AESTHETIC MECHANISM OF GRAPHIC COMPOSITION: AN ANALYSIS BASED ON EVENT RELATED POTENTIAL TESTING

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Abstract
This research promotes the application of cognitive psychology in the appreciation of folk-art works. The brain neuroscience has been increasingly integrated to various disciplines to solve practical problems. In this paper, the brain neuroscience is introduced to the aesthetics for an in-depth analysis on the aesthetic mechanism of graphic composition. First, the concept of neuro-aesthetics was described in the context of arts, aesthetics and the brain. Based on the theories of brain neuroscience, the author set up an aesthetic cognitive model and an aesthetic processing model for the aesthetics of graphic compositions. Next, the Art Nouveau decorative paintings were selected for graphic composition experiments on interest points and balance. The aesthetics of space composition were measured by event related potential (ERP) testing. The results show that the mechanism of inwards preference exists in graphic composition; there is a significant left-to-right brain difference in the graphic aesthetics; the brain’s neural activities related to the aesthetics of space composition can be improved through professional training. The research provides a new angle to the study of aesthetics of graphic composition.

Key words: Brain neuroscience, Graphic composition, Aesthetic mechanism, event related potential (ERP) Testing

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INTRODUCTION
The graphic composition creativity is closely linked to the aesthetic mechanism. The aesthetic mechanism can effectively guide the graphic creation and design through the neural and psychological effects. The origin of western aesthetics is philosophy and its research object is art, which is the application of philosophical thoughts in the field of aesthetics, and it is also an overall evaluation of literary phenomena (Moshagen & Thielsch, 2010). In the process of development of aesthetic theories appeared the analysis of the aesthetic spirit, the Gestalt school, Berlyne and the new experimental aesthetics, etc., and it is generally believed that aesthetics can be divided into aesthetic perception, aesthetic appreciation, and aesthetic judgment stages (Reis, Biavatti, & Pereira, 2008). The earlier period of aesthetic research is based on theoretical research and lacks of experimental argumentation. With the development of theories and related technologies in cognitive neuroscience, the study of aesthetic mechanism and psychological activities has entered a new period of development (Ishai, Fairhall, & Pepperell, 2007).

Summarizing previous research findings on the creativity aesthetics of graphic composition, there is few researches that combine the brain neuroscience with aesthetics, especially there’s even fewer researches focus on the brain neurocognition of composition creativity aesthetics (Fitzgerald, 2015). In previous studies of brain subjects and aesthetics, studies based on Event-Related Potentials (ERP) revealed that negative potentials appeared in the time window of 300-400ms in the aesthetic judgment process,
while in the time window of 380-730ms, positive potentials were detected at the lateralized part of the right brain. However, there is no empirical analysis of the differences in the ERP potentials of the different experimental subjects in the aesthetic process of different art objects, or of the differences in the characteristic waveforms presented by the left and right brains in the aesthetic process (Cussen, 2002).

Based on the elaboration of neuroaesthetics theories, this paper summarizes the aesthetic cognitive model and aesthetic processing model of the graphic composition creativity. For the problems and deficiencies of the model and previous researches, this paper designs an interest points and balance experiment for graphic composition, and an ERP experiment for aesthetics of space composition. Both the experimental subjects and the experimental materials adopt a contrasting model, which reflects the different types of experimental subjects’ aesthetic perception of different types of experimental materials and the differences in brain neurocognition. This paper scientifically sums up that there is a “inwards preference” aesthetic mechanism existing in the creation of Art Nouveau decorative paintings, and concludes the actual difference between the aesthetic mechanism and the ERP. Through the empirical study of brain neurocognition, this paper realizes the analysis of the Art Nouveau decorative paintings, reveals the aesthetic mechanism of graphic composition creativity, and at the same time has important significance for guiding the creative design of graphics.

NEUROAESTHETICS AND AESTHETIC PSYCHOLOGY THEORETICAL MODELS

Neuroaesthetics

Art, aesthetics and brain

Generally speaking, neuroaesthetics is a discipline that highly summarizes the interrelationship between art, aesthetics, and the brain. Since the 1980s, the relationship between brain activity and aesthetics has become a hot topic in the psychology field, and neuroaesthetics emerged at the right moment (Chatterjee & Vartanian, 2014). Neuroaesthetics has put forward eight principles of art aesthetics, respectively are: peak shift principle, isolation, grouping, contrast, perceptual problem solving, visual metaphor, symmetry, generic viewpoint and the Bayesian logic of perception. All these laws are based on the past researches of psychology, ethology, and Gestalt theory (Conway & Rehding, 2013).

