Effects of Color Tone of Dynamic Digital Art on Emotion Arousal

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Abstract. The fast-paced life of contemporary society increases people's psychological stress, and a piece of creative digital art may help relieve the stress. Color has a certain contribution to adjusting a person's emotion. The interactivity and dynamics of digital art bring different experiences to our vision. This article was to present our work on the topic of whether different tones of still and dynamic digital art could make an impact on the emotion arousal. Over two experiments, 106 participants were invited to transfer the styles of 8 abstract images by adding blue and red tones. The dynamic creation processes were recorded to be used as stimuli, and three-dimensional valence-arousal-enjoyment model was used to measure emotions. The result of the experiment showed that adding different tones to digital art had no significant impact on the emotion arousal, however some participants expressed certain interests in the dynamic presentation of the creation process. The insights from this work could provide input to the design of digital art in emotion intervention and stress management.

Keywords: Emotion · Digital art · Color tone · Interactivity

1 Introduction

While humans are born with creativity in their most active minds, art is able to nourish the spirit of humans by its abundant spiritual nourishment in return, which enriches the human experience [1]. The wide variety of painting art does not only give various inspiring philosophies, but also gives people leisure and satisfaction. The painting art therapy [2] has enabled abstract art to become a communication bridge between art and the psychology field, which can help people to deal with stress and anxiety.

In paintings, color gives people the most direct and effective intuitive feelings. Paul Cézanne states that "First of all, a painting is and shall present color" [3]. The painters have combined cultures by practices, explorations on the application and expression of color, giving the color a wider range of expression. This article focused on the integration

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of digital technology and art, where much was to be explored for emotion intervention and stress management.

Researchers are exploring and researching on digital art [4] in the area of emotion cognition from the visual dimensions. One of such dimensions is for example motion. The interpretation of motion quoted in the book *Art and Visual Perception*, "Motion is the strongest visual appeal to attention…Human beings are similarly attracted by movement" [5]. The article was to look into another dimension, namely, color, to experiment with the features of digital art, to explore how the process of changing color tone in abstract art dynamically could increase people's attention on tone change and whether the sensation of interactive experience would be increased.

French philosopher, Hippolyte Adolphe Taine, states that "The interaction between different colors will give us different impressions, so the combination of colors will have different expressions [6]". One of the mentioned "the interaction between different colors" is color tone, and "different expressions" suggests that different interactions could affect people's emotions. A lot of research has been done to investigate the impact of color on emotion, mostly focused on red and blue tones [7]. The work presented in this article was to verify whether the addition of blue and red tones in digital art via still and dynamic ways would have different effects on emotion arousal.

2   Related Work

Tone is a term originated from music. It refers to pitch in musical works. Color tone refers to the tint in paintings, and it is the tonal key of a picture. Color connection is formed by dominant color and color schemes, and it is responsible for the overall color effect of all colors in a picture [8]. The color tones vary in hue, shade, purity, and temperature. In terms of hue, there are green, blue, red, yellow tones, etc.

Henri Matisse said, "The main function of color should be to serve expression [9]". Different applications of color bring different feelings to people. For example, the Man Golden Helmet by Rembrandt in brown tones conveyed an atmosphere of majesty and sorrow; By using light and pleasant tones, the Gypsy Girl by Frans Hals depicted a young gypsy wench who seemed happy with her life; The Massacre at Chios by Eugène Delacroix described the cruelty of the killing by intense brownish red; Henri Matisse used blue in his paintings to neutralize the emotions incurred by the colorful paintings, bringing people fancy purity and serenity. Art can satisfy people's aesthetic needs and stimulate people's inner emotions and awareness.

The effect of color on emotional perception has been found in internet web page design [10] and physical space [11]. Space where its dominant color was red, would be more possibly described as "stimulus induction", and this was identical to the viewpoint of Birren [12]. Birren believed that warmer colors (e.g. red and yellow) were more capable of further evoking emotion from an individual compared with cool colors (e.g. blue and green). In industry, the color psychology has broadly applied to use color tone to influence human behaviour. In the application areas of interior design and architecture, a systematic impact of color on emotion was often assumed [13]. For instance, in comparison to the medium and short wavelength of lights (blue or green), the light mainly consisting of a longer wavelength (red) would raise a higher arousal [14].

