

Investigation of the Relationship between Artworks and Real Objects Using AI and Psychological Experiments

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Abstract. 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. We focused on how new AI technology called “style transfer” can convert photos into artistic images with a specific style. This paper challenges the problem of investigating the relationship between real objects and artworks by using this style transfer capability and the methodology of psychological experiments.

Keywords: Real object and art, Abstract art, GANs, Style Transfer, Psychology

1 Introduction

Artworks represented by paintings began as drawings of real objects represented by landscapes 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. In this paper, instead of directly approaching the issue of what abstract art expresses, we try to investigate the relationship between real objects and artworks.

We focused on the fact that AI based on deep learning has progressed rapidly in recent years [9]. New AI technologies generate realistic human face images [10] and convert photos into artistic images with a particular art style [11]. We think that using these new AI technologies can approach the relationship between natural objects and artworks.

This paper challenges this issue using AI's style transfer capability and the psychological experiment methodology. The style transfer function can convert a real object into an image with a specific art style. Then the obtained images are evaluated based on a psychological experiment. We assume that if the evaluation shows good results, there is a strong connection between the real object and the art style. This means that

the art style tries to extract and express an essential part of the real object, or in other words, tries to abstract the real object. Our previous research reported the basic idea and preliminary result [18]. This paper describes the methodology and a more detailed analysis of the results.

2 Related Works

2.1 Art Style Transfer Using CycleGAN

New technologies called GANs have emerged based on recent advances in AI [9]. GANs consist of two networks: generation networks (G), and discrimination networks (D), as shown in Fig. 1. The training process is a minimax game between G and D. G tries to generate new data (fake images) that resembles the training data as much as possible, and D tries to distinguish between real and fake data as precisely as possible. After this game reaches its equilibrium state, G and D could perform their best, and one might use G to generate new data from random noise or specific input data. The characteristic of GANs is that network training can converge with relatively small training samples.

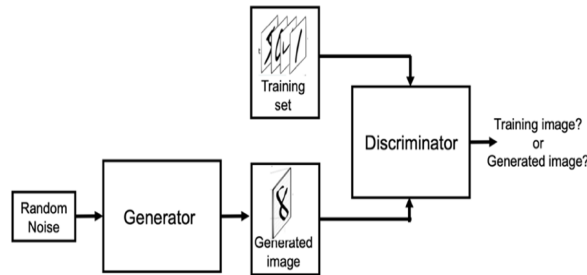


Fig. 1. GANs basic configuration [9]

Various types of GANs have been proposed, and we are interested in CycleGAN [11]. CycleGAN can convert an image set into a different type of image set and vice versa. Figure 2 shows that, using this capability, the mutual conversion between a photo and a Monet-like image. We call this capability the “style transfer function.”

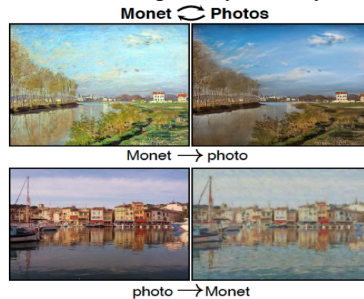


Fig. 2. CycleGAN achieves conversion between a Monet painting and a landscape photo. [11]

2.2 Research on Art Style and Art Abstraction

In the late 19th century, Fechner started quantitative research on art evaluation, called experimental aesthetics, by measuring people's emotions, such as comfort and discomfort [12]. Then, various studies followed his achievement in psychology, such as investigating the beauty of art, art style, etc.

For example, Farkas [13] investigated what kind of artworks people preferred and found that they preferred famous artworks. Winston and Cupchik [14] investigated the difference in preference between professionals and amateurs using fine art and secular paintings. Their research revealed that experts prefer fine arts, and amateurs prefer secular paintings.

There are many investigations on abstract art, especially comparing figurative and abstract paintings [5 - 8]. For example, Freedman compared the preference for abstraction and complexity of paintings among three adult groups: elementary education students, art education students, and professors and graduate students. She found that the first group most preferred the low-abstraction-low-complexity paintings, and the third group preferred the high-abstraction-high-complexity paintings [5]. Pihko et al. investigated the preference for abstract art between laypersons and experts by changing the abstraction level of paintings. They found that the level of abstraction affected the aesthetic judgment of laypersons but had no effect on experts [6]. 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 art experts' subjective and qualitative opinions. The approach from the science and technology side is only a few [8].

