VISUAL COGNITION AND AESTHETICS OF PAINTING LAYOUT: AN ANALYSIS BASED ON EVENT RELATED POTENTIAL SIGNALS

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Abstract

In recent years, visual aesthetics, especially the painting aesthetics, has become a hot topic in aesthetic research. However, aesthetic psychologists have not paid enough attention to the layout of paintings. Therefore, this paper explores the aesthetic psychological mechanism of painting layout based on event related potential (ERP) signals. With eight paintings as the stimuli, the ERP signals of subjects were measured and analyzed to reveal their psychological mechanism in the appreciation of painting layout. The results show that, during the aesthetic process, the left and right brain regions differ greatly in the ERP activities, and the ERP waveforms reflect the subjective preferences; the subjects majoring in art pay high attention to the layout of the entire painting, and have strong ERP signals for paintings with aesthetic regularity. The research results shed new light on the visual cognition and aesthetics of works of art.

Key words: Event Related Potential (ERP) Signals, Aesthetics, Psychological Mechanism, Layout.

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INTRODUCTION

Aesthetics is a complex behavior with strong subjective initiative, and it’s a high-level social emotion (Bornstein, 1989). According to the aesthetic objects, aesthetics can be divided into visual aesthetics, auditory aesthetics and literary aesthetics (Rijlaarsdam, Pappa, Walton et al., 2016). Wherein, visual aesthetics mainly include paintings, abstract shapes, characters, etc. (Schroeder, Smith, Brennan et al., 2012; Weikum, Brain, Chau et al., 2013). Visual aesthetic psychological research mainly focuses on the psychological mechanisms in the aesthetic process of famous paintings, photographs and even pictures (Hecht, Hudson, Connors et al., 2016; Ming, Zhang, Yi et al., 2015).

At present, the painting research carried out in the field of psychology includes studies of professional level and color preference for the paintings, etc. (Bortoluzzi, Blaya, Salum et al., 2014; Gloster, Gerlach, Hamm et al., 2015; Trompetter, Bohlmeijer, Fox et al., 2015); there are also researchers who had concluded aesthetic activity psychological models based on aesthetic psychological research, such as the aesthetic psychobiology models, visual aesthetic cognitive models, etc. (Rani, 2013; Bertera & Bailey-Etta, 2001). However, the existing models only preliminarily revealed the process of aesthetic cognition processing, and did not explain or clarify the specific internal mechanism of aesthetics (van der Put, Asscher, & Stams, 2016), meanwhile there’s also a lack of research on the aesthetic psychological mechanism of painting layout (Huebner, Dejong, & Cobbina, 2007), and the unique neural circuit of aesthetic activities has not been specified, either (Dietrich, Smiley, & Frederick, 2007).

FOUN DATION OF PAINTING LAYOUT AESTHETIC RESEARCHES
Painting layout

Painting layout means that the artist expresses the theme of the work or achieves the aesthetic effects by arranging the relationship and position of the objects in a certain space and integrating the partial images into a whole. However, the aesthetics of painting layout is influenced by cultural and psychological factors.

Neural foundation of aesthetics

In order to explore the neural foundation of the aesthetic process and analyze the physiological mechanism in the process of artistic creation, the neurological aesthetics has gradually emerged in recent years, which mainly uses non-invasive brain imaging techniques such as EEG, magnetoencephalography, and ERP, and combines with the frequently-used report method in traditional aesthetic experiments to study the brain functions.

The brain neural networks involved in the aesthetic process are mainly low-level sensory processing cortex, high-level processing cortex, evaluation-related cortex, and subcutaneous tissues, such as occipital cortex, parietal cortex, lateral prefrontal cortex, median frontal cortex, the insula, and the like.

EXPERIMENTAL RESEARCH

Research methods

A total of 25 subjects had participated in the experiment, including 14 male and 11 female. The subjects were divided into a professional group and an unprofessional group according to their professional level of painting. Wherein the unprofessional group consisted of psychology major students from a school, they have no painting basics, and there were 8 male and 6 female in this group; meanwhile the professional group consisted of 11 subjects who were all art major students, including 7 male and 4 female, and they had never participated in any psychological experiment before. All subjects were right-handed. In the experimental process, 3 subjects had more artifacts, so their data was not credible. Therefore, there were 22 subjects actually, 12 in the unprofessional group, and 10 in the professional group.

Experimental materials

The study had selected 8 pictures for the experiment (see Figure 1), and all were judged by 8 scholars or painters with art major background. The judging procedure was: follow the instructions appearing on the computer screen (see Figure 2) to judge whether the picture is “beautiful” or "not beautiful". Each picture appeared 20 times. In the end, pictures ranked the top 4 were judged to be “beautiful pictures”, and pictures ranked the bottom 4 were judged to be “ugly pictures”.