In comparison with traditional painting art, the strength of digital art is apparent. The emergence of dynamic media, e.g. animation, audio, video etc., has broken the monotonous traditional painting art, further enriched the visual sensation, and increased the interactivity and entertainment. As the main visual element of painting art, color can effectively convey emotion, combine with dynamic effect display, and more effectively convey information, which can be used as an effective way to attract viewers. In our work we tried to compare the process of presenting the image style transfer process in a dynamic way to the process with still images. We hypothesized that the presentation of the process of adding color tones by this approach would have certain effects on human emotion. The three-dimensional valence-arousal-enjoyment emotion model was adopted to conduct emotion analysis based on collected data.

3   Study Design

3.1   Stimuli

The experiment applied the open data set of abstract artworks established in 2010 by Machajdik and others, including 280 pieces of abstract artworks that contains only color and texture, with no identified objects to evoke emotion without simulating any specific objects. In this article, 8 images (Fig. 1) were selected from the data set, 4 of them were with a low arousal level (Sad and Content), and 4 with a high arousal level (Angry and Excited).
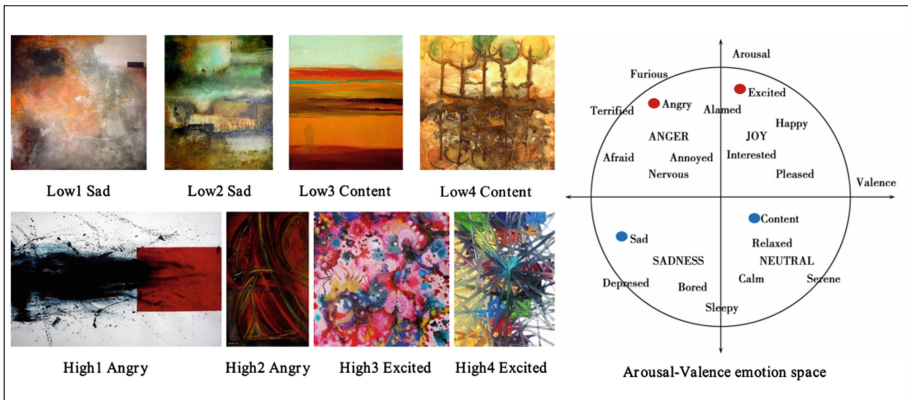

Fig. 1. 8 abstract images with low and high arousal

Each image was added stylish pictures manipulated with red and blue tones. They were displayed in 2 ways, one was in still motion (16 images, see Fig. 2), using the PowerPoint (PPT) format. The other was in dynamic way (16 videos, see Fig. 3 for production process).

The production process was captured in 16 videos (see Fig. 3). The style transfer processes were visually recorded and edited, that each image creation lasts for 30 s in
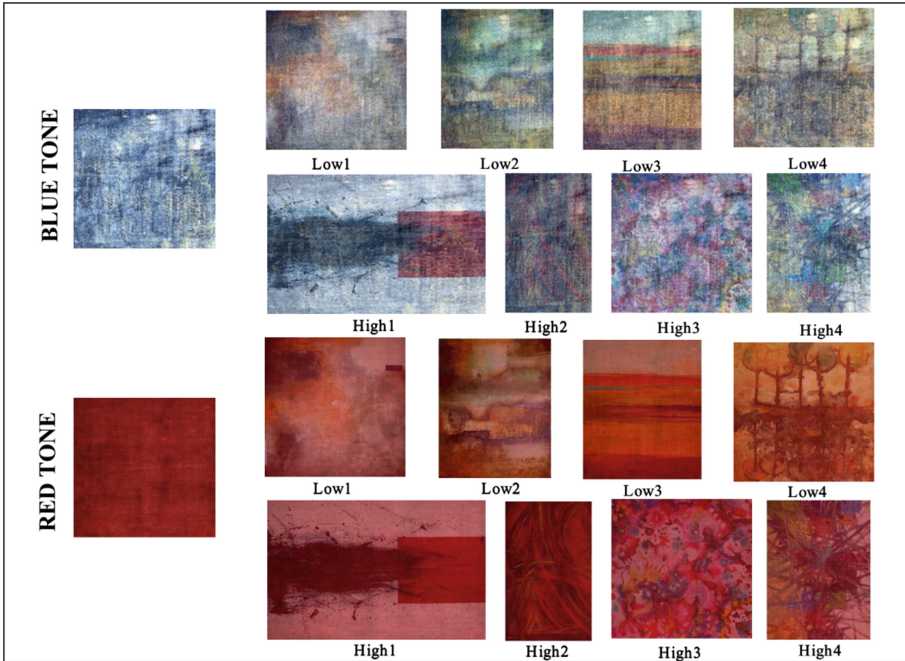
Fig. 2. 8 images manipulated with blue and red tone. (Color figure online)

