



Investigation of Art Abstraction Using AI and Psychological Experiment

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Abstract. The history of painting began as drawing natural objects, and modern painting has entered the era of abstract painting. Although the relationship between the real things and the figurative paintings that depict them is clear, real things and abstract paintings have not yet been clarified. On the other hand, AI has made rapid progress in recent years, and new technologies such as converting photographs into art-like images have emerged. This study examines the relationship between abstract paintings and natural objects by combining the AI style transfer function and psychological experiment.

Keywords: Abstract art · Abstraction · GANS · Style transfer · Psychological experiment

1 Introduction

The history of painting began as drawing the landscapes and other natural things around us as accurately as possible and gradually began to express them abstractly. Moreover, modern painting has entered the era of abstract painting. What and how does painting abstract and express? This question has been discussed in various ways, but it has not been clarified yet. Traditional discussions are primarily by art experts, and there are few examples of science and technology approaching this issue.

On the other hand, AI based on deep learning has made rapid progress in recent years [1]. New technologies emerge to generate fake images of exact human faces [2] and convert photos into art-like images of a particular genre [3]. Can these new AI technologies approach painting evaluation and abstraction issues in art?

In this research, we will approach the issue of what paintings are trying to abstract by examining the relationship between paintings and real things using the style transfer function of AI. We use the AI style transfer function to convert a natural object into an image with a specific art style and evaluate whether the conversion is successful or not. If the evaluation result is good, there is a strong relationship between the real thing and the art style. In other words, the art style is an abstraction of reality. We adopted the methodology of the psychological evaluation experiment to evaluate the image obtained by the style transfer. By combining AI's style transfer function and psychological evaluation experiments, we approach what painting is trying to abstract.

2 Related Works

2.1 Art Style Transfer Using CycleGAN

Recent advances in AI have created new technologies called GANs [1]. GANs consist of generation networks that try to generate images as close to the real thing as possible and identification networks that try to distinguish between real and fake images as accurately as possible, as shown in Fig. 1. It has the characteristic that training converges with fewer training samples.

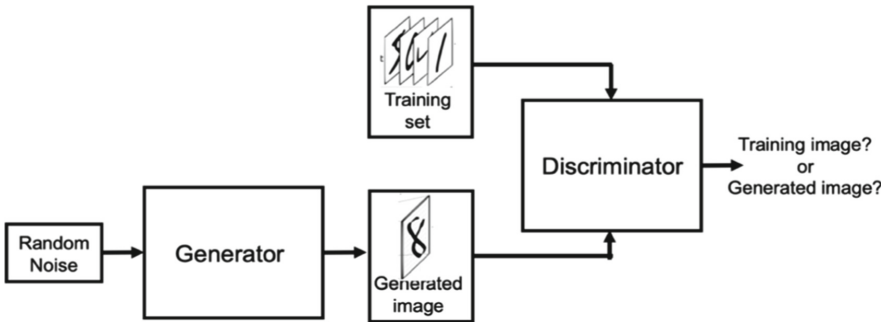


Fig. 1. Basic configuration of GANs

Among various GANs, we focused on CycleGAN [3]. CycleGAN aims to generate an image similar to the original image by reconverting the converted image, as shown in Fig. 2. CycleGAN allows mutual conversion between two image sets. For example, using this capability, a photo can be converted into a Monet-like image, as shown in Fig. 3, called the style transfer function.