Figure 1. Pictures used in the experiment

![Figure 1. Pictures used in the experiment](image)

Figure 2. A schematic drawing of the judging of experimental materials

![Figure 2. A schematic drawing of the judging of experimental materials](image)

Experimental devices

The experiment used the ERP recorder produced by Brain Products of Germany, and adopted the software VisionRecorder for ERP signal recording. The experimental materials were displayed by a computer monitor in the laboratory. The ERP signals of the subjects were recorded by the leads placed on the underside and the outer side of the eyes. The reference electrodes were placed on both sides of the earlobe, the grounding electrode was Cz, the sampling frequency was 500 Hz, and the contact resistance of the electrodes and the scalp was less than 5 KΩ. The experimental results were analyzed by Vision Analyzer.
Experimental procedure

The experiment was carried out in a brain electrical laboratory where the temperature, light, and humidity were maintained in a suitable level, and the laboratory shielded both external sounds and electromagnetic signals. At the beginning of the experiment, the subjects entered the laboratory, and the experimenter introduced the basic conditions of the experiment to the subjects and helped them put on the electrode cap. When the lead resistance was reduced to less than 5KΩ, the experimenter began to introduce the experimental precautions, and the subjects started the experiment according to the instructions showed on the computer screen. After 16 exercises and a short break, the subjects entered the formal experiment, which was divided into two parts, and the subjects rested for 2 minutes between the two parts. The experiment process took about 40 minutes.

During the experiment, the screen displayed “+” for 500 milliseconds. After the fixation point disappeared, the experimental pictures appeared, and each picture was displayed for 1500 milliseconds. Subjects judged the picture, pressed “Y” if he or she thought the picture was “beautiful”, and pressed “N” if it’s “not beautiful”. After the judgement was completed, the picture disappeared and a blank screen appeared, after a 1000 milliseconds interval, the next picture appeared. If a subject’s judgement was inconsistent with the original classification of the picture, the program would prompt once. If the subject did not respond during the picture presentation, the next picture would be presented. Each picture was repeated 15 times at random.

RESULTS ANALYSIS

P300 characteristic wave

According to the beautiful-ugly type of the experimental materials and the professional level of the subjects, the aesthetic judgement results of the subjects on the pictures were classified and superimposed to obtain the ERPs curve, as shown in Figure 4.

As can be seen from the figure, the experiment induced the P300 wave.

Figure 4. The aesthetic ERPs waveform of spatial composition induced by P4 loci

Amplitude distribution differences

In order to analyze the P300 amplitude distribution differences, variance analysis of repeated measures was conducted on the electrode’s loci (left, middle, right, front, back)(1=F, 2=Fc, 3=C, 4=Cp, 5=P), the picture type (beautiful, ugly), and the subject’s professional level (unprofessional, professional).

The results showed that the picture type had the greatest influence on the amplitude of each locus, and the amplitude of the picture induced by beautiful picture was larger than that of the ugly picture. The electrode being in the left or in the middle had no influence on the amplitude, but the amplitude was significantly smaller when the electrode was in the right. When the electrode was in the back, the amplitude was larger. At the same time, the left-right and front-back loci of the electrode had significant
interactions; the picture type, the left-right loci and the subject’s professional level had obvious interactions as well (see Table 1 for details).

Table 1. Statistical indicators of F, df and P

| No. | Factor                                      | F     | df | P     |
|-----|--------------------------------------------|-------|----|-------|
| 1   | Type of picture                            | 5.387 | 1  | 0.034 |
| 2   | Amplitude of the right or left side         | 8.324 | 2  | 0.001 |
| 3   | Amplitude of front or back                 | 25.371| 4  | <0.001|
| 4   | Interaction of different side              | 4.956 | 8  | <0.001|
| 5   | Interaction of different type of picture, right or left, and the professional background | 2.271 | 8  | 0.021 |

Judging speed differences

When studying the picture judging speed of the subjects, it’s found that the time for judging a beautiful picture was shorter than that for an ugly one. The electrode being in the left or in the middle had no influence on the judging time, but when the electrode was in the right, the judging time was significantly shorter. The influence of electrode being in the front and in the back is: when the electrode was at the locus Cp of the parietooccipital area, the judging time was the shortest, followed by P, C, and Fc, and the judging time was the longest when the electrode was at the locus F. The left-right and front-back loci of the electrode had significant interactions; and the picture type, the front-back and left-right loci had obvious interactions as well (see Table 2 for details).