3 Relationship between Art and Real Objects

CycleGAN's style transfer function described above made it possible to model the relationship between an artwork and a real object. The relationship between landscape and landscape drawings is illustrated in Fig 3, which shows that landscape drawing is obtained as a landscape transformation. More abstract expression is shown in Fig. 4, meaning that art extracts a real object's essence.

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 [15], as is shown in Fig 5. The painting and the real object are strongly related if the transformation works well. In other words, the essence of the real object is extracted and expressed in the painting.

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 eval-

uate the obtained artistic images, we have adopted the framework of psychological experiments to evaluate whether the transformation was successful or not. The investigation of the relationship between artworks and real objects became possible using such a methodology.

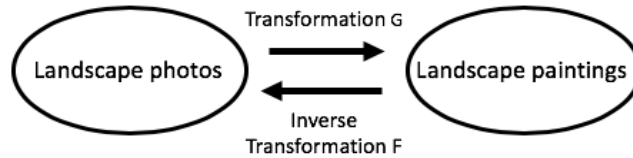


Fig. 3. Connection between landscape paintings and landscape photos.

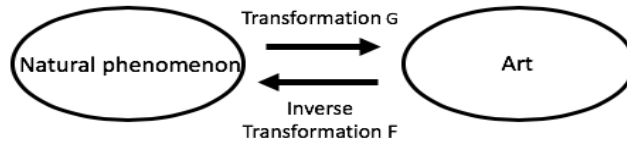


Fig. 4. Connection between art and natural phenomenon.



Fig. 5 Several failed transformation results, from portrait to Ikebana-like images [15].

4 Style Transfer of Real Objects Using Cycle GAN

CycleGAN's style transfer function converts various types of real objects into images with various art styles. The three kinds of paintings and photos below were used as artworks with specific art styles of the West and the Orient.

1) Ikebana (Japanese flower arrangement)

The feature of Ikebana is to express nature using flowers and plants. At the same time, Ikebana is not representing nature as a miniature. It expresses nature with only a few flowers and plants. In other words, Ikebana expresses nature in a minimalistic method. So, it is interesting to investigate whether the transformation between Ikebana photos

and real objects works well or not. About 500 images were selected from Flickr for the training of CycleGAN. Several examples of Ikebana photos are shown in Fig. 6.



Fig. 6. Examples of Ikebana photos.

2) Shan-Shui painting

Shan-Shui painting was born in the 5th century in China. We consider them figurative drawings expressing the landscape in black and white. However, Shan-Shui is not a figurative landscape drawing. However, it is drawn based on the painter's imagination. Furthermore, different from the Western perspective method based on the physical laws, the different perspective method "San-en [16]" is adopted. San-en is a method to combine landscapes seen from multiple directions (looking up, looking in parallel, looking down) into one painting. It is interesting to investigate whether the transformation between real objects and Shan-Shui painting works well or not. About 300 images selected by using Google Image search were used for the training of CycleGAN. Several examples of Shan-Shui paintings are shown in Fig. 7.

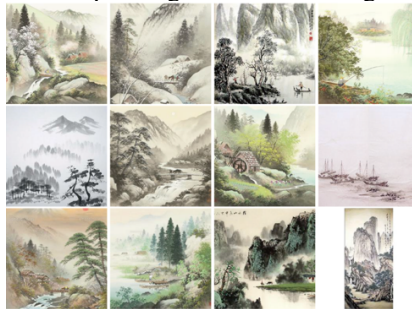


Fig. 7. Examples of Shan-Shui paintings.

3) Kandinsky's painting

Kandinsky is well known as the pioneer of abstract paintings in Western art history. We can assume that his artworks may relate to real objects compared to recent abstract paintings. Therefore, Kandinsky's paintings were used to investigate their relationship with real objects. About 300 images were selected from WikiArt for the training of CycleGAN.

