

An Approach To Investigate Abstraction in Art Using AI and Psychological Experiment

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Abstract

The history of paintings began with drawing real objects such as landscapes. However, the relationship between artworks and real objects became unclear as time passed. As it is sometimes difficult for ordinary people to understand artworks, especially in the case of abstract paintings, it would be preferable to investigate the relationship between a specific artwork or art style and real objects. On the other hand, AI has made rapid progress in recent years, and new technologies, such as converting photographs into art-like images, called "style transfer," have emerged. This paper challenges the approach of investigating abstraction in art by studying the relationship between artworks and real objects. We used the methodology of combining the AI style transfer function and psychological experiment.

Keywords: Abstract art, Style transfer, Psychological experiment

1 Introduction

The history of painting began by drawing landscapes and other real objects around us as our eyes capture them. The paintings gradually changed to express them abstractly. Especially in the case of modern abstract paintings, ordinary people feel difficulty understanding what they express. Regarding abstract expression in art, various discussions and considerations have been done [1 - 4], but these are primarily by art experts and are difficult for ordinary people to understand. Although there are various approaches from a psychological and scientific point of view [5 - 8], further studies are necessary.

On the other hand, AI based on deep learning has made rapid progress in recent years [9]. New technologies have emerged to generate fake images of human faces [10] and convert photos into art-like images of a particular genre [11]. We think these new AI technologies can approach the relationship between paintings and real objects.

In this paper, instead of directly approaching the issue of what abstract art expresses, we try to investigate the relationship between artworks and real objects by combining the style transfer function of AI and the methodology of psychological experiments. We use the AI style transfer function to convert a real object into an image with a specific art style. Then we evaluate whether the conversion is successful or not based on a psychological experiment. We assume a strong relationship between the real object and the art style if the evaluation result is good. This means that the art style tries to extract and express an essential part of the real object.

2 Related Works

2.1 Art Style Transfer Using CycleGAN

Recent advances in AI have created new technologies called GANs [9]. GANs consist of generation networks and identification networks, as shown in Fig. 1. Generation networks try to generate fake images as close to the actual images as possible, and identification networks try to distinguish between real and fake images as accurately as possible. It has the characteristic that training converges with fewer training samples.

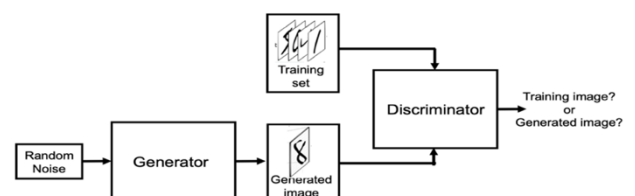


Figure 1: Basic configuration of GANs [9].

Among various GANs, we focused on CycleGAN [11]. CycleGAN aims to generate an image similar to the original image by reconverting the converted image. CycleGAN allows mutual conversion between two image sets. For example, using this capability, a photo can be converted into a Monet-like image and vice versa, as shown in Fig. 2. This capability is called the "style transfer function."

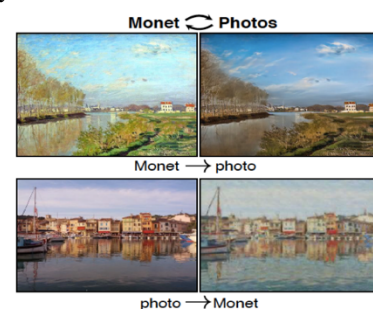


Figure 2: Conversion between a landscape photo and a Monet painting using CycleGAN [11].

2.2 Research on Art Style and Art Abstraction

There are many investigations for abstract art, especially comparing figurative and abstract paintings [5 - 8]. For example, Belke et al. investigated whether the evaluation would change or not when style-related information is given and found that such information positively changes the opinion of the subjects [7].

At the same time, many discussions have been done regarding abstract art and abstraction [1 - 4]. Some of them are from an aesthetical point of view [1][2], and others are from a philosophical point of view [3][4] on what art abstraction is. However, most of them are qualitative based on the subjective opinions of art experts. A few researchers from the science and technology side have approached this issue [8].

3. Relationship between Real Objects and Art

By using the style transfer function of CycleGAN, it is possible to model the relationship between a real object and an artwork. Figure 3 illustrates the relationship between landscape and landscape painting, showing that landscape painting is a transformation of the landscape. Figure 4 shows this more abstractly. Figure 4 means that art expresses the essence of a real object.