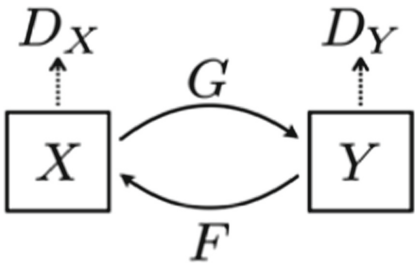


Fig. 2. Basic concept of CycleGAN

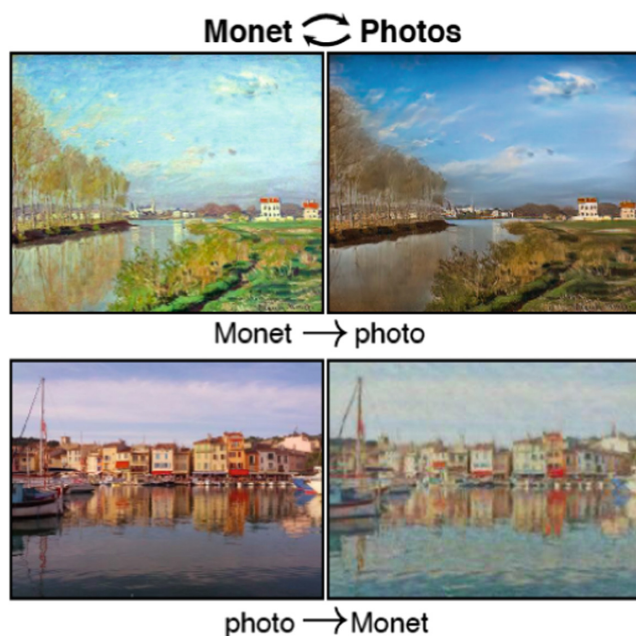


Fig. 3. Conversion between landscape photos and Monet painting using CycleGAN [2]

2.2 Research on Art Style and Art Abstraction

Research on how people evaluate the art, especially painting, began in the late 19th century when Fechner began experimental aesthetics to measure people's emotions, such as comfort and discomfort, quantitatively. Since then, various studies in psychology have been conducted to investigate the beauty of art and the emotions that derive from it. Various studies have also been conducted on art style research.

For example, Okada and Inoue [4] conducted a psychological experiment on whether figurative painting or abstract painting was preferred and showed that figurative painting was preferred. Farkas [5] investigated people's favorite works of art using Surrealist paintings and found that famous artworks were preferred. As a study investigating the differences in the evaluation of paintings between art professionals and amateurs, Winston and Cupchik [6] experimented on whether professionals and amateurs prefer fine art paintings or mundane paintings. As a result, it was found that experts prefer fine arts, and amateurs prefer secular paintings. Elina Pihko et al. [7] also studied how professionals and amateurs change their assessments as the abstraction of paintings progresses. They found that, while experts do not change much in their assessments as the abstraction progresses, the evaluation value by amateurs decreases as the abstraction progresses.

Much research has been done on what and how art is abstracted [8, 9], but all are qualitative based on the subjective opinions of art experts. Few types of research from the science and technology side have approached this issue.

3 Relationship Between Real Things and Art

In this paper, we try to approach the issue of what the painting is trying to abstract by combining the style transfer function of CycleGAN and the psychological evaluation experiment. The basic idea is as follows.

By using the style transfer function of CycleGAN, it is possible to model the relationship between a real thing and a painting. Figure 4 illustrates the relationship between landscape and landscape painting, showing that the landscape painting is a transformation of the landscape. Figure 5 shows this more abstractly. Figure 5 shows that art is an expression of the essence of a real thing. If this transformation works, there is a strong relationship between the painting and the real thing. In other words, it shows that the painting takes out and expresses the essence of the real thing or abstracts the real thing.

The framework of psychological experiments by the subjects can be used to evaluate whether or not the conversion was successful. Using such a methodology makes it possible to know what the painting is trying to abstract and express.

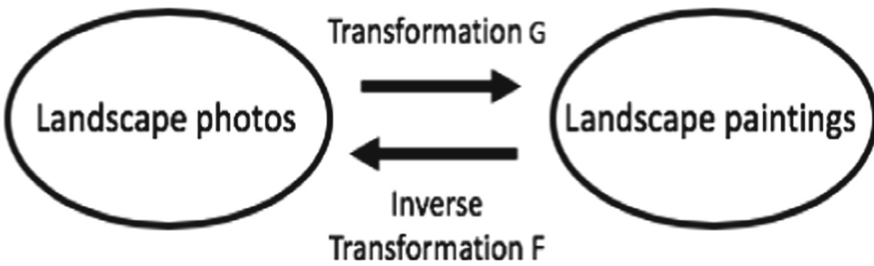


Fig. 4. Relationship between landscape photos and landscape paintings.

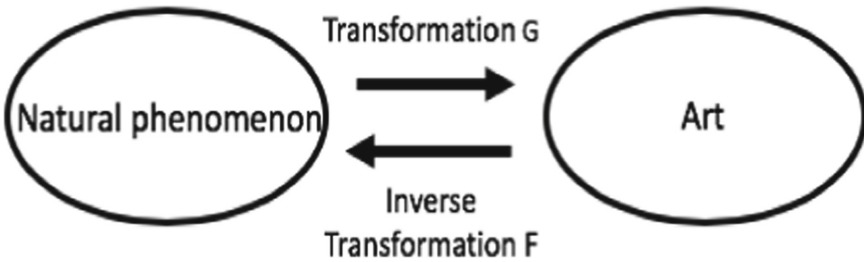


Fig. 5. Relationship between natural phenomenon and art.

