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Research on the Preference of Public Art Design in Urban Landscapes: Evidence from an Event-Related Potential Study

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Abstract: As urbanization quickens, the role of public art in urban landscape design gains prominence. Nevertheless, how stylistic characteristics of landscape public art affect aesthetic preferences remains insufficiently discussed, particularly with objective assessment methods. The use of event-related potential (ERP) can offer neurophysiological evidence to support research and practice in landscape art design. We employed a 2 (artistic features) × 2 (professional proficiency) repeated-measures design, involving abstract and figurative experimental stimuli; both experts and non-experts participated, with their aesthetic reactions and relevant electroencephalographic data recorded. Behavioral findings show a preference for figurative public artworks regardless of professional background. From neurophysiological outcomes, stimuli elicit an elevated N100 during early perceptual processing, signifying increased attentional resources. During aesthetic processing, figurative stimuli more effectively evoke positive emotions, particularly among professionals, yielding a heightened P200 response. Conversely, abstract stimuli may evoke a higher N200 amplitude, reflecting augmented negative biases. Nevertheless, non-experts exhibit no marked differences in their stimulus responses during aesthetic processing. Research indicates that low-level physical attributes of public artworks are initially noted, while the visual processing of artistic traits lies at a higher perceptual level, necessitating specialized expertise involvement. Furthermore, the complexity of visual perceptual processing plays a significant role in the assessment of landscape art preferences. This study not only offers crucial reference indices for designing urban landscapes that satisfy diverse public aesthetic needs but also lays the foundation for neural techniques to assess landscape design preferences and expands the field of landscape design research.

Keywords: urban landscape design; public art; ERP; aesthetic preferences; abstract and figurative; professional expertise

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1. Introduction

1.1. Public Art in Urban Landscapes

According to the "2022 World Cities Report" published by UN-Habitat [1], the urban population in 2021 accounted for 56% of the global population, a figure projected to rise to 68% by 2050. With the advancement of urbanization, people's aesthetic demands for urban spaces are increasing daily [2]. Public art, as a new urban norm in the cityscape, has been widely used for embellishing and beautifying urban spaces [3–5]. They not only elevate the aesthetic standards of the space but also attract people's attention to specific locations [6,7]. The unique role of public art in urban aesthetics has transcended mere visual attraction. Not only does it contribute to the improvement of life quality in urban settings, but it also acts as a catalyst in the construction of urban landscapes. Furthermore, meticulously designed public art can metamorphose undeveloped urban areas into dynamic community hubs, thus promoting the regeneration of the city [8,9]. While a growing body of research has investigated the societal [10,11], cultural [12], and economic [13] aspects of public art, gaps still persist in the understanding of its aesthetic mechanisms. To be more specific, the majority of current studies depend on subjective methodologies like case analyses [14,15] and surveys [16,17] for measuring the aesthetics of public art. Although these conventional approaches are valuable, they are still inadequate in offering objective and measurable data. This limitation underscores the need for innovative methodological approaches. To fill this research void, our study adopts event-related potential (ERP) as an objective measure for evaluating the aesthetic mechanisms of landscape public art, a pioneering approach that blends art theory, urban landscape design, and neuroscience, representing the innovation of this research. Through the study, we can not only offer efficient guidance to designers, thereby refining the design of urban landscape art, but can also further augment the aesthetic experiences of individuals in urban public areas. Additionally, the study enriches the body of neuroaesthetic evidence within the field of public art, offering substantial reference value for directing the creation of urban landscape art.

1.2. Abstract and Figurative Stylistic Features

Public art's main goal is to meet the aesthetic demands of the general populace while concurrently serving to enhance and beautify spaces [7,8]. Therefore, the aesthetic appreciation and experience of the audience are crucial to the design of art pieces [18]. In the field of art research, how stylistic features such as those described as abstract or figurative influence the public's aesthetic perception and evaluation has been extensively studied [19,20]. The selection of these styles can profoundly impact the acceptance and interaction level of public art in urban landscapes.