As is shown in Fig. 2, the transformation works well when there is a similarity or a strong relationship between images in the two image sets [11]. Also, we confirmed that when there is little similarity, such as between portrait or horse photos and Ikebana (Japanese flower arrangement) photos, the transformation does not work well, or over-transformation occurs [12], as is shown in Fig 5. This means the fact that the transformation works well suggests a strong relationship between the painting and the real object. In other words, it shows that the painting takes out and expresses the essence of the real object or abstracts it.

Our basic methodology is to investigate the relationship between two image sets based on evaluating whether the transformation works well or not. As AI cannot evaluate the obtained artistic images, the framework of psychological experiments using subjects was adopted to evaluate whether the conversion was successful. Using such a methodology makes it possible to investigate the relationship between paintings and real objects.

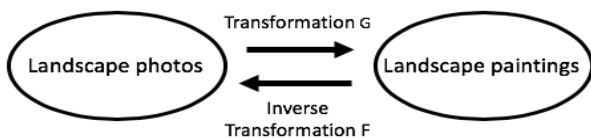


Figure 3: Relationship between landscape photos and landscape paintings.

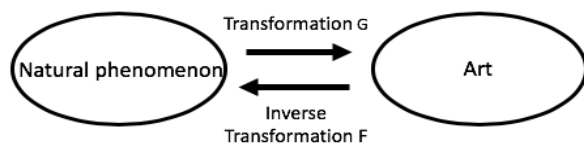


Figure 4: Relationship between natural phenomenon and art.



Figure 5: Several failed transformation results between portrait and Ikebana photos [12].

4 Style Transfer of Real Objects Using CycleGAN

We use the style transfer function of CycleGAN to convert multiple types of real objects into images with multiple art styles. We used the following three types of paintings and photos as artworks with specific art styles 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. This means that Ikebana is trying to express nature in a minimalistic way. So, it is interesting to investigate whether the transformation between Ikebana photos and real objects works well or not. We used about 500 images selected from Flickr for training CycleGAN. Figure 6 shows several examples of Ikebana photos.



Figure 6: Examples of Ikebana photos.

2) Shan-Shui

Shan-Shui is a painting born in China in the 5th century. At first glance, it looks like a figurative painting expressing the landscape in black and white. However, it is not a drawing of the actual landscape but the painter's imagination. Furthermore, in contrast to the perspective method that follows the laws of physics in the West, the perspective method called "San-en [13]," which incorporates landscapes seen from multiple directions into one painting, is adopted. Therefore, it is interesting to investigate whether the transformation between real objects and Shan-Shui painting works well or not. We used about 300 images selected by Google Image search for training CycleGAN. Figure 7 shows several examples of Shan-Shui paintings.



Figure 7: Examples of Shan-Shui paintings.

3) Kandinsky Painting

Kandinsky is the founder of Western abstract painting. Compared to recent abstract paintings, his artworks may relate to real objects. Therefore, we decided to use Kandinsky's paintings to investigate their relationship with real objects. We used about 300 images selected from WikiArt for training CycleGAN.

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

4) Landscape Photo

At first glance, Ikebana and Shan-Shui paintings look like figurative representations of landscapes. However, as mentioned above, they are considered essential or abstract representations of landscapes. Therefore, it is an interesting question whether or not the landscape photos can be converted well into an Ikebana style or a Shan-Shui style by style transfer. On the other hand, as the relationship between Kandinsky's abstract paintings and landscape photo is unknown, it is interesting to find the relationship. We used about 1000 images for training CycleGAN. About 500 are distant views of natural scenery, and the remaining 500 are near. Figure 8 shows several examples of landscape photos.



Figure 8: Examples of landscape photos.
(<https://www.pexels.com/search/landscape/>)

5) Cityscape photo

We used city landscape photos as another real object. Artificial cityscapes are modern landscapes and may be compatible with Western abstract paintings. Also, it is interesting to see how this relates to Ikebana photos and Shan-Shui paintings. We used about 1000 images for training CycleGAN. About 500 are distant views of cityscapes, and the remaining 500 are near views. Figure 9 shows several examples of cityscape photos.



Figure 9: Examples of cityscape photos.
(<https://www.pexels.com/search/city%20landscape/>)

5 Psychological Evaluation Experiment of Obtained Image

5.1 Data Used in Psychological Evaluation Experiments

The style conversion from the photos to images with different art styles obtained the following 12 types of image sets.