motion. As a type of art language, oil painting is a rich one. It has plenty of color relations and expressions. Therefore, oil painting was adopted in the style transfer process. ALab and SmartPainting were used. These two software tools are developed by the Engineering Research Center of Computer Aided Product Innovation Design, the Ministry of Education, China. They were used to carry out algorithm techniques to realize image style transfer methods meanwhile showcase the process of image manipulation with brushwork.
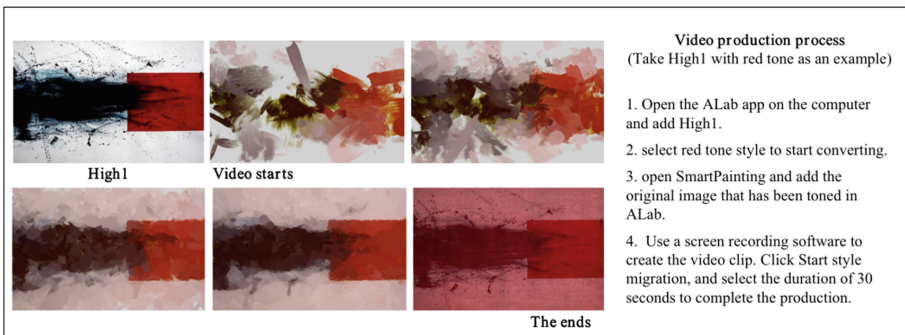

Fig. 3. Video production process of High1 with red tone. (Color figure online)

3.2 Participants

We recruited 106 participants from Zhejiang University for 2 experiments. They were at the education level of college or above, and with computer literacy. The test was arranged during the pandemic period, and the videos and questionnaires were sent to participants for the online experiments. The participants watched the videos on a computer, and filled out the questionnaires following the intervals of the process.

3.3 Experiment Design

Experiment 1

Participants
There were 53 participants in Experiment 1 (31 women and 22 men; Aged between 18 to 35, M = 21.4, SD = 4.1). All participants reported good vision, no color feebleness, nor color blindness.

Stimuli
Blue and red tones were added in each of the 8 images, which were divided into 2 sets, and played in order, see 1-A and 1-B of Fig. 4. 26 participants were in Group A (blue tone) and 27 participants in Group B (red tone).
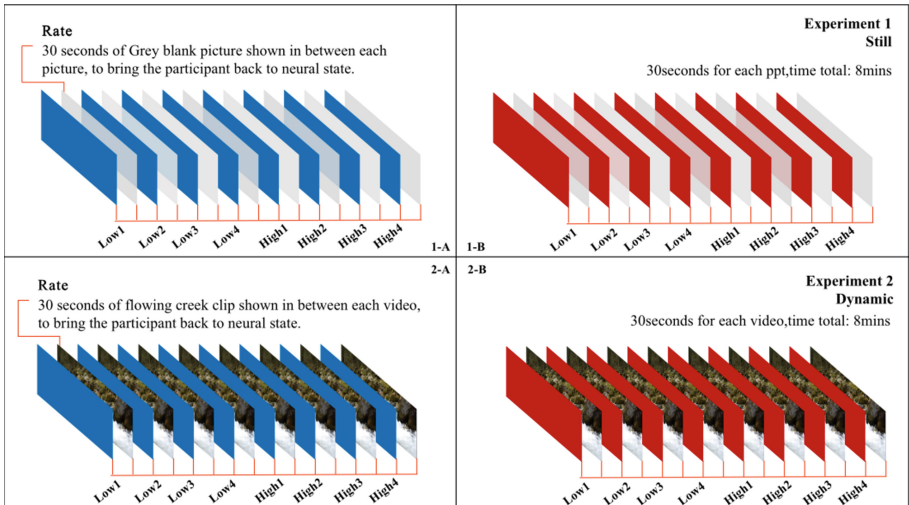