We used the following two types of photos as real objects.

4) Landscape photo

We tend to consider Ikebana and Shan-Shui as figurative representations of landscapes. However, as mentioned before, they extract and express the essence of landscapes or, in other words, the abstraction of landscapes. It is interesting to investigate whether the AI style transfer function can convert well landscape photos into an Ikebana or a Shan-Shui style image. At the same time, it is interesting to find the connection between Kandinsky's abstract paintings and landscape photos. About 1000 landscape images were selected and used for the training of CycleGAN. About 500 are distant landscape views, and the remaining 500 are near views. Figure 8 shows several examples of landscape photos.

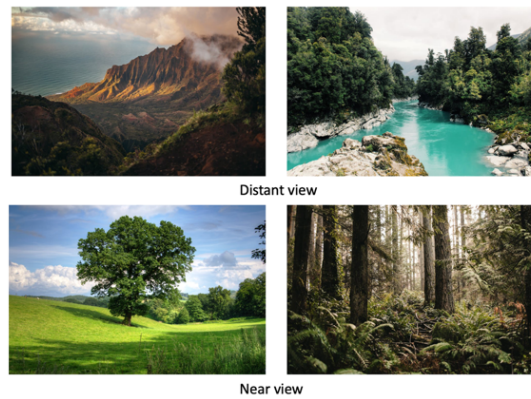


Fig. 8. Examples of landscape photos. (<https://www.pexels.com/search/landscape/>)

5) Cityscape photo

Cityscape photos were used as another real object. Cityscapes are modern artificial landscapes. We considered that they might be compatible with Western abstract paintings. Also, it is exciting to see how cityscape photos relate to Ikebana photos and Shan-Shui paintings. About 1000 cityscape photos were used for the training of CycleGAN. About 500 are distant views, and the remaining 500 are near views. Figure 9 shows several examples of cityscape photos.



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

5 Psychological Evaluation of Obtained Images

5.1 Data Used in Psychological Evaluation Experiments

The following twelve image sets were obtained by the style transfer from the photos to images with different art styles.

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

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

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

Image sets 4: Three image sets obtained by converting cityscape new view photos into (Ikebana, Kandinsky, and Shan-Shui) styles.

We have selected fifteen images from each of these image sets and used them for the psychological experiments. Figures 10 and 11 are several examples of the images used in the experiment.

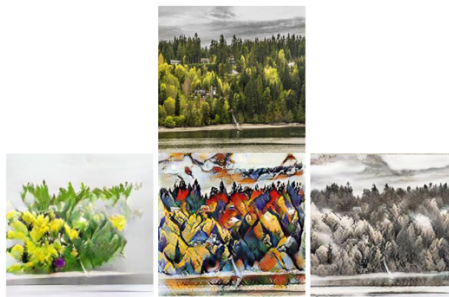


Fig. 10. Upper: Image of distant landscape view, Bottom: Images transferred into Ikebana, Kandinsky, and Shan-Shui styles.



Fig. 11. Upper: Image of distant cityscape view, Bottom: Images transferred into Ikebana, Kandinsky, and Shan-Shui styles.

5.2 Subjects

We selected forty-eight students of Kyoto University as subjects. Their age ranges from late teens to twenties. Among the forty-eight subjects, twenty-six are males, and twenty-two are females (male: 54%, female: 46%). Although none are students who specialize in art, they have studied art history and gained basic knowledge about art in high school and university. In addition, since the condition for participating in the experiment was "he/she is interested in art and often appreciates 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 four types of original photos (distant landscape view, landscape near view, distant cityscape view, cityscape near view) x fifteen images mentioned above, were shown to and evaluated by the subjects.

The subjects rated each image following the below 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 go around the images and change their evaluation score freely until they were satisfied.

Question 1: Does the image look like X?

Here X is an 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 an 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 Results of the Experiment and Discussion

6.1 Results of the Experiments

Figures 12 - 13 show the graphs of the averaged evaluation scores for all the subjects for the above two questions. In 6.2, we will discuss more details for each of the results.