Image sets 1: Three image sets obtained by converting landscape photos (distant views) into (Ikebana, Kandinsky, Shan-Shui) style.

Image sets 2: Three Image sets obtained by converting landscape photos (near views) into (Ikebana, Kandinsky, Shan-Shui) style.

Image sets 3: Three image sets obtained by converting cityscape photos (distant views) into (Ikebana, Kandinsky, Shan-Shui) style.

Image sets 4: Three image sets obtained by converting cityscape photos (near views) into (Ikebana, Kandinsky, Shan-Shui) style.

Fifteen images were selected from each of these image sets and used in our psychological experiments. Figures 10 and 11 are several examples of the images used in the experiment.



Figure 10: Upper: Images of distant landscape views, Bottom: Images converted into Ikebana, Kandinsky, and Shan-Shui styles.



Figure 11: Upper: Images of distant cityscape views, Bottom: Images converted into Ikebana, Kandinsky, and Shan-Shui styles.

5.2 Subjects

Forty-eight students from Kyoto University joined the experiment as subjects. Their age is from late teens to 20s. Among the 48 subjects, 26 are males, and 22 are females (male: 54%, female: 46%), and the number of students is balanced. Although none are students who specialize in art, they have studied art history and gained basic knowledge about art at high school and university. In addition, since the condition for participating in the experiment was "he/she is interested in art and often appreciate art at museums," they have the essential ability to appreciate and evaluate traditional and contemporary art.

5.3 Experimental Method

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

The evaluation was based on a psychological method in which the subjects rated the following two questions using a seven-point Likert scale rating from 1 (not at all) to 7 (exactly right).

Because of the Covid-19 situation, the experiment was conducted online using Google Forms. We asked the subject to use their laptop computer with a size of 13" – 15". There was no time limit for the evaluation, and we allowed the subjects to watch around the images and change their evaluation score freely until they were satisfied.

Question 1: Does the image look like X?

Here X is Ikebana photo, Kandinsky art, or Shan-Shui painting, depending on the image shown to the subject. This question asks whether or not a landscape/cityscape photo transferred into an X-style image looks like X. We hypothesized that the evaluation score is high when there is a strong relationship between the original landscape/cityscape photo and X.

Question 2: Does the image look like a new X?

Here X is Ikebana photo, Kandinsky art, or Shan-Shui painting, depending on the image shown to the subject. This question asks whether a landscape/cityscape photo transferred into an X-style image looks like the new art of X or not. As is well known, sometimes combining two different types of things could create new art. For example, the combination of day and night can create a surrealistic image. Therefore, we hypothesized that there is a possibility of generating new types of art by combining existing artwork and landscape/cityscape photos.

6 Experimental Results and Discussion

In this experiment, scape (landscape/cityscape), view (distant/near), and art genre (Ikebana/Kandinsky/Shan-Shui) affect the results. Therefore, we conducted tree-way ANOVA and then conducted multiple comparisons.

6.1 Evaluation of 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, Shan-Shui). In other words, how much the

characteristics of the original art are retained. The results of multiple comparisons using the Holm method are shown in Fig. 12 (comparison between landscape and cityscape), Fig. 13 (comparison between distant and near views), and Fig.14 (comparison among Ikebana, Kandinsky, and Shan-Shui).

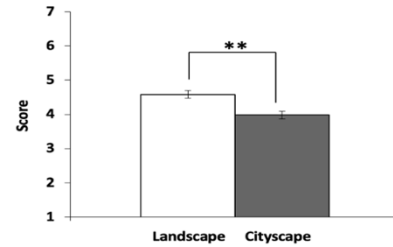


Figure 12: Comparison between landscape and cityscape.

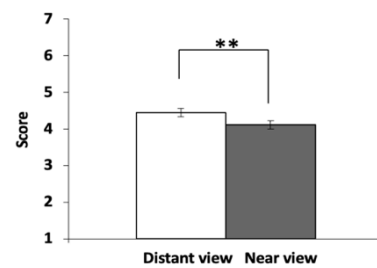


Figure 13: Comparison between distant view and near view.

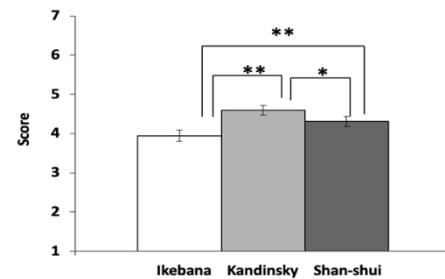


Figure 14: Comparison among three art genres.