Some scholars directly believe that outstanding artists must be neurologists, they apply aesthetic principles to their artistic creation under the guidance of perceptual theories. This makes neuroaesthetics gradually link the art to the brain.

The neural basis of aesthetics

The objective of neuroaesthetic research is actually to explore the neural basis of aesthetic activity, with the development of non-invasive brain-wave imaging techniques such as electroencephalography (EEG), magnetoencephalography (MEG), event-related potential (ERP) and functional magnetism resonance imaging (fMRI), the research on combination of brain function and aesthetics has gradually deepened (Mawer, 2012). From the perspective of neurology, aesthetics is a multi-level and multi-component complex psychological process, and the correlative cerebral cortex includes low-level sensory processing cortex, high-level processing cortex, evaluation judgment and emotion-related cortex; brain areas involved in aesthetics from a neurophysiological perspective including occipital cortex, parietal cortex, lateral prefrontal cortex, anterior cingulate, insula, etc. As an intersection of art, psychology, and biology, neuroaesthetic plays an important role in the study of aesthetic activities (Davis, Ashworth, & Spriggs, 1998).

Theoretical model of aesthetic psychology

Visual aesthetic cognition model

The basic flow of the visual aesthetic cognition model is shown in Figure 1. This model assumes: 1. The composition of visual aesthetics; 2. The aesthetic experience is accumulated in the aesthetics of multiple components. As shown in the figure, visual esthetics includes perceptive process, cognitive processes, and emotional reactions. The early stage of visual processing includes the analysis and extraction of visual stimuli such as color, image, shape, brightness, and motion. It is known from previous neural analysis that the occipital cortex is the corresponding neural structure in the early stage (Nieminen, Istók, Brattico et al., 2011). The mid-
processing of the attention-altering object term visual and the repeating process afterwards. The corresponding neural structure is the frontal-parietal cortex. The later processing stage is the further processing of the aesthetic object, and then makes an aesthetic decision and like-or-dislike judgement, and its associated neural structure includes the medial frontal cortex, and the ventral striatum.

**Aesthetic processing stage model**

Scholars have verified the separation of appraisal aesthetic judgement tasks from descriptive symmetry judgement tasks through aesthetic experiments, by symmetry processing, they based on social and moral cue evaluation to judge the overlap of neural network part (Jacobsen, 2013). In the aesthetic process, the seven elements of psychology, body, content, people, situation, succession, and simultaneity are closely related. By summarizing the model of aesthetic processing, it can be divided into three stages, as shown in Table 1:

**Table 1. The model of aesthetic processing divided into three stages**

| Stage               | Aesthetic content | Concrete content                     |
|---------------------|-------------------|--------------------------------------|
| Feeling stage       | Aesthetic judgment| Visual and auditory perception        |
| Central processing  | Classification    | Thinking, recalling, making decisions |
| stage               |                    | Dancing, singing, painting            |
| Output stage        | Explicit stage     |                                      |

Feeling stage is the cognitive processing of aesthetic complexity and symmetry; the central processing stage is the judgment of aesthetic objects; the output stage is the corresponding action based on aesthetic judgment (Liu, 2003).

Due to the complex characteristics of aesthetics, long-term researches are focusing more on the qualitative research of aesthetics, while domestic researches that combine with empirical research from a quantitative point of view is still at blank.
more attention on the premise of the expansion of traditional Chinese culture, and quantitative research on the Art Nouveau decorative paintings will become a research hotspot. 2. Ignoring the role of the picture frame in the composition, the frame has a decisive influence on the aesthetic effect of the overall composition of the Art Nouveau decorative paintings. 3. The research methods of composition aesthetics need to be further improved. Due to the limitations of the research materials, the viewers can't make aesthetic judgments on the premise of displaying all the composition possibilities. Therefore, subjective judgments of beauty and ugliness can only partially reflect the aesthetic psychological laws.

In order to better study the specific internal mechanism of aesthetics, this paper uses the Art Nouveau decorative paintings as the research subjects, and adopts ERP test to conduct quantitative aesthetic research on the graphic composition creativity of paintings.