People's aesthetic appreciation of urban public art falls within the realm of visual cognition, encompassing various stages of information processing. Affect accompanies cognitive processing interactively, thereby leading to corresponding aesthetic judgments and evaluations [21]. As articulated by Leder et al. [22], this includes perception, the gathering of implicit memory, explicit categorization, cognitive mastery, and evaluation. Through top–down cognitive processes, such as personal experiences and emotions, combined with bottom–up visual analyses, like color, lines, textures, and other visual attributes [23,24], temporary models of the visual world are established and validated or updated according to the information provided by sensory stimuli [25–27]. The subjective experience of artwork might involve multiple cognitive processes from perception to memory, varying with the abstractness of the art [28–30]. Figurative art often depicts true forms of life, such as humans, animals, and objects, displaying accurate proportions, dimensions, and precise details and features [31]. As a result, they frequently serve as commemorative and symbolic representations of events and individuals [32,33]. The specific information and actual events portrayed in figurative art enable viewers to rapidly process visual information, matching it with corresponding knowledge and memory, making it more readily comprehensible [34]. However, the intricate decoration and historical figures in figurative art may sometimes create impressions of elitism and political propaganda, thereby sparking controversy [35,36]. Abstract art, emphasizing elements like form, space, and material, often abandons concrete shapes and appearances, opting instead for simplified shapes, lines, and colors to convey themes and emotions [5,37]. They frequently challenge viewers' expectations, stimulate their imaginations, and invite them into more proactive and exploratory modes of artistic perception [38]. While some audiences may appreciate the ambiguity and openness of abstract artworks, the uncertainty may make it challenging to effectively link cognition with visual representation during the information processing stage, requiring further elaboration of meaning [39]. This may prove challenging for some, making abstract art confusing or inaccessible. While different styles of public art often lead to debates [40,41], these controversies further highlight the differences in aesthetic preferences between experts with professional art knowledge and training and ordinary people who, despite lacking formal education, still participate in and appreciate public art [42,43]. To what extent do figurative and abstract artistic expressions influence people's aesthetic preferences? How do the public and artists perceive these different forms of artistic expression? Delving deep into these questions is crucial in guiding the design and creation of inclusive and attractive public spaces that cater to the varying tastes and cultural backgrounds of the audience.

1.3. Aesthetic Emotions, Fluency Theory, and Expertise

Aesthetic preference is defined as the degree of admiration and affection for visual stimuli, or the aesthetic evaluation of such stimuli [44,45], and is closely associated with factors such as aesthetic experience and emotions [46], the level of processing difficulty [47,48], and the expertise of the participants [21,49].

Researchers posit that aesthetic experience is a "perceive–feel–sense" capability, indicating the involvement of cognitive, emotional, and reward-related processes when evaluating artistic creations [24,50]. Leder et al. [22] assert that aesthetic experience initially manifests as a cognitive process, subsequently transforming into an ever-growing emotional state, ultimately culminating in aesthetic sentiment; conversely, Chatterjee and Vartanian [51] contend that aesthetic pleasure is profoundly influenced by our cognitive system. Pleasurable aesthetic emotions often correlate with positive aesthetic experiences [52]. Emotional reactions to art play a vital role in determining aesthetic preferences, as studies have shown that emotions influence the formation of preferences and decision making [53,54]. Additionally, the theory of fluency is an influential perspective, arguing that the ease or fluency of processing an artwork contributes to enhancing its aesthetic allure [48]. From this standpoint, art that is easily processed and understood is more readily favored. Moreover, the personality, training, and expertise of the viewer are also significant. A high degree of openness to experience, or a craving for novel experiences, is associated with a broader aesthetic preference and a more profound appreciation of artistic works. Research has shown that experts and non-experts differ in their aesthetic preferences and experiences, with experts exhibiting a stronger perception of unique artistic features compared to laypeople [21,49,55]. In conclusion, the emotions and expertise people engage in when appreciating and interacting with art affect their ultimate aesthetic preferences. However, these factors are subjective and dynamic, and given the complex information processing mechanisms of the audience's brain, describing these differences based on experience presents a challenge [18,47]. Therefore, scientifically measuring these disparities is a significant and difficult issue.