Table 2. Statistical indicators of F, df and P

| No. | Factor                                      | F     | df | P     |
|-----|--------------------------------------------|-------|----|-------|
| 1   | Type of picture                            | 9.643 | 1  | 0.008 |
| 2   | Amplitude of the right or left side         | 3.807 | 1.689 | 0.050 |
| 3   | Amplitude of front or back                 | 6.271 | 4  | <0.001|
| 4   | Interaction of different side              | 2.291 | 8  | 0.027 |
| 5   | Interaction of different type of picture, right or left, and the professional background | 2.597 | 4  | 0.045 |

P4 locus amplitude variance

Form the variance analysis of the P4 locus amplitude we can see that (see Figure 5): the P300 amplitude of the subject when he or she was looking at a beautiful picture was larger than that of an ugly picture, the influence of the picture’s beautiful-ugly type was significant. The interaction between the picture type and the subject’s professional level, and the main effect of the subject’s professional level were not significant.

The results of the variance analysis of the C3 locus amplitude showed that the picture type had a significant influence. The interaction between the picture type and the professional level of the subjects, as well as the main effect of the subject’s professional level did not reach the significant level.

In addition, when a subject was looking at beautiful and ugly pictures, the amplitudes of the P300 waveforms at the F3, F4, P3, Pz, Fc3, Cp3, Cp4, and Cpz loci were significantly different, and the response intensity of the beautiful pictures was significantly stronger than that of the ugly pictures.

Figure 5. Differences in amplitude of different picture types

P4 locus response speed analysis

It can be seen from Figure 6 that, for the response speed of the P4 locus, the main effect of the picture type was at a critical level. Other main effects and interaction effects were not significant. At the C3 locus, the main effect of the picture type reached an extremely significant level, and the subjects’ response speed to the P300 characteristic wave of the beautiful pictures was significantly faster than that of the ugly pictures. In the latency of the F3, F4, Fz, Fc3, Fc4, Fcz, and Cpz loci, the picture type also had a significant influence, and the subjects responded faster to the beautiful pictures than the ugly ones.
In addition, analysis showed that under different experimental conditions, the amplitudes of P3 and P4 loci were significantly different, the main effects of the picture type and the left-right brain were significant, and the amplitude of P4 locus was larger than that of P3 locus. Moreover, in terms of response speed, all the main effects did not reach a significant level.

Variance analysis of the C3 and C4 amplitudes showed that the main effect of the picture type reached critical. The main effect of left-right brain was obvious, the C4 amplitude was larger than C3, and the amplitudes of the right brain monitoring loci were significantly larger than those of the left brain. Therefore, the P300 characteristic wave had obvious differences between the left and the right brain.

**Differences in the P300 component of the professional level of the subjects**

The professional level of the subjects had little influence on the judgement of the picture type. The average correct rate of the ugly picture judgement was slightly higher than that of the beautiful picture judgement, which was 72.4% and 68.3% respectively.

The professional background of the subjects did not show any advantages during the experiment. The professional group’s judgement rate for the two types of pictures was slightly lower than that of the unprofessional group. From the analysis of P300 characteristic wave amplitude and response speed at different loci of subjects in the two groups (see Figure 7) we can see that, the main effect of the professional level of the subjects, and the interaction effect of the picture type and the professional level of the subjects were both not significant.

As shown in Figure 8, at locus C3, for the professional group, there’s significant difference in the P300 latency of beautiful and ugly pictures, the subjects’ judgement speed of the beautiful pictures was significantly faster than that of the ugly pictures. Therefore, the professional level of the subjects had some influence on the judgement of picture type. The professional group had a stronger discriminating ability, their response speed of the beautiful pictures was faster, and the intensity was stronger.

**CONCLUSIONS**

With the development of aesthetics, the painting aesthetics has gradually gained widespread attention, but there is still a lack of aesthetic psychological research on the aesthetics of picture layout. In this paper, the ERP signal analysis was carried out by using brain event-related loci to study the aesthetic
psychological mechanism of picture layout, and the following research conclusions were obtained:

(1) The P300 characteristic wave of loci at the parietal lobe may be a characteristic wave related to the aesthetic judgement of picture layout, and there were obvious differences between the left and the right brain. Beautiful pictures induced larger amplitudes than the ugly pictures, and the amplitudes of loci in the right brain were larger than those in the left brain.

(2) The subjects’ aesthetic judgement and the classification of the materials had high consistency. The correct response rate for the two types of picture layout was close to 70%, and the average correct rate for the ugly pictures was slightly higher than that of the beautiful pictures.

(3) The professional level of the subjects had certain influence on the characteristics of the cranial nerve activity of the picture layout aesthetics, but did not reach a significant level. For beautiful pictures, the judgement speed of the professional subjects was faster and and the intensity was stronger.

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