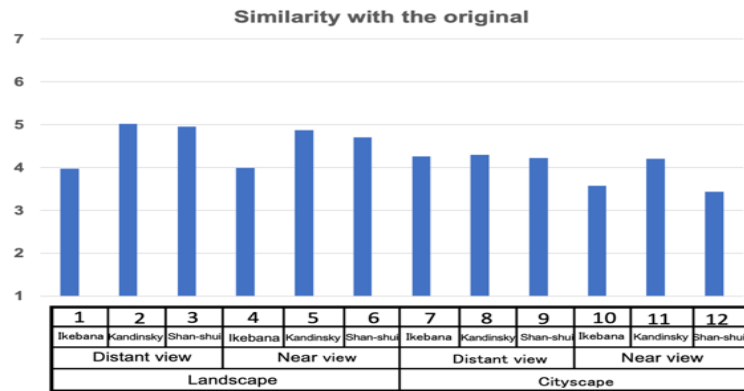


Fig. 12. Mean evaluation ratings of similarity to the original.

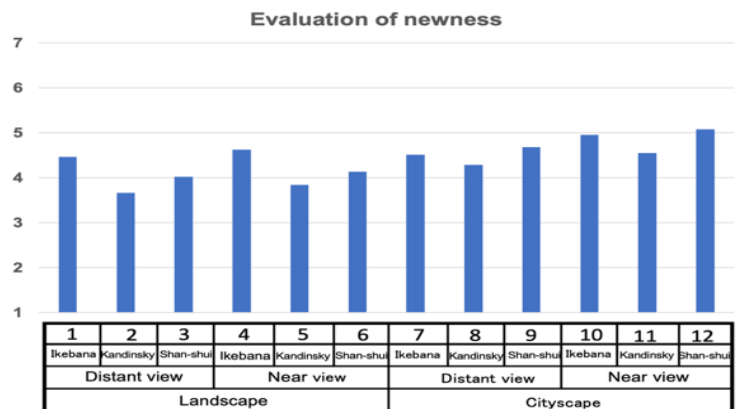


Fig. 13. Mean evaluation ratings of newness compared to the original.

6.2 Discussion

1) Evaluation of similarity with the original

In this evaluation, the subjects evaluated the similarity of the presented image to the original art (Ikebana, Kandinsky, or Shan-Shui). This means that they evaluated to what extent the characteristics of the original art are maintained.

There are three factors: scape (landscape/cityscape), view (distant view/near view), and genre (Ikebana/Kandinsky/Shan-Shui). Therefore, to further investigate Fig. 12, a three-way ANOVA was conducted. The results show that all of the main effects of

scape, view, and genre are significant (scape: $F(1, 47)=104.6, p<.01$, view: $F(1, 47)=79.9, p<.01$, genre: $F(2, 94)=14.7 p<.01$). The results of multiple comparisons are shown in Fig. 14 (comparison between landscape and cityscape), Fig. 15 (comparison between distant and near views), and Fig.16 (comparison among Ikebana, Kandinsky, and Shan-Shui).

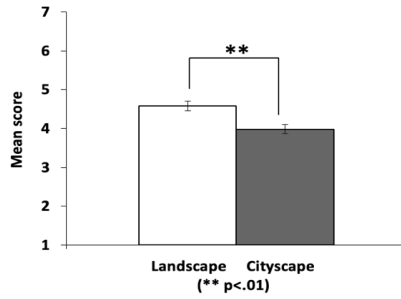


Fig. 14. Comparison between landscape and cityscape.

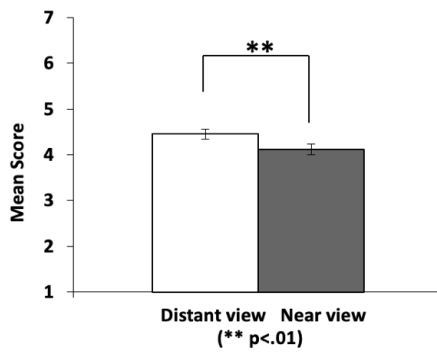


Fig. 15. Comparison between distant view and near view.