The multiple comparisons in Fig. 12 show that the evaluation value of the landscape is significantly higher than that of the cityscape ($p < .01$). Also, Fig. 13 shows that the evaluation value of the distant view is significantly higher than the near view ($p < .01$). This means that there is a strong relationship between these art genres and the landscape, especially the distant view of the landscape. In other words, these art genres extract the essence of the landscape.

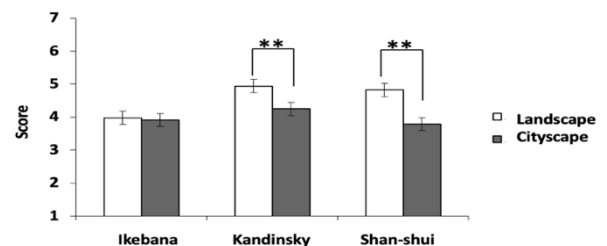


Figure 15: Comparison of evaluation values between landscape and cityscape by genre.

For genres, it is noteworthy that Kandinsky art's evaluation value is high. As shown in Fig. 14, its evaluation value is significantly higher than the Ikebana ($p<.01$) and higher than the Shan-Shui painting ($p<.05$). Furthermore, Fig. 15 compares each art genre's evaluations of landscapes and cityscapes. For Kandinsky art and Shan-Shui paintings, landscapes have significantly higher evaluation values than cityscapes ($p<.01$). Interestingly, Kandinsky's paintings have a significantly higher evaluation value for the landscape than the cityscape ($p<.01$). We expected that Kandinsky's art, a product of modern times, is compatible with artificial objects such as cityscapes, but the results denied our expectation. We can say that Kandinsky's paintings have a strong relationship with landscapes. In other words, they retain the flow of realism and impressionism. It is also noteworthy that, as shown in Fig. 14, Ikebana has a significantly lower evaluation value ($p<.01$) than Shan-Shui and Kandinsky. We expected Ikebana would be highly evaluated because the affinity between Ikebana and the landscape is considered good. However, the results were contrary to the expectation. The reason for this will be explained later.

6.2 Evaluation of newness

In this evaluation item, we asked the subjects to evaluate whether the presented image is recognized as new art compared with the original art (Ikebana, Kandinsky, Shan-Shui). The results of multiple comparisons are shown in Fig. 16 (comparison between landscape and cityscape), Fig. 17 (comparison between distant view and near view), Fig. 18 (comparison among Ikebana, Kandinsky, and Shan-Shui), and Fig. 19 (comparison between landscape and cityscape for each art genre).

As shown in Fig. 16, the cityscape has a significantly higher evaluation value than the landscape ($p<.01$). The images obtained by converting the cityscape, an artificial object, into each art genre style are evaluated as newer as art than the landscape. As Fig. 17 shows the comparison between the distant and the near views, the near view is significantly higher than the distant view ($p<.01$). Probably, the reason is that a specific tree or a specific building is retained in the obtained images and evaluated as new.

Regarding the comparison among three genres, Ikebana is highly evaluated, contrary to Fig. 14. As shown in Fig. 18, the evaluation values are higher in the order of Ikebana, Shan-Shui, and Kandinsky. In addition, Ikebana and Shan-Shui have significantly higher evaluation values than Kandinsky ($p<.01$).

The fact that "Does the image look like new Ikebana?" was evaluated high while "Does the image look like Ikebana?" was evaluated low is a remarkable result. Probably, this is because the subjects, accustomed to seeing Ikebana, have a strict aesthetic eye for Ikebana. The images of landscapes and cityscapes converted into the Ikebana style are evaluated as different from Ikebana they are accustomed to appreciating. On the other hand, the subjects indicated that the images obtained by converting the landscape or the cityscape into an Ikebana style are new Ikebana. As mentioned earlier, Ikebana is an essential representation of nature in a

minimalistic way. These results reveal that the Japanese subjects understand the essence of Ikebana well.

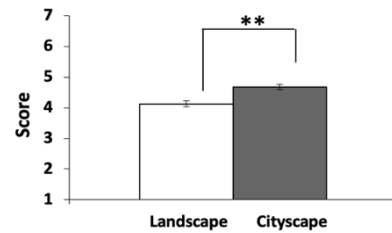


Figure 16: Comparison between landscape and cityscape.