1.4. Aesthetic Research on Urban Public Art

Currently, aesthetic research on public art mainly focuses on areas such as questionnaire surveys [16,17] and case studies [14,15]. For instance, Peruzzi et al. [15] uncovered the presence of stereotypical impressions of female figures and the insufficiency of cultural policies in the Italian urban environment through an analysis of aesthetic and cultural aspects of 34 urban sculptures distributed across Italian territory. Meanwhile, Tang et al. [17] discussed the aesthetic experiences of tourists regarding iconic public art through a survey, finding that related aesthetic factors can serve as an indicator of the public art experience.

While these research methodologies are facile in execution and cost-effective, the data collected suffer from considerable limitations. Questionnaires, though a commonly employed quantitative research tool, are easily influenced by both external and internal factors as people respond to them. Their feelings might not correspond with actual experience, and respondents may deliberately alter their answers instead of offering their initial, unfiltered cerebral reactions [56,57]. Furthermore, numerous other elements such as rewards, time constraints, or peer pressure could lead to a distortion of the respondents' feelings, thereby possibly preventing the survey results from truly reflecting the respondents' authentic thoughts [58]. Consequently, to address these issues, explorations have begun to employ neuroscience methods to more profoundly investigate the brain's responses to art.

1.5. Aesthetic Assessment Based on Neuroscience

In recent years, the field of neuroscience has laid the physiological and methodological foundations for the study of aesthetic preferences [59,60], wherein event-related potentials (ERPs) have emerged as a complex, non-invasive method for measuring and mapping the topography of brain activity [61,62]. The experimental principle of ERPs involves recording the potential changes in the brain regions of subjects induced by specific external sensory, cognitive, or active stimuli. Through techniques such as superimposed averaging and time–frequency analysis, these subtle physiological signals are extracted from spontaneous EEG activity. ERPs are highly suited for the gathering of brain data, boasting the advantages of cost-efficient experimental design and an extraordinarily high temporal resolution [63,64]. ERPs encompass three critical metrics: amplitude, latency, and scalp distribution [65]. By determining the mean amplitude of ERP across various time segments, one can study the disparities in different environments. Latency, measured in milliseconds, refers to the time interval between the commencement of a stimulus and the attainment of its peak. Observing the ERP distribution across the entire scalp, we can identify which regions of the brain are activated when a stimulus appears. For instance, the parietal P200 refers to a positive ERP component active in the parietal lobe area of the brain, peaking approximately 200 ms after stimulus onset. Researchers typically select components and brain regions based on different experimental objectives and analyze electrode points within the chosen brain areas to obtain relevant data on ERP components. For example, in Markey et al.'s ERP study on painting semantics, the N300/400 and P600 components related to visual semantics were observed, and the midcentral region (FC1, FC2, C1, Cz, C2, CP1, CPz, CP2) in which these components are active was selected for analysis [66]. These three key factors in ERPs offer insights into human psychological activity [62]. Certain researchers have employed ERPs to explore the neural responses to various stimuli that induce users' aesthetic preferences [64,67]. Furthermore, ERPs have been utilized to study the relationship between levels of professionalism and aesthetic values [21,49,68]. Ultimately, ERP components can not only reflect human emotional activity but can also assist in understanding the complexity of cognitive functions within the brain [69,70].

The N100 is an ERP component associated with attention, typically reaching its peak within the 100–200 ms following a stimulus. As an exogenous visual element, it is related to the allocation of attentional resources elicited by the stimulus, subsequently influencing the participant's recognition of visual characteristics [71,72]. Certain studies have revealed that the N100 is sensitive to low-level visual features, and its amplitude is correlated with the physical attributes of the stimulating material [71,73]. In perceptual processing, the participant's attention and recognition handling may be influenced by physical factors such as shape and material. Notably, a higher N100 amplitude signifies a greater allocation of attentional resources to visual feature recognition [63,74]. Moreover, the aesthetic perception of artworks among different individuals has been demonstrated to have a connection with the N100 component. For instance, Else et al. [49] discovered that art experts, when engaging in the appreciation of art, elicited a greater N100 amplitude compared to non-experts. Consequently, based on the analysis, we propose Hypothesis 1 as follows:

H1: *In the face of experimental stimuli pertaining to urban public art, experts induce a greater N100 amplitude than non-experts.*

P200 is an ERP component that reaches its peak approximately 200 ms after stimulation, specifically involved in visual aesthetic processing. It is capable of reflecting the allocation of early attentional resources and emotional arousal [75,76]. Aesthetic evaluation encompasses not only attention but also an emotional experience. When exposed to positive or favored stimuli, the P200 amplitude experiences a corresponding increase [74,77,78]. For example, Fudali-Czyż et al. [78] observed that the P200 amplitude elicited when participants viewed beautiful paintings was greater than when viewing less attractive ones. Cao et al. [77] found in their study on mobile phone images that attractive anthropomorphic icons induce larger P200 responses than their non-anthropomorphic counterparts. Based on the research, we propose the following Hypothesis 2:

H2: *People's responses to favored public art may induce a larger P200 response.*

The N200 is an ERP component that reaches its peak within a 200–350 ms time window after stimulation, is closely related to cognitive processes such as automatic stimulus recognition, selective attention, and perception, and is considered an endogenous negative component [79,80]. Moreover, existing research has affirmed that the N200 is associated with aesthetic preferences [81]. Researchers have found that individuals, when confronted with items they dislike or deem to have low aesthetic value, trigger a more substantial N200 response. For instance, Handy et al. [82] observed an increase in N200 amplitude in the central frontal area in response to disliked logos in a commercial symbol study. Similarly, Telpaz et al. [83] discovered in product preferences that products with a lower preference index elicited a greater N200 response compared to those highly favored. Therefore, in conjunction with the studies, we propose the following Hypothesis 3:

H3: *People's reactions to disliked urban art may induce a greater N200 response.*

This study aims to delve into the differences in aesthetic preferences towards urban public art under various artistic characteristics as well as the neural mechanisms underlying these differences. This paper employs the ERP research method, recording relevant brainwave data through a 2 (feature type: abstract, figurative) × 2 (group type: experts and non-experts) repeated-measures design. We propose the hypothesis that aesthetic preferences for different types of urban public art may trigger variations in the ERP amplitudes of the N100, P200, and N200. These changes can reflect the neural activities of the participants, further revealing the perceptual details in their aesthetic processing behavior. This study highlights the following innovations:

1. Utilizing ERP technology to record brain activities, we unveil the visual neural processing mechanisms during people's aesthetic appraisal of urban public art, providing objective evaluation methods and neural-level data support in the field of urban landscape design;
2. We compare the effects of abstract and figurative styles on different groups, distinguished by professional background levels, offering a new research perspective, an aspect less focused on in previous studies;
3. This study can offer insights into the design of urban public art. Understanding the preferences of the public is crucial for effective design. By considering the aesthetic needs of the public and the freedom and diversity of artists' creations, we can inspire designers and artists, promoting the creation of urban public spaces with greater artistic appeal;
4. We provide instances and support for exploring landscape aesthetic activities using cognitive neuroscience techniques, offering new evidence for the development of landscape design theory.

2. Materials and Methods

2.1. Participants

Based on previous studies and sample size estimation using G*Power 3.1 [49,78], we invited a total of 40 participants to take part in this study. However, the data of 4 subjects were excluded due to excessive artifacts caused by physical movements. Consequently, the data from the remaining 36 subjects were incorporated into the study, comprising 18 experts (mean = 26 ± 2.85 years, Min = 23, Max = 33, 9 females) and 18 non-experts (mean = 22 ± 1.88 years, Min = 20, Max = 26, 9 females). In our study, the term "expert" refers to individuals with extensive knowledge and understanding of art, including but not limited to artists. Experts hailed from the School of Design Art and the Fine Arts College of Jingdezhen Ceramic