4 Style Transfer of Real Things Using Cycle GAN

We will carry out experiments to investigate the relationship between real things and art using CycleGAN. To do this, we use the style transfer function of CycleGAN to convert multiple types of natural things into images with multiple art styles.

We used the following three types of paintings as abstract art of the West and the East.

(1) Ikebana (Japanese Flower Arrangement)

Ikebana expresses nature using actual flowers and plants. However, it does not represent nature as a miniature but tries to express nature with as few flowers and vegetation. Ikebana is trying to express nature in a minimalistic way. So we can think of Ikebana as art that abstractly expresses nature.

Here, we used about 500 images selected from Flickr for training CycleGAN.

(2) Shan-Shui

Shan-Shui is a painting born in China in the 5th century. At first glance, it looks like a figurative painting that expresses the natural landscape in black and white, and many people understand it as such. However, it is not a drawing of the actual natural landscape but the painter's imagination. In that sense, it can be said that the Shan-Shui is an abstract painting. Furthermore, in contrast to the perspective method that follows the laws of physics in the West, the perspective method called "San-en," which incorporates landscapes seen from multiple directions into one painting, is adopted. Therefore, Shan-Shui is an oriental abstract painting.

We used about 300 images selected by Google Image search for training CycleGAN.

(3) Kandinsky Painting

Kandinsky is considered to be the founder of Western abstract painting. Compared to recent abstract paintings, they have some relationship with real things. Therefore, we decided to use Kandinsky's painting to represent Western abstract painting.

Here, we used about 300 images selected from WikiArt for training CycleGAN.

On the other hand, we used the following two types as natural objects.

(4) Landscape Photo

Many realist paintings are realistic representations of landscapes. At first glance, Ikebana and Shan-Shui paintings look like figurative representations of natural landscapes, but as mentioned earlier, they are considered abstract representations of natural landscapes. Therefore, it is an interesting question whether or not the landscape photos can be converted into an Ikebana style or a Shan-Shui painting style by style transfer. On the other hand, the relationship between Kandinsky's abstract paintings and landscape photography is unknown, so it is interesting to find out what the relationship is.

Here, we used about 1000 images selected from <https://www.pexels.com/search/landscape/> for training CycleGAN. About 500 of them are distant views of natural scenery, and the remaining about 500 are near views.

(5) Cityscape photo

We used a city landscape photograph as another real thing. Artificial urban landscapes are modern landscapes instead of natural landscapes and are expected to be compatible

with Western abstract paintings. It is also interesting to see how this relates to Ikebana and Shan-Shui paintings.

Here, we used about 1000 images selected from <https://www.pexels.com/search/city%20landscape/> for training CycleGAN. About 500 are distant views of cityscapes, and the remaining about 500 are near views.

5 Psychological Evaluation Experiment of Obtained Image

5.1 Data Used in Psychological Evaluation Experiments

The above style conversion experiment obtained the following 12 types of image sets.

1. Image set that converts landscape photos (distant views) into Ikebana style
2. Image set that converts landscape photos (distant views) into Kandinsky style
3. Image set that converts landscape photos (distant views) into Shan-Shui style
4. Image set that converts landscape photos (near views) into Ikebana style
5. Image set that converts landscape photos (near views) into Kandinsky style
6. Image set that converts landscape photos (near views) into Shan-Shui style
7. Image set that converts cityscape photos (distant views) into Ikebana style
8. Image set that converts cityscape photos (distant views) into Kandinsky style
9. Image set that converts cityscape photographs (distant views) into Shan-Shui style
10. Image set that converts cityscape photos (near views) into Ikebana style
11. Image set that converts cityscape photos (near views) into Kandinsky style
12. Image set that converts a cityscape photograph (near views) into Shan-Shui style.

Fifteen images were selected from each of these image sets and used in psychological experiments. Figure 6 shows several examples of the image used in the experiment.

5.2 Subject

Forty-eight students from Kyoto University were used as subjects. The age is from late teens to 20s.