**Graphical composition creativity experiment**

In order to lay a foundation for the experimental research of ERP, first of all, the interest points and the overall balance of graphic space composition creativity are studied. The points of interest refer to the parts which gather people’s eyes when they are appreciating a decorative painting, it involves the position and orientation of a single composition. Balance is the orientation relationship between the interest points and the picture frame.

**Research methods**

(1) Experimental subjects

The experimental groups are divided into normal group and professional group, there are 38 people in the normal group and 28 people in the professional group. The normal group is consisted of high school students from a high school in Shanghai, and they have not received formal educating and training in painting skills; the professional group is consisted of sophomore graduate students from the School of Art of one university in Shanghai, all of whom have been trained in formal decorative painting skills and engaged in painting-related professional works.

(2) Experimental materials

The Art Nouveau works of decorative paintings by Alphonse Mucha are selected as experimental materials, as shown in Figure 2.

*Figure 2. Art Nouveau decorative paintings by Alphonse Mucha*
Through the combination of different orientations for the decorative pattern elements on the left and the right, the experimental subjects were required to make aesthetic evaluation. For the works on the left (Figure 1), the earring is the basic decorative elements of the character portrait on the composition, and it includes four auxiliary pattern elements on the left (1) (2) (3) (4); for the picture on the right, the earring is also the basic decorative elements, including two heavy gray elements of the decorative colors at the positions of (5) and (6): horizontally upward; the viewing angle: vertically upward, with the angle of orientation of 90°.

(3) Experimental procedures

Subjects were asked to freely combine the decorative factors of the paintings to form a complete works. According to the different orientations of the two, a total of 64 random combinations were performed. Subjects were asked to choose the combination works which they considered to be “good-looking” or “not-good-looking”. SPSS16 was used to perform statistics on the experimental results of normal and professional groups.

(4) Experimental results

In this paper, experimental subjects used computers to draw a picture of “decorative painting” by combining different orientations. A character and an interest point were set in the entire picture, and the same element combining with the interest point was used as space composition, so as to form a new decorative painting with horizontal, vertical and different quadrants.

By analyzing the proportion of good-looking and not-good-looking pictures selected by the experimental subjects, it can be seen that, when the paintings present a diagonal relationship, the composition seems more beautiful, and the percentage of diagonal orientation selected by the professional group is 8.7% higher than that of the normal group, which are 48.7% and 40%, respectively. Further analysis shows that when they are facing the inner side of the picture frame, the aesthetic effect is even better, showing a “inwards preference” characteristic, the drawing effect of the combination of the interest point and the picture frame shows a better aesthetic feeling to the viewers through balance and composition effects. There is a significant difference between the professional group and the normal group in the creativity aesthetics of graphic composition. The professional group grasps the position of interest point, the quadrant relationship and inward-outward orientations of the composition more appropriately, and they take into account the balance and mutual relations between themselves and the composition objects, and between the background and the picture frame. Through this experimental study, it is also proved that the creative aesthetics of graphics can be improved through training.

ERP RESEARCH ON THE GRAPHIC COMPOSITION CREATIVITY AESTHETICS OF DECORATIVE PAINTINGS

Due to the complexity of aesthetic activities, there is no corresponding area in the brain that especially controls the aesthetics of humans. Instead, the neural network consisting of the cerebral cortex and the secondary cortex coordinates the aesthetics of the human brain. The study of neurological cognition in the aesthetic process has always been a research hotspot. The application of MEG, EEG and other technologies has achieved certain research results. This experiment uses ERP to study the neurophysiological process of the creativity aesthetics of graphic composition. This paper uses the experimental materials in chapter 3 as a source of nerve stimulation for ERP experiments. The brain electrical characteristics of the subjects in different groups are recorded during the space composition aesthetic activities, and the brain characteristic waves in the process are analyzed, and the differences in neural activities between the professional group and the normal group are compared.

Research methods

(1) Experimental subjects

There are 22 experimental subjects in all, the 10 subjects in the professional group are sophomore graduate students from the School of Art of one university in Shanghai; the 12 subjects in the normal group are sophomore graduate students from East China Normal University Psychology School. The professional group has skillful painting composition skills, while the normal group has no painting skills and received no professional painting training. Experimental subjects are all right-handed and have no history of mental illness.

(2) Experimental materials
The experimental materials are the 8 decorative paintings marked as "good-looking" or and 8 as "not-good-looking" in the third chapter. The painting pictures have no differences in size, height or resolution.