Fig. 4. Procedures of Experiment 1 & Experiment 2.

Procedure
An online survey was created at www.wjx.cn, an online survey and questionnaire platform. Participants were divided into two groups randomly. Group A watched the slides in blue tone, and Group B watched the slides in red tone. The participants were asked

to evaluate the levels of arousal, valence, and enjoyment for each image or video. The 0–10 rating scale was applied to evaluate arousal, valence, and enjoyment. To evaluate arousal, a rating of 0 (no arousal, e.g. calm) to 10 (the highest arousal, e.g. excitement) was scaled; To evaluate valence, a rating of 0 (negative) to 10 (positive) was scaled; To evaluate enjoyment, a rating of 0 (no enjoyment) to 10 (full of enjoyment) was scaled.
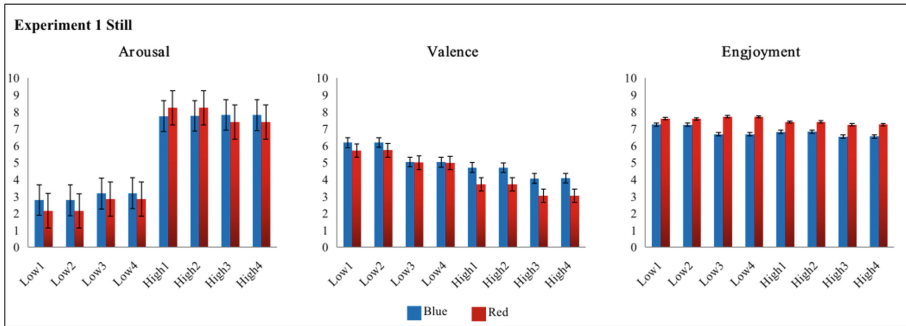

Fig. 5. Bar plots of mean arousal, valence and enjoyment ratings in Experiment 1.

Result and Discussion
The results showed that, regardless of the conditions, there was no significant difference in the level of arousal with of the 8 stimuli images. Figure 5 showed the results of arousal, valence and enjoyment levels. Among the 53 participants, 45 claimed that they had watched all of the slides, and none of them said they had not watched any slides. As a result, all participants had at least a glance at blue or red toned images, which shall be enough to trigger color association.

Experiment 2

Participants
There were 53 participants in Experiment 2 (30 women and 23 men; Aged between 18 to 64, M = 25.8, SD = 10.8). All of them reported good vision, no color feebleness, nor color blindness.

Stimuli and Procedure
Blue and red tones were added in each of the 8 images, which were divided into 2 sets. The image style transfer process was edited and recorded as videos, see 2-A and 2-B of Fig. 4. 26 participants were in Group A (blue tone), and 27 participants in Group B (red tone).

Result and Discussion
The average ratings of arousal, valence and enjoyment under each condition were calculated, see Fig. 6. Regardless of the conditions, there was no significant difference between the arousal of the original images and the arousal of the images with additional tones. There was also no significant difference in arousal in dynamic conditions. The