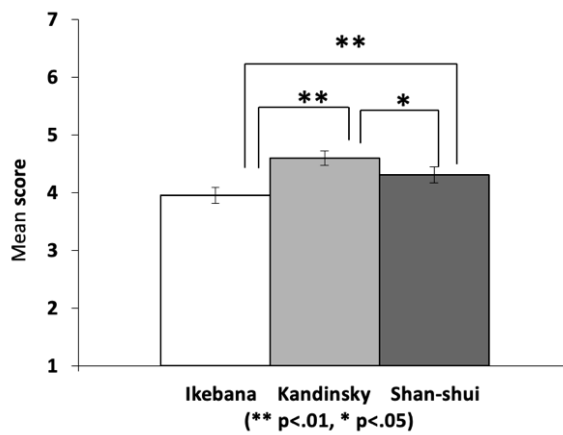


Fig. 16. Comparison among three art genres.

The multiple comparison results in Fig. 14 show that the landscape obtained an evaluation value significantly higher than the cityscape ($p < .01$). Also, Fig. 15 shows that the distant view obtained an evaluation value significantly higher than the near view ($p < .01$). These results mean that there is a strong relationship between these art genres and the landscape, especially the distant view of the landscape. In other words, we can say that these art genres extract the essence of the landscape.

For genres, it should be pointed out that Kandinsky art's evaluation value is high. As shown in Fig. 16, its evaluation value is significantly higher than Ikebana ($p < .01$) and higher than the Shan-Shui painting ($p < .05$).

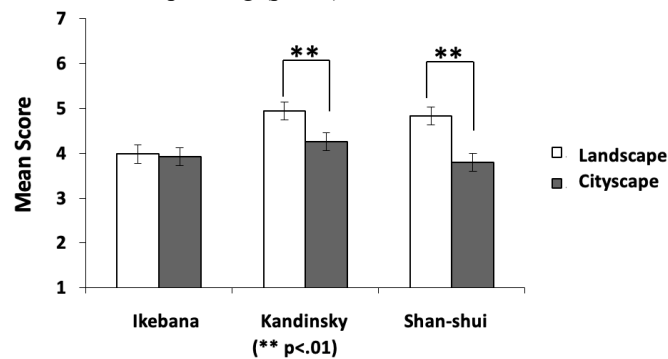


Fig. 17. Comparison of evaluation values between landscape and cityscape by genre.

As the effect of interaction between scape and genre was significant ($F(2, 94)=71.3$ $p < .01$), multiple comparisons based on scape and genre were carried out. Fig. 17 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 assumed that Kandinsky's art, a product of modern times, is compatible with artificial objects such as cityscapes, but the results denied our assumption. We can say that Kandinsky's paintings have a strong relationship with landscapes. In other words, they are retaining the flow of realism and impressionism.

It should be stressed that, as shown in Fig. 16, Ikebana has a significantly lower evaluation value ($p < .01$) than Shan-Shui and Kandinsky. We expected that the evaluation of Ikebana would be high as we considered that Ikebana and the landscape have a good affinity. However, the results denied our expectations. The reason for this will be explained later.

2) Evaluation of newness

In this evaluation, the subjects evaluated whether the presented image is appreciated as new art compared with the original art (Ikebana, Kandinsky, or Shan-Shui).

To further investigate Fig. 13, a three-way ANOVA was conducted. The results show that all of the main effects of scape, view, and genre are significant (scape: $F(1, 47)=59.5$, $p < .01$, view: $F(1, 47)=36.6$, $p < .01$, genre: $F(2, 94)=16.5$ $p < .01$). The results

of multiple comparisons are shown in Fig. 18 (comparison between landscape and cityscape), Fig. 19 (comparison between distant view and near view), and Fig. 20 (comparison among Ikebana, Kandinsky, and Shan-Shui).

Moreover, as the effect of interaction between scape and genre is significant ($F(2, 94)=14.5$ $p<.01$), multiple comparisons based on scape and genre were conducted. Fig. 21 shows the comparison between landscape and cityscape for each art genre.