(3) Experiment equipment
The experiment equipment is a German 256-lead ERP recorder, with a 32-lead electrode cap, filter bandpass is 0.1~100Hz, modulus sampling frequency is 500Hz, resistance is less than 5KΩ.

(4) Experimental procedure
The experiment was carried out in the brain electrical screening laboratory. The subject put on an electrode cap to prepare for the experiment. The experimental procedure was as follows: 1. The experimenter prepared to start the experiment under the instruction of the guidelines; 2. The computer screen showed “+” for 500ms, and then appeared the image stimulus and lasted for 1200ms; 3. The subject chose F for good-looking, and J for not-good-looking; 4. The next image appeared after an 800ms interval for repeated aesthetic judgment. A total of 8*2*10, 160 operations were performed, recording the results of aesthetic judgment and response time.

Analysis of research results
The experimental analysis time interval is between -200ms to 1000ms, perform baseline correction, artifact rejection and overlapping averaging to obtain the average waveform. The computer recorded signal points of the experiment were F3, F4, Fz, C3, C4, P3, P4, etc., and the peak component P300 was marked from the ERP result.

(1) P300 characteristic waveform of space composition aesthetics
All the composition aesthetic judgment results of the professional group and the normal group were classified and superimposed, and four ERP curves of professional-beautiful, professional-ugly, normal-beautiful, and normal-ugly were obtained, in which the P4 ERP curve is shown as Figure 3.

Through the variance analysis of the amplitude of each point on the ERP curve, we can see that, in terms of the amplitude of each point, the main effect of the image type is significantly different, $F=5.274$, $df=1$, $p=0.0035$, the good-looking pictures induced amplitude is significantly greater than the amplitude induced by the not-good-looking pictures, there are significant interactions between the image type, left and right space position, and front and back space positions and various variables of the professional group, $F=2.274$, $df=8$, $p=0.0025$. The P300 amplitude was used as the main parameter for each brain electrical signal measurement point, and the amplitude difference of the graphic composition aesthetics was counted, the results are shown in Figure 4.

**Figure 3.** P4 induced space composition aesthetic ERP waveforms

![Figure 3. P4 induced space composition aesthetic ERP waveforms](image-url)
Figure 4. The amplitude of each point in the aesthetics of different composition types

From the average value of amplitude, it is easy to see that for different composition aesthetic situations, the intensity of the brainwave response of the test subject to "beautiful" composition is greater than that of the intensity of the "ugly" composition, and it can be judged in the aesthetic process, according to the distribution of the electrodes in the left and right brains, there is a significant difference in left and right brain ERP waves.

(2) ERP difference analysis between normal group and professional group

From the P300 waveform and latency, there is no significant difference between the professional group and the normal group. This may be because the space composition aesthetics is a basic neurocognitive process. There are similar aesthetic psychological laws in the professional group and the normal group. From the latency period of amplitude, we can see that the response speed of the professional group's judgment on the space composition of "beautiful" and "ugly" is obviously faster than that of the normal group, which shows that professional training can influence the speed of aesthetic judgment and thus distinguish the beautiful and ugly images.

CONCLUSION

In order to better promote and instruct the graphic design creativity, this paper starts from the aesthetic mechanism to develop aesthetic neurophysiology research. First, it explained the neuroaesthetics and its related theoretical models, designs aesthetic experiments between a professional group and an experimental group. In the experiment, brain electrical test technology was introduced to perform ERP analysis in the aesthetic process. The main conclusions and significance of this paper are as follows:

Using the Art Nouveau decorative paintings as experimental materials, through the quantitative analysis model, this paper obtained an aesthetic result of “inwards preference” in the aesthetic judgments. In the experiments, this paper demonstrated that it is easier to grasp the space composition rules of interest point and balance through professional painting training.

In ERP experiment, the P300 characteristic wave (latency 300-500ms) of the composition aesthetic judgement located in the parietal lobe of the brain was obtained. In the aesthetic judgement of the professional group and the normal group, it was learned that the professional training had an effect on the neurocognition of the graphic composition aesthetic creativity, and had a significant influence on the aesthetic evaluation criteria, the speed of aesthetic judgment, and the type of space composition.

The research of this paper started from the empirical experiment and studied the brain neurocognition of space composition aesthetics, it has certain values in inspiration and reference for the domestic neuro-aesthetic research, and is conducive to the realization of better graphic
creative design.

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