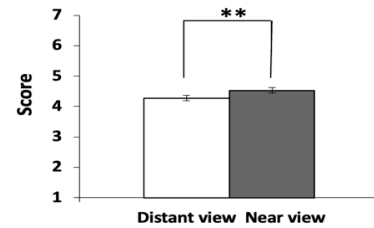


Figure 17: Comparison between distant view and near view.

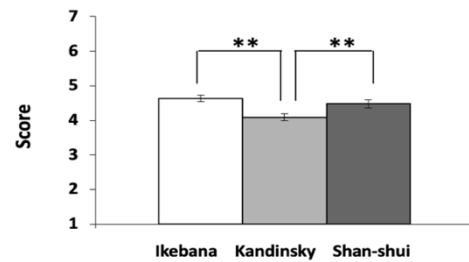


Figure 18: Comparison among three art genres.

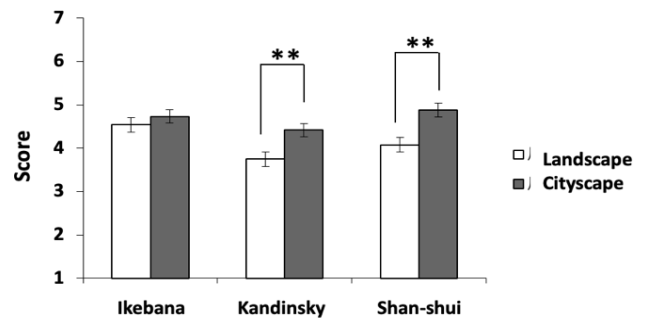


Figure 19: Comparison between landscape and cityscape for each art genre.



Figure 20: Shan-Shui painting by Yang Young Liang (<https://www.yangyongliang.com>)

Also, as is shown in Fig. 19, it is evaluated that a new Shan-Shui painting is obtained by converting the cityscape to a Shan-Shui painting style. Chinese artist Yang Young-Ryan creates artworks where a cityscape and a Shan-Shui painting are combined [14] (Fig. 20), which embodies this evaluation result.

7 Conclusion

In this study, we investigated the relationship between real objects and art. Art is considered an expression of the essence of real objects. However, a few studies have approached this issue from the science and technology side. Here, we focused on a technology called “style transfer” achieved by a recent AI technology, CycleGAN, which can achieve transformation between two image sets, such as a horse image set and a zebra image set.

This technology makes it possible to make photographs into images with a specific art style. We assume that the conversion works well when there is a similarity between the original photo and the art style. For example, the successful conversion of a landscape into a landscape painting means that the landscape painting is an expression extracting essential features of the landscape.

We investigated the relationship between Ikebana/Kandinsky art/Shan-Shui paintings and real objects. We used landscapes (distant/near views) and cityscapes (distant/near views) as real objects. Then the landscape/cityscape images were converted into Ikebana/Kandinsky art/Shan-Shui painting styles using the style transfer function of CycleGAN. Then, the obtained images were evaluated based on psychological experiments using two questions; how similar the converted images are to the original art style and whether they can offer possibilities of generating new art for the original art style.

The results show that the relationship between Ikebana photos and landscape/cityscape is not vital. On the other hand, landscape/cityscape photos transferred into the Ikebana style were highly evaluated as new types of Ikebana. For this, we did some consideration, and we hypothesize that the subjects, Japanese university-level students, have a high level of aesthetics to evaluate Ikebana and severely evaluated the images converted into Ikebana style but at the same time found a possibility of new Ikebana.

For Kandinsky's art, the result shows that there is a strong relationship between it and landscape. At the same time, landscape/cityscape photos converted into Kandinsky style were not highly evaluated as new types of Kandinsky art. For this, we did some consideration, and we hypothesize that Kandinsky's art still closely relates to real objects such as landscapes.

The result for Shan-Shui is somewhere in between Ikebana and Kandinsky art. One exciting result shows that cityscape photos converted into Shan-Shui style obtained a high evaluation score as new art. Moreover, we found that the combination of cityscape and Shan-Shui already exist in Yang Young Liang's artworks which are highly evaluated as new types of art.

Based on these results, we believe we could approach the relationship between real objects and art; in other words, we could somewhat approach what abstraction means. However, we understand that we are still far away

from it. For future research, we reconsider our research methodology, especially the questions asked to the subjects, and try to investigate the relationship between art and real objects more precisely. Based on this, we try to approach the essential question of what specific artwork or art genre tries to express.

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