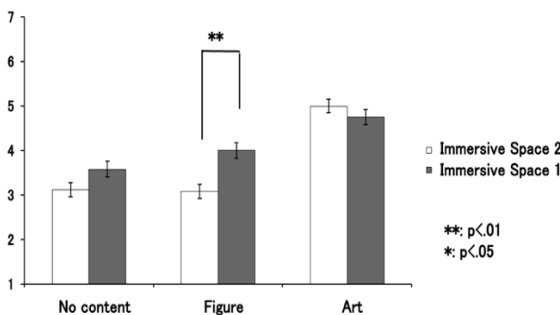


Fig. 9. Multiple comparison results for environment (Motivation factor)

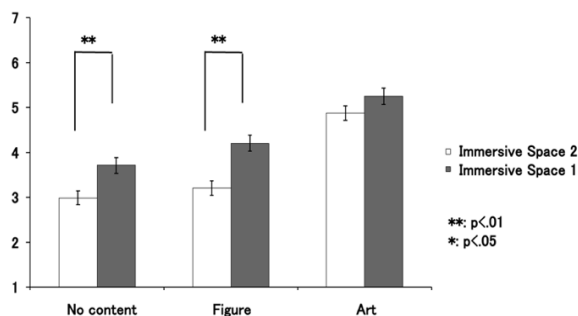


Fig. 10. Multiple comparison results for the environment (Creativity Factor)

These results indicate a significant difference between Immersive Space 1 and 2 for Figure and Rest, although it depends on the factor. However, for Art, there is no significant difference between Immersive Spaces 1 and 2 for any of the factors. This indicates that although the

physical characteristics and visibility conditions of Immersive Spaces 1 and 2 differ, subjects' psychological evaluations of the art content remained stable across both environments.

6 Results of ECG Data Analysis

6.1 ECG data used in the analysis

For Immersive Space 1, physiological data (ECG: electrocardiogram, EEG: electroencephalogram, and skin potentials) were measured in 40 subjects, of whom 22 were able to measure all three types of data successfully. For Immersive Space 2, the same physiological data were measured in 52 subjects, and 39 of the 52 subjects successfully measured all three data types. In this paper, we focused on the ECG data and analyzed 22 subjects for Immersive Space 1 and 39 subjects for Immersive Space 2.

6.2 Analysis methods for ECG data

Heart rate variability, the periodic fluctuation of the interval between adjacent peaks (RRI) obtained from ECG data, reflects autonomic nervous activity. We focused on the following heart rate variability indices obtained from the RRI.

SDNN: Standard deviation of RR interval

RMSSD: root mean square of the difference between adjacent RR intervals

pNN50: Ratio of difference between adjacent RRIs exceeding 50 msec

HF: High-frequency component from frequency analysis of RR interval data

LF/HF: Ratio of the low-frequency component to the high-frequency component

SDNN, RMSSD, pNN50, and HF are used as indices of parasympathetic activity, while LF/HF is used as an index of sympathetic activity. These are obtained as time series data for each of the three types of content (Art, Figure, and Rest). In this paper, we compared Art, Figure, and Rest using values obtained by averaging the time series values.

6.3 Comparison of the Immersive Spaces 1 and 2 by two-factor ANOVA of ECG Data

The results of Immersive Spaces 1 and 2 were directly compared using ECG data to see if there was a significant difference in the results. Two-factor ANOVA was used to compare the two directly. The results are shown in Figs. 11 through 15.

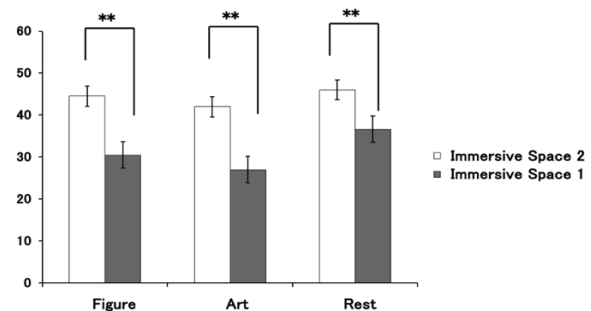


Fig. 11. Results of multiple comparisons for the environment (SDNN)

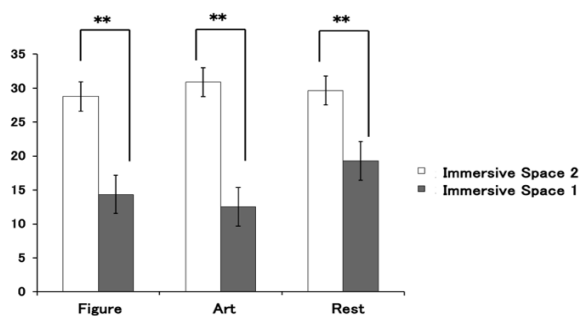


Fig. 12. Results of multiple comparisons for the environment (RMSSD)