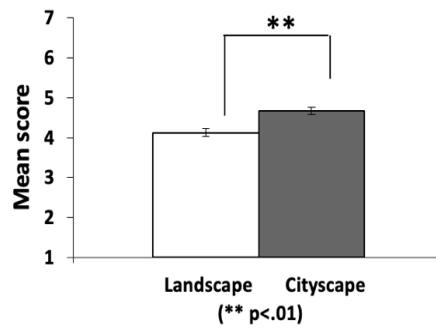


Fig. 18. Comparison between natural and cityscapes.

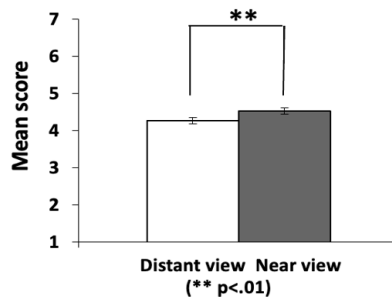


Fig. 19. Comparison between distant view and near view.

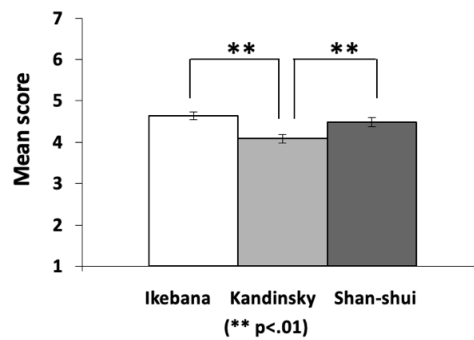


Fig. 20. Comparison among Ikebana, Kandinsky, and landscape paintings.

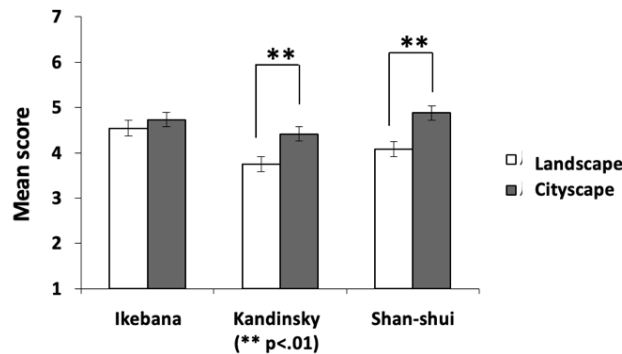


Fig. 21. Comparison between landscape and cityscape for each art genre.

As shown in Fig. 18, 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 are evaluated as newer as art than the landscape. As Fig. 19 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 the features of a specific tree or a specific building are retained in the obtained images and evaluated as new.

Regarding the comparison among three genres, Ikebana is highly evaluated, contrary to 1). As shown in Fig. 20, the evaluation values are high 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 actual 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.

Also, as is shown in Fig. 21, the subject evaluated that a new Shan-Shui art could be obtained based on the transformation of the cityscape to a Shan-Shui style. Chinese artist Yang Young-Ryan creates artworks where the combination of the cityscape and a Shan-Shui painting is realized [17] (Fig. 22), which embodies this evaluation result.



Fig. 22. Shan Shui painting by Yang Young Liang (<https://www.yangyongliang.com>)

7 Conclusion

In this study, we investigated the connection between Ikebana photos/Kandinsky artworks/Shan-Shui paintings, and real objects to investigate whether art expresses the essence of a real object. We used landscapes (distant/near views) and cityscapes (distant/near views) as real objects. The conversion of the landscape/cityscape photos into Ikebana style/Kandinsky art style/Shan-Shui painting style was conducted using CycleGAN's style transfer function. The evaluation of the obtained images was conducted based on psychological experiments. The following questions were asked; how similar the converted images are to the original art genre and whether they can be considered new art for the original art genre.

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. This was contrary to our expectations. Our present hypothesis is that the subjects, Japanese university 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 art the result shows that there is a strong relationship between Kandinsky art and landscape. At the same time, landscape/cityscape photos converted into Kandinsky style were not highly evaluated as new types of Kandinsky art. Also, this was contrary to our expectations. 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 as a new type of art.

Based on these results, we could approach the connection between real objects and art. In other words, we could approach to some extent 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 reveal the relationship between art and real objects.

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