5.3 Experimental Method

A total of 180 images, consisting of three types of art styles (Ikebana style, Kandinsky style, Shan-Shui painting style) $\times$ 4 types of original photos (natural landscape distant view, natural landscape near view, cityscape distant view, cityscape near view) $\times$ 15 images mentioned above, were evaluated by the subjects.

The evaluation was based on a psychological method in which the subjects answered the following four types of questions in seven stages (1 to 7).

Question 1: How similar is it to (Ikebana, Kandinsky art, Shan-Shui painting)?

Question 2: Please evaluate the newness as (Ikebana, Kandinsky art, Shan-Shui painting).

Question 3: Please evaluate when viewed as figurative art.

Question 4: Please evaluate when viewed as abstract art.

The experiment was conducted online using Google Form.



(Top: Landscape photos of distant views, Bottom: Images converted from landscape photos into Ikebana, Kandinsky, and Shan-Shui styles.)



(Top: Cityscape photos of distant views, Bottom: Images converted from cityscape photos into Ikebana, Kandinsky, and Shan-Shui styles.)

Fig. 6. Examples of images used in the psychological experiment.

6 Experiment Results and Discussion

6.1 Experiment Results

Figures 7, 8, 9 and 10 show graphs of the obtained results for each of the above four questions.

6.2 Discussion

(1) Similarity with the Original

In this evaluation item, we asked the subjects to evaluate how similar the presented image is to the original art (Ikebana, Kandinsky art, or Shan-Shui painting). In other words, the question is how much the characteristics of the original art are retained.

It should be noted here that the evaluation value of the natural landscape is generally higher than that of the cityscape. This seems to support the assumption that art