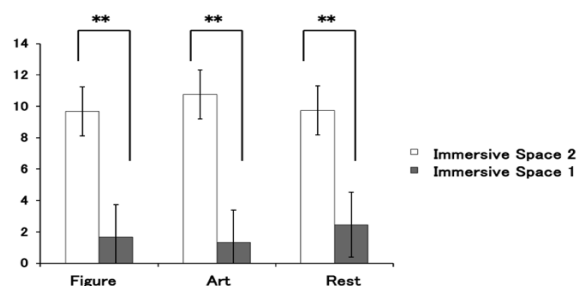


Fig. 13. Results of multiple comparisons for the environment (pNN50)

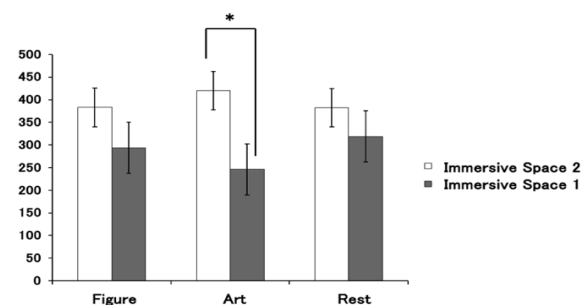


Fig. 14 Results of multiple comparisons for the environment (HF)

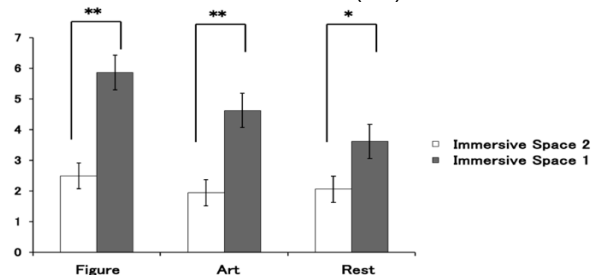


Fig. 15. Results of multiple comparisons for the environment (LF/HF)

These results show that indices associated with parasympathetic activity—SDNN, RMSSD, pNN50, and HF—were significantly higher in Immersive Space 2 compared to Space 1 during art viewing. In contrast, the LF/HF ratio, an index of sympathetic activity, was significantly lower in Space 2. These findings suggest that art appreciation in Immersive Space 2 induces a more relaxed physiological state than in Immersive Space 1.

7 Comparison of Psychological Response and ECG Data Analysis

This study measured both subjective evaluations and physiological responses (ECG indices) during art appreciation in two immersive environments to examine the impact of spatial conditions. The results revealed a clear divergence between psychological evaluation and physiological data.

Psychological evaluations showed no significant differences between Immersive Spaces 1 and 2 across the four factors: Impression, Relaxation, Motivation, and Creativity. This suggests that viewers' conscious impressions of the artwork remained stable regardless of spatial context.

In contrast, ECG data revealed distinct differences. In Immersive Space 1, sympathetic activity was more dominant, as indicated by a higher LF/HF ratio. Conversely, Immersive Space 2 showed higher parasympathetic indicators such as RMSSD, pNN50, and HF, indicating a more relaxed physiological state. These results demonstrate that while viewers may report similar impressions, their bodies respond differently to changes in spatial environment.

This asymmetry can be attributed to the hierarchical nature of human information processing. Psychological evaluations involve reflective, contextual judgments primarily governed by higher-order cognition in the prefrontal cortex. In contrast, physiological responses reflect unconscious autonomic regulation via the brainstem. As a result, subtle differences in visual immersion and spatial design can manifest physiologically even in the absence of conscious awareness.

8 Conclusion

This study examined how immersive spatial environments influence psychological and physiological responses to art. While subjective evaluations remained consistent across environments, physiological indices varied significantly. These findings reveal a divergence between conscious and unconscious responses, suggesting that spatial design can modulate bodily states even when subjective impressions are stable. This dual-layered structure of art experience highlights the need to consider both perception and embodiment in understanding aesthetic engagement.

References

- [1] Mikaela Law, et al., "Evidence for the effects of viewing visual artworks on stress outcomes: a scoping review," *BMJ Open*, Vol.11, No.6 (2021).
- [2] Ryohei Nakatsu, et al., "Construction of Immersive Art Space Using Mirror Display and Its Evaluation by Psychological Experiment," *EAI ArtsIT 2023* (2023).
- [3] Ryohei Nakatsu, et al., "Construction of Immersive Art Space and Its Evaluation Using ECG Data," *WMSCI2023* (2023).
- [4] Akane Kitagawa, et al., "Human Metrics Explorer System for Multi-Device Physiological Measurements in Emotion Estimation," *SII 2024*, pp. 184-189 (2024).
- [5] Yunian Pan, et al., "Sound of Ikebana: Creation of Media Art Based on Fluid Dynamics," *International Journal of Humanities, Social Sciences, and Education*, Vol. 8, No. 3, pp. 90-102 (2021).