blue group recognized the Low arousal images with the addition of blue tone as more pleasant than the High arousal image with the addition of red tone in the red group. In addition, in the same condition, minimal changes were observable in all conditions (Figs. 5 and 6). Moreover, the result stayed the same with the data of valence. We combined data from 2 experiments and made an analysis of the impact of still and dynamic conditions (n = 53 per condition). Again, arousal ratings were not significantly different in the red compared to the blue condition. The a priori statistical power of this analysis was better than 0.8 (N = 106, single-tailed, independent-sample t-test).
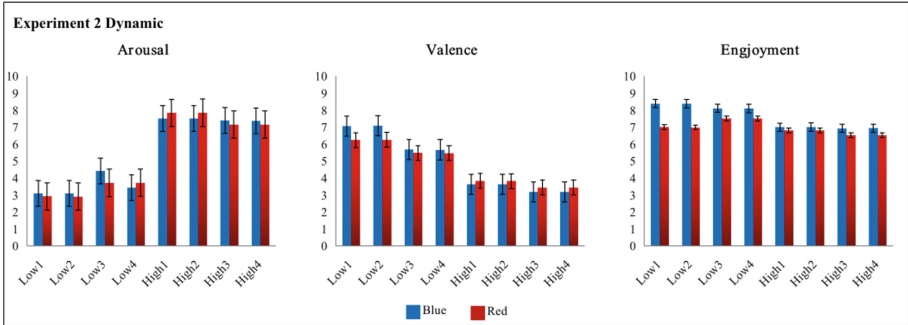

Fig. 6. Bar plots of mean arousal, valence and enjoyment ratings in Experiment 2.

4   Discussion and Future Work

The result did not support the assumption of the effect of digital art with the addition of tones on emotional arousal, whether in still or in dynamic conditions. In contrast, many researches have indicated that the emotional attribute of color is irreplaceable in any visual art form. The nature of color is an electrical signal formed by the retina struck by different wavelength of lights and then identified and processed by the brain. The research focused more on hue to emotional arousal. The settings of unadjusted saturation and brightness etc., might have been the reasons for not having an expected effect.

The article combined the features of digital art [15], presenting the process of changing color tone of images in a still or dynamic way. The transformation process of the formation of an image, starting from painting the outline with an oil painting brush, was artistic and rhythmical. It was a transformation of color in a flow, by presenting to the participants in the dynamic way, making the conveyance of a flat image to integrate with the characters of motion. However, only little change was made to people's emotional arousal, and it might be because of the video duration or other factors in the formation of the final image.

Furthermore, as a result of human mental activities, the digital art image implies rich affective semantics and messages. Kang et al. [16] conducted a research on different affections generated by different colors, and used quantization of 3-dimensional space to estimate the affection of color; Machajdik et al. [17] extracted the color, texture, layout

and content feature from drawings and paintings; Zhao and the team [18] discussed about the concept of art principle and its impact on images and emotions. Our work merely focused on emotional intervention by the color of low-level features, which may be one of the causes of the results.

The concrete objects which may cause specific emotions for the participants had been removed from the selected abstract paintings in the article. It was primarily consisted of visual features: line, color, texture, space, color block etc. [19]. By the applications of these type of visual features, it brought certain stimulation to human senses, affection resonance could be produced while people were watching abstract paintings [20]. Hence, only focusing on the change of hue may not be able to influence the affection towards the abstract paintings.

Another limitation was the physical experiment environment. As it was the pandemic period, it was not applicable to arrange for all participants to be tested in one single laboratory and use the same screens in the same environment. It was out of our control to collect data in a reasonably controlled physical space. We were unable to confirm whether different sizes of screens may influence the effect of tone on arousal. On the other hand, the article presented abstract still paintings with the addition of tones with the adoption of a dynamic way, which may also have a certain impact on participants.

Moreover, we will recruit more participants for the reliability and validity of the experiment. Last but not least, physiological data collection could be added in the future research [21], e.g. measurements of skin conductance, myoelectricity, electrocardio etc., to coordinate with the surveys for a comprehensive observation on the impact of arousal.

5   Conclusion

The research has indicated that, changing the color tone of digital art in either still or dynamic way had little effect on people's emotion arousal. We need to consider integrating other features in digital art to achieve the goal. Such features are, for instance, music and animations, and we could add these features into digital art stimuli so as to increase interactivity. Nevertheless, this research provided insights into using color tone for emotion intervention, that could lead to more explorations in the innovative use of digital art for emotion intervention and as one of the interesting directions, for managing stress and anxiety.

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