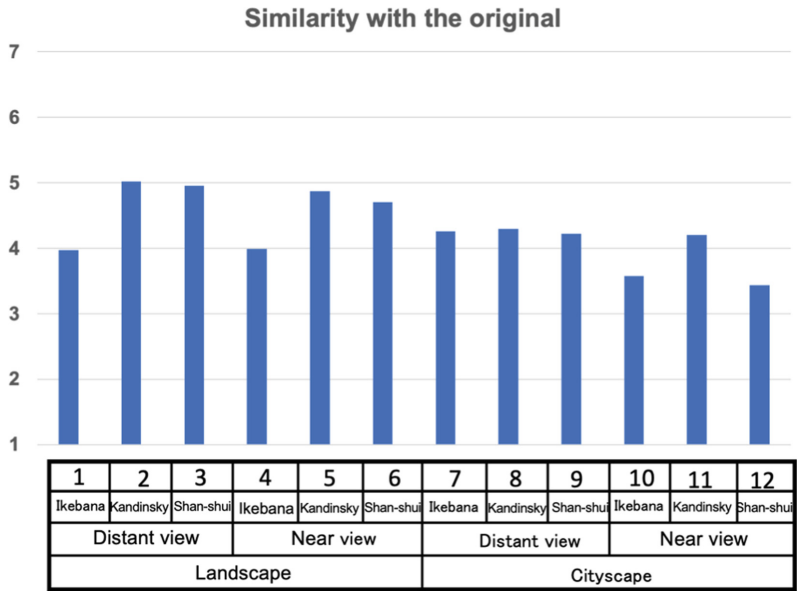


Fig. 7. Similarity to the original

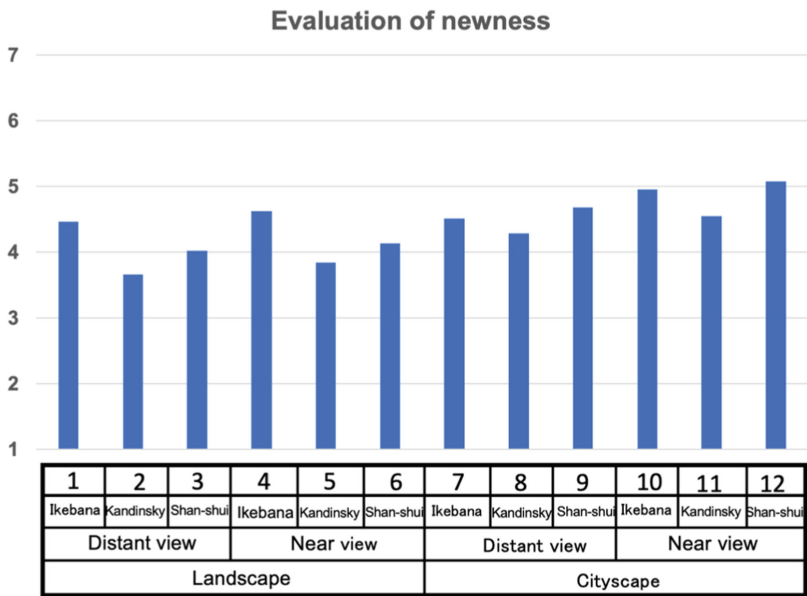


Fig. 8. Evaluation of newness

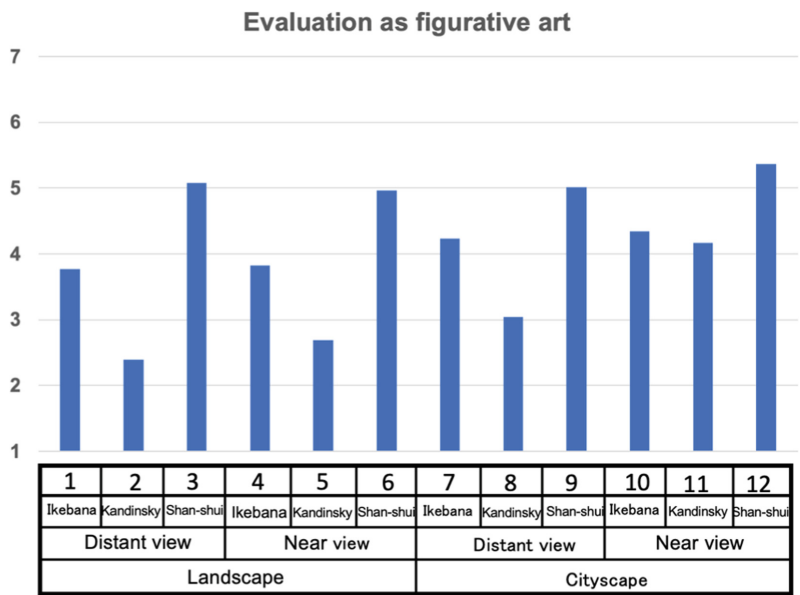


Fig. 9. Evaluation as a figurative painting

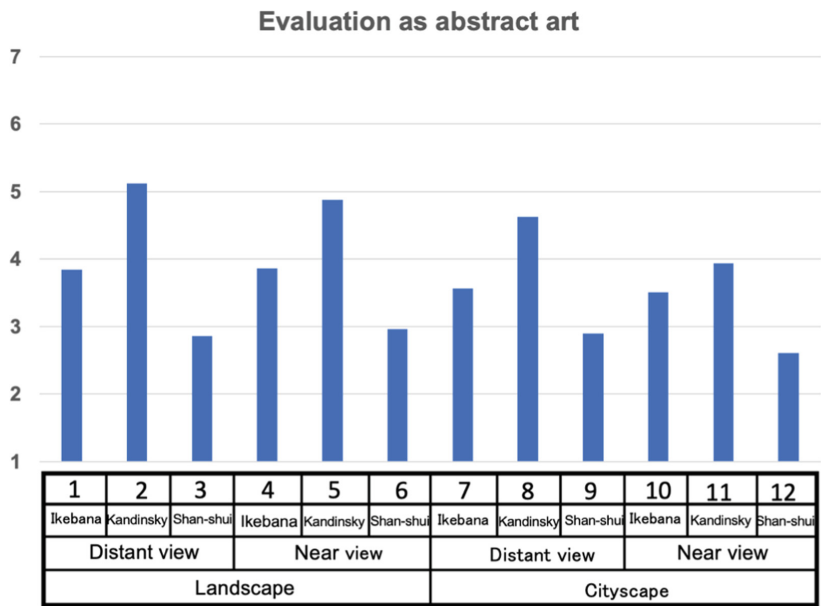


Fig. 10. Evaluation as an abstract painting

is essentially an abstraction of the natural landscape. In particular, it is noteworthy that Kandinsky's evaluation value is high. This, when combined with the fact that Kandinsky has been said to be the founder of abstract painting, may indicate that abstract painting is the continuation of the flow of realists and impressionists who express real things.

