



Electroencephalogram Experiment Based Analysis of Aesthetic Fatigue on Chinese Traditional Garden

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ABSTRACT

Traditional Chinese garden is the most significant landscape and tourism resources with high historical value and aesthetic meaning. The sustainable development of tourism resources has homogenized more and more traditional garden resorts where many tourists are attracted to visit at a higher frequency. As a result, it is inevitable for some tourists to generate aesthetic fatigue for these landscapes. This paper launches three rounds of indoor and outdoor tests separately on the four Chinese traditional garden such as Humble Administrator's Garden, the Lingering Garden, the Surging Wave Pavilion and the Lion Grove Garden with electroencephalogram (EEG) technology in attempt to analyze subjective scores of subjects and EEG data. The results reveal some phenomena as landscape playbacks and visits increase: the mean value of EEG attentions declines gradually; the attractiveness of garden photographs to subjects gradually weakens; the novelty, scene abundance, color sensitivity and overall harmonization of four gardens are rated badly, all of which significantly show a phenomenon of aesthetic fatigue. When analyzing the factors affecting the visitors' aesthetic fatigue, we found that the mean value of EEG attentions has a significantly positive correlation with landscape novelty, scene abundance, color sensitivity and overall harmonization when $\text{sig} < 0.05$.

Key Words: Chinese Traditional Garden, EEG Test Technology, Aesthetic Fatigue, EEG Data

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356

Introduction

Chinese traditional garden not only has a long history but also carries rich elements in cultures. As some important representatives in the history of the world's gardens, Chinese traditional garden are no doubt the essences of historical landscape heritages with extremely high tourism values (Rosley *et al.*, 2014). They contain the four major landscape elements, i.e. mountains, waterfalls, plants and buildings which all have a strong literati flavor and a high aesthetic value with prominent features (Zanten *et al.*, 2016). As the people's living quality gets better and better, coupled with the gradual enrichment of tourism projects, great

changes have taken place in the tourism industry, for example, in trip types, tourism characteristics and the quality of landscapes. Traditional garden tourism has become the way people get recreation in the contemporary era (Schüpbach *et al.*, 2015). However aesthetic fatigue is never evitable while contenting visitors with visual enjoyment and aesthetic experience (Sherren *et al.*, 2011).

Tourism, as an integral part of the people's spiritual entertainment, has seen an unprecedented prospect and a higher growth rate (Amorim *et al.*, 2017). By far, it has infiltrated into all fields of our daily life. Compared with the

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programming travel routes, people more prefer a soul destination and a spiritual habitat, and naturally resort to those traditional, natural and classical garden landscapes. The tourism developments are often carried out on these scenes. It is well known that the tourism journey will be accompanied with landscape aesthetics as the most important factor in sightseeing process and a psychological process for pleasurable sensations. It, however, is believed that people will generate aesthetic fatigue in the tour of the traditional garden as homogenized (Petrova *et al.*, 2015; Zervou, 2017; Musacchio, 2009; Bajwa *et al.*, 2015). With the wide application of EEG experimental technology and cross-neurology, the aesthetic fatigue has been gradually introduced into the studies on the EEG analysis science and psychology (Lubowski-Jahn, 2011; Mateo *et al.*, 2016). Based on the EEG experiment technology, this paper presents and analyzes the phenomena of aesthetic fatigues generated by people when they visit the Humble Administrator's Garden, the Lingering Garden, the Surging Wave Pavilion, the Lion Grove Garden, and obtain people's aesthetic perception and EEG data about Chinese traditional garden by indoor and outdoor tests.

Overview of gardens and test design

Overview of four famous gardens in Suzhou

In this paper, four famous gardens in Suzhou, i.e. the Humble Administrator's Garden, the Lingering Garden, the Surging Wave Pavilion, and the Lion Grove Garden, are chosen for EEG experiments. Among these gardens, the Humble Administrator's Garden is the largest existing traditional Chinese garden in China, built in the Ming Dynasty (Lu *et al.*, 2010; Frank *et al.*, 2013). After hundreds of years of vicissitudes in life, it still carries the characteristics of boundlessness and grandness just as the garden in the Yangtze delta does. The Lingering Garden features architectural layouts and encompasses mountains and waterfalls, blending the artistic elements of gardening in the South China. The Surging Wave Pavilion is one of the oldest traditional gardens in Suzhou. There are many rockeries, green trees, buildings and waves in the garden, and plants form a glance of elegant scenery. The Lion Grove Garden is the most typical traditional garden where the rockery in the garden is shaped like a lion. It is superb in stones laying craftsmanship and follows the principle of nature in the whole layout. And besides, it has epitomized the traditional Chinese gardening skills. The four

famous gardens in Suzhou are well known around the world and attract plenty of visitors for tours every year. These four Chinese traditional garden, therefore, best fit for the experiment on how the aesthetic fatigue for Chinese traditional garden is avoided.

Experiment design program

In this paper, four famous Chinese traditional garden are taken as the samples. The test uses the EEG acquisition device with ThinkGear ASIC Module as the core, and is conducted in the lab where the landscape photos of four samples are offered, and outdoor where there are the real landscapes. There are a total of 100 subjects, divided into 10 groups (male to female ratio 1: 1), and in order to reduce the test error, each group are tested under the uniform conditions.

In the lab, the subjects wear the EEG acquisition device and turn it on as required. The 40 photos for 4 samples prepared in advance (10 photos for each) are disorganized in sequence and played back for 3 times on the multimedia projector, each is shown for 5 seconds. After live show, subjects rate these photos, while EEG acquisition device will continue to monitor changes in EEG nerve, and access to the subjects' attention values.

In the outdoor, the subjects wear the EEG device and turn it on as required. The four gardens are visited on the site according to the specified route and rated after the tour. Repeat the above process in successive three days. In the end, a comparative analysis of subjective scores of subjects and attention values acquired by EEG is made.

Test results and analysis

Statistical analysis of aesthetic perception of garden landscape in the lab

Figure 1 gives the scores of the subjects under the indoor environment. As we can see, with the increase of the playbacks, the EEG attention value of the subjects decreases gradually, and the testee's attractiveness to the landscape photos of four samples gradually weakened. There are four objects for rating: landscape novelty, scene abundance, color aesthetics and overall harmonization, for which a statistical sheet of scores is accessed respectively. It can be seen that with the increase of the number of photos playbacks, the attention of the subjects to the landscape photograph of the one garden sample gradually decreases, and the scores of them in the



second round of playback deviate greatly from that in the first and third rounds. Table 2 is the statistical sheet for the mean values of EEG attentions of subjects in the lab test, which shows that with the increase in the number of playbacks, the mean value of EEG attentions gradually decreases at a high rate, that is to say, there is a significant aesthetic fatigue. Note that, when playing the second round of photos, the standard deviation and error of EEG attention values of the subjects are lower than that in the first and third rounds.

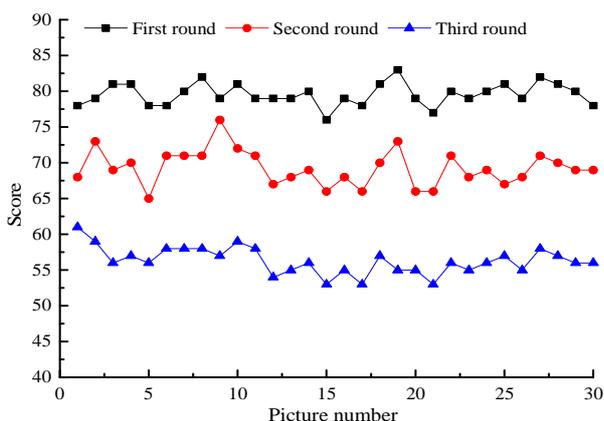


Figure 1. The indoor experiment object to the image score

Table 1. The indoor test score statistics describe three pictures

| Rounds | N | Mean value | Standard deviation | Standard error value |
|--------------|----|------------|--------------------|----------------------|
| First round | 30 | 79.5106 | 1.37224 | 2.100 |
| Second round | 30 | 69.1076 | 2.41030 | 6.241 |
| Third round | 30 | 56.0769 | 1.84756 | 3.344 |

Table 2. The indoor experiment of brain waves attention mean statistics

| Rounds | Mean value | Standard deviation | Standard error value |
|--------------|------------|--------------------|----------------------|
| First round | 82.78 | 4.037 | 0.646 |
| Second round | 64.95 | 3.250 | 0.503 |
| Third round | 45.08 | 3.726 | 0.600 |

Statistical analysis of aesthetic perception of garden landscape in outdoor test

Figures 2 to 5 show the curve of mean value of EEG attentions as a function of visit frequency in three rounds of tests on the visits of subjects in the four gardens. During the first round of tests on the tour of the Humble Administrator's Garden, the mean value of testee's EEG attentions continue to rise to around 90 in the first half way and drop to 85 or so in the latter half way. As the number of excursions increases, the Humble Administrator's Garden gradually decreases its appeal to the

subjects who have showed an obvious aesthetic fatigue. In the first round of tests on the tour of the Lingering Garden brain, the mean value of EEG attentions goes up within a short time, and then declines slightly until it gets stable. In the second round of tests, the mean value of EEG attentions decreased more significantly than that in the first round. In the third round, the mean value of EEG attentions is slightly lower than that in the second round, and the fluctuation is much weaker than that of first two rounds. During the tour of the Surging Wave Pavilion in the first round, the average EEG attentions is stabilized at around 90 in the pre-tour and then drops to around 82. In the second round and the third round, the average EEG attentions declines significantly, which shows a general tendency of increasing first and then decreasing and finally stabilizing. Subjects undergo a continuous decline in the average EEG attentions during the tours of the Lion Grove in three rounds, but there is a little difference in the decline rate.

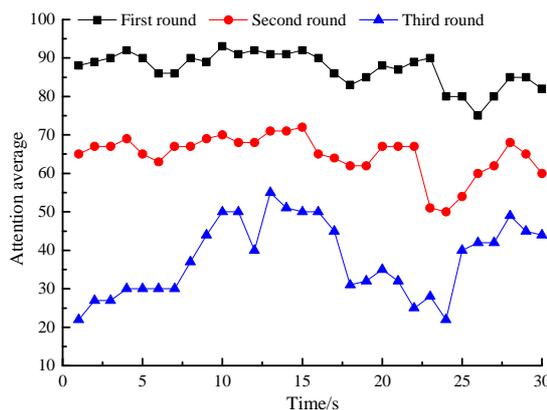


Figure 2. Subjects in the Humble Administrator's Garden visit wave mean value of attention over time map

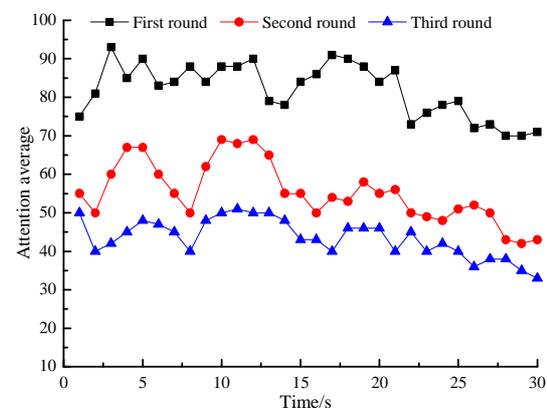


Figure 3. Subjects in the Lingering garden visit wave mean value of attention over time map



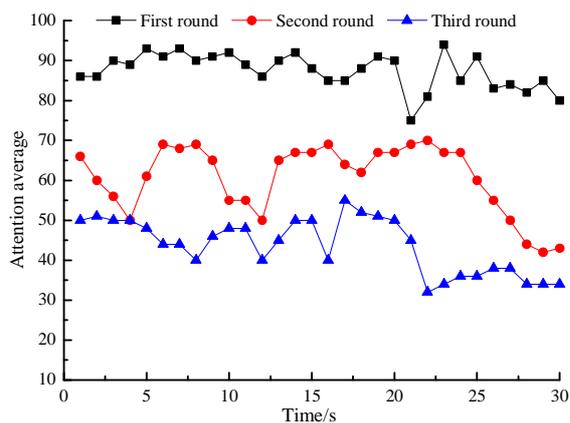


Figure 4. Subjects in the Surging Wave Pavilion visit wave mean value of attention over time map

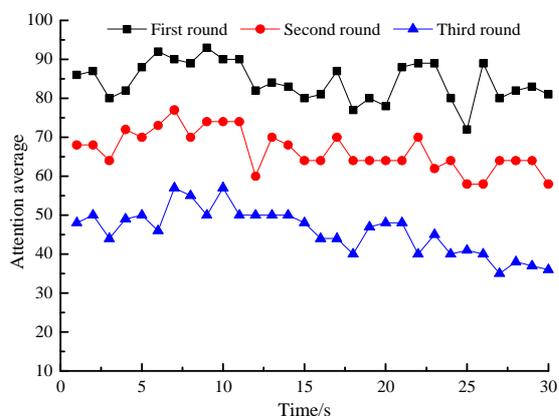


Figure 5. Subjects in the Lion Grove Garden visit wave mean value of attention over time map

Table 3. Attractions along the way the brain wave value and the standard deviation

| | First round | Second round | Third round |
|------------|-------------|--------------|-------------|
| Mean value | 60.46 | 53.25 | 48.10 |
| Variance | 9.61 | 14.09 | 13.05 |

Table 4. The outdoor test brain waves attention mean statistics

| Rounds | Mean value | Standard deviation | Standard error value |
|--------------|------------|--------------------|----------------------|
| First round | 83.19 | 0.964 | 0.241 |
| Second round | 57.55 | 1.410 | 0.382 |
| Third round | 47.39 | 0.555 | 0.135 |

Table 3 shows the real-time EEG values and standard deviations of the subjects when traveling the four gardens along the route in the outdoor test. The average EEG attentions of the subjects in the three rounds are 60.46, 53.25 and 49.10, respectively, and differ a little in the second and third rounds, but are significantly different between individuals in three rounds. Table 4 gives the mean values of EEG attentions of the subjects in outdoor tests. The average EEG attentions in the three rounds of tests are in turn 83.19, 57.55

and 47.39. The second round of tests has the most significant standard values and errors.

Analysis of landscape aesthetic fatigue the Chinese traditional garden

Analysis of rating data

It is found by the analysis of the questionnaires conducted in the laboratory test and the overall reliability test of the questionnaires that the three samples, the Humble Administrator's Garden, the Lingering Garden, and the Surging Wave Pavilion, all have a higher overall credibility. Figure 6 and Figure 8 are the tendency charts of scores rated on the Humble Administrator's Garden, the Lingering Garden, and the Surging Wave Pavilion, respectively. It can be seen that the testee's rating trend of ups and downs is roughly consistent with the developing trend, that is, the landscape score in the first part is higher than that in the latter part. Conduct an analysis on the correlation between average EEG attentions obtained from the three rounds of outdoor tests and the landscape scores given by the testees. As shown in Table 5, in three rounds, the correlation coefficients between the average EEG attentions and the landscape scores are 0.682, 0.676 and 0.638, respectively, and $\text{sig} < 0.01$, which shows that both have a significantly positive correlation at $\text{sig} < 0.01$. In addition, there is a positive correlation between the EEG attentional mean values in the first round and in the second, the third rounds, so does between the second round and the third round. Among the three rounds, $\text{sig} > 0.01$ indicates a significant positive correlation between both, and the correlation coefficients are all greater than 0.9.

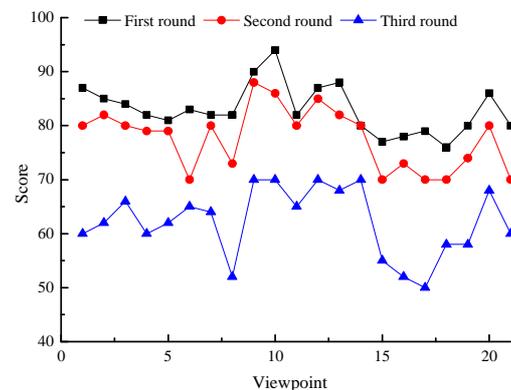


Figure 6. The round visit Humble Administrator's Garden to landscape attractions score chart



Table 5. All round the attention value analysis and corresponding score correlation table

| Types | Rounds | Statistics | Attention value | | | Score | | |
|-----------------|----------|-------------|-----------------|--------|-------|-------|--------|-------|
| | | | First | Second | Third | First | Second | Third |
| Attention value | First | Correlation | 1 | 0.426 | 0.515 | 0.682 | 0.404 | 0.459 |
| | Second | Saliency | - | 0.017 | 0.096 | 0.007 | 0.203 | 0.144 |
| | Third | Correlation | 0.426 | 1 | 0.881 | 0.676 | 0.780 | 0.736 |
| | First | Saliency | 0.017 | - | 0.001 | 0.019 | 0.002 | 0.007 |
| | Second | Correlation | 0.515 | 0.881 | 1 | 0.638 | 0.685 | 0.819 |
| Score | Third | Saliency | 0.096 | 0.001 | - | 0.030 | 0.016 | 0.003 |
| | First | Correlation | 0.682 | 0.676 | 0.638 | 1 | 0.977 | 0.903 |
| | Second | Saliency | 0.006 | 0.019 | 0.029 | - | 0.001 | 0.001 |
| | Third | Correlation | 0.404 | 0.780 | 0.685 | 0.977 | 1 | 0.937 |
| | First | Saliency | 0.203 | 0.001 | 0.016 | 0.001 | - | 0.001 |
| | Second | Correlation | 0.459 | 0.736 | 0.819 | 0.903 | 0.937 | 1 |
| Third | Saliency | 0.144 | 0.007 | 0.003 | 0.001 | 0.001 | - | |

Table 6. The experimental object for landscape scale

| Garden | Rounds | Attention mean value | Score | Novelty | Richness | Color beauty | Overall coordination |
|-------------------------------|--------|----------------------|-------|---------|----------|--------------|----------------------|
| Humble Administrator's Garden | First | 86 | 85 | 22 | 21 | 21 | 21 |
| | Second | 65 | 78 | 20 | 20 | 19 | 19 |
| | Third | 39 | 61 | 13 | 17 | 12 | 19 |
| Lingering Garden | First | 83 | 78 | 23 | 11 | 23 | 21 |
| | Second | 66 | 69 | 17 | 13 | 21 | 18 |
| | Third | 45 | 59 | 13 | 11 | 17 | 18 |
| Surging Wave Pavilion | First | 88 | 72 | 23 | 9 | 17 | 23 |
| | Second | 53 | 64 | 17 | 10 | 18 | 19 |
| | Third | 25 | 52 | 15 | 11 | 11 | 15 |
| Lion Grove Garden | First | 88 | 81 | 22 | 19 | 21 | 19 |
| | Second | 61 | 72 | 20 | 16 | 17 | 19 |
| | Third | 45 | 64 | 15 | 15 | 15 | 19 |

Table 7. Attention value and scale factor a analysis table

| Model | Non-standardized coefficient | | Standardized coefficient | t | Sig. | Correlation | | |
|--------------|------------------------------|----------------|--------------------------|--------|-------|-------------|---------|---------|
| | B | Standard error | Trial edition | | | Zero order | Partial | Section |
| Constant | -72.001 | 17.323 | - | -3.850 | 0.001 | - | - | - |
| Novelty | 3.055 | 0.654 | 0.568 | 4.746 | 0.001 | 0.804 | 0.658 | 0.305 |
| Garden phase | 0.514 | 0.367 | 0.110 | 1.378 | 0.165 | 0.338 | 0.243 | 0.088 |
| Color | 1.620 | 0.697 | 0.217 | 2.324 | 0.026 | 0.785 | 0.403 | 0.140 |
| Coordinate | 2.079 | 1.229 | 0.175 | 1.681 | 0.003 | 0.742 | 0.311 | 0.108 |

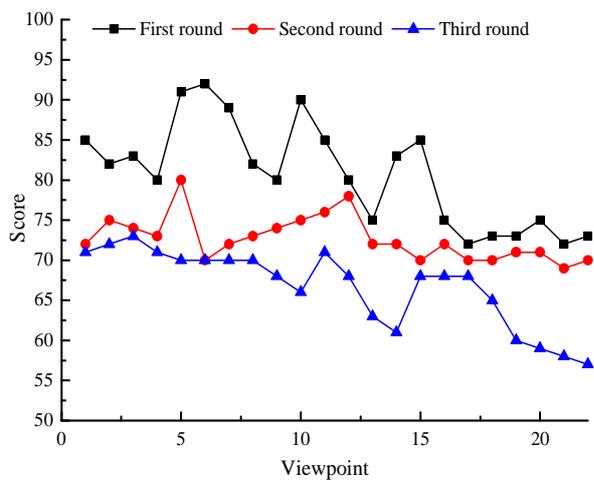


Figure 7. The round trip to Lingering garden landscape attractions score chart

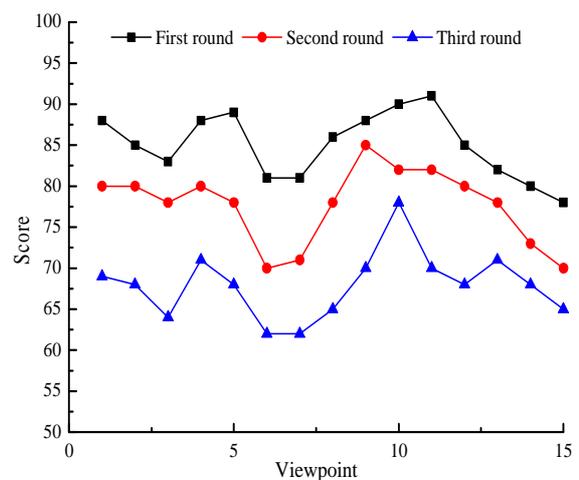


Figure 8. The round trip to the Surging Wave Pavilion landscape grade trend graph



Analysis of factors affecting aesthetic fatigue of Chinese traditional garden

The subjects' ratings on the Chinese traditional garden include landscape novelty, scene abundance, color aesthetics and overall harmonization, as shown in Table 6. It can be seen that, as the test rounds increase, the scores of landscape novelty, scene abundance, color aesthetics and overall harmonization for the four garden samples all decline, which shows an obvious aesthetic fatigue. Regression analysis of the four groups of scores deduces that the regression sum of squares is far greater than the residual sum of squares, and the fitting regression is statistically meaning. The fitting regression equation is given below:

$$Y_i = 3.166X_{i1} + 0.525X_{i2} + 1.630X_{i3} + 2.081X_{i4} - 73.012 \quad (1)$$

Where, Y_i is the mean value of EEG attentions to the landscapes of gardens in the round i ; X_{i1} , X_{i2} , X_{i3} and X_{i4} are respectively the scores of landscape novelty, scene abundance, color aesthetics and overall harmonization.

Table 7 is the analysis table for correlation between the average EEG attentions and the rating factor coefficients. The values t in the t -test are 4.746, 1.378, 2.324 and 1.681, respectively, and $\text{sig} < 0.05$, which implies that the mean value of EEG attentions has a significantly positive correlation with the landscape novelty, scene abundance, color aesthetics and overall harmonization at $\text{sig} < 0.05$.

Conclusions

In this paper, three rounds of indoor and outdoor tests were conducted on the representative samples, i.e. Humble Administrator's Garden, the Lingering Garden, the Surging Wave Pavilion, and the Lion Grove Garden, respectively, using the EEG test technology, based on which to analyze the subjects' aesthetic fatigue, the specific conclusions were drawn as follows:

(1) In laboratory tests, as the playbacks of landscape pictures increased, the mean value of EEG attention decreased gradually at a high rate so that there was an obvious aesthetic fatigue. In the second round, the standard deviations and errors of EEG attentions were all less than that in the first and third rounds.

(2) In outdoor tests, as the number of visits the tourists did increased, the attractiveness of the landscape to the subjects gradually decreased, which thus showed an obvious

aesthetic fatigue. The mean value of EEG attentions of the testee for landscapes differs a little between the first and the second rounds, so does between the second and the third rounds, but a lot among three rounds.

(3) The regression analysis shows that the mean value of EEG attentions has a significantly positive correlation with the novelty, the scene abundance, color sensitivity and overall harmonization of four landscapes when $\text{sig} < 0.05$.

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