On the other hand, it is also noteworthy that the evaluation value of Ikebana is near the median value of four and not very high. Initially, we expected that Ikebana would be highly evaluated because it is thought that the affinity between Ikebana and the natural landscape is good, but the results were contrary to expectations. This may be because the subjects are almost all Japanese, and Japanese people have many opportunities to watch various types of high-ranked Ikebana. Therefore, they have a strict appreciation eye for the ideal appearance of Ikebana, and it is not easy to recognize a landscape image that has been style-converted as a real Ikebana.

(2) Evaluation of Newness

In this evaluation item, we asked the subjects to evaluate whether the presented image is recognized as a new form for the original art (Ikebana, Kandinsky art, or Shan-Shui painting).

What is noteworthy here is that cityscapes generally have higher evaluation values than natural landscapes. It can be understood that the image obtained by style transfer of the cityscape, which is an artifact, is evaluated higher for its newness as art than the image obtained by style transfer of the natural landscape. In particular, the Shan-Shui painting has a higher evaluation value than the Ikebana and Kandinsky art. This means that the subjects evaluated that a new landscape painting was obtained by converting the cityscape into a Shan-Shui-like image. We sometimes see artworks by Chinese artists in which the cityscape looks like a Shan-Shui painting. Probably there is something similar to this.

(3) Evaluation as Figurative Art

We asked the subjects to evaluate how much the presented image looked like figurative art in this evaluation item.

The evaluation value of Kandinsky art, an abstract painting, especially the evaluation of natural scenery converted into Kandinsky style, is low when evaluated as figurative art. On the other hand, Shan-Shui paintings have a high rating of 5 or higher for natural and urban landscapes. Understandably, a Shan-Shui-style natural landscape is highly evaluated as a figurative painting. However, it is interesting that an image of a city landscape in a Shan-Shui painting style also has a high evaluation value. This may correspond to what we mentioned earlier that the Shan-Shui painting looks like a figurative painting at first glance but has the aspect of an abstract painting that expresses a mental landscape.

It is also noteworthy that the evaluation value of the natural landscape image made into an Ikebana style is low. As mentioned earlier, the subjects, mostly Japanese, are usually in contact with high-quality Ikebana and have a high aesthetic eye for Ikebana, which may lead to strict evaluation results.

(4) Evaluation as Abstract Art

We asked the subjects to evaluate how much the presented image looks like an abstract image in this evaluation item.

It may be natural, but the evaluation of Ikebana and Shan-Shui paintings is low. This corresponds to Ikebana and Shan-Shui paintings are generally understood as figurative expressions rather than abstract expressions. As mentioned earlier, Ikebana and Shan-Shui paintings are high-dimensional abstract expressions while seemingly figurative. Such high-dimensional expressions may be difficult to reflect in the evaluation values at this stage.

7 Conclusion

In this study, we investigated the relationship between real things and art. Art is an abstract expression of a real thing or an expression of the essence of a real thing. However, it seems that research to prove it has not been done. Here, we focused on a technology called style transfer, which is achieved by a recent AI technology called GANs, especially a technology called CycleGAN, which can generate images with art styles of a specific art genre on photographs.

Using this technology makes it possible to make photographs, etc., into images with a specific art style. Of course, everything cannot be well converted into an image with an art style. It has the characteristic that it can be converted well when there is some similarity between the original photo and the art. This means that successful conversion shows a close relationship between the original image and the art. For example, successfully converting a natural landscape into a landscape painting style means that the landscape painting is an abstract expression of the natural landscape.

We decided to investigate the relationship between Ikebana, Kandinsky art, and Shan-Shui paintings and natural things from this way of thinking. As the actual objects, we decided to use natural landscapes and urban landscapes and also decided to use two types of landscape photographs, distant and near landscapes, for each. First, these landscape photographs were converted into Ikebana style, Kandinsky art style, and Shan-Shui painting style using the style transfer function of CycleGAN. Then, the obtained images were evaluated based on psychological experiments. The evaluation criteria were the following. How similar the converted images are to the original art genre. Whether or not they can offer new possibilities for the original art genre. How high they are evaluated when viewed as figurative art, and how high they are evaluated as abstract art. Since AI itself does not have a function to evaluate the generated images, the evaluation used the framework of the psychological evaluation experiment by the subjects.

As a result, some new findings were obtained as described in the discussion. Since sufficient analysis has not been performed yet, we would like to perform detailed analysis

such as analysis of variance (ANOVA) in the future. Based on this, we plan to proceed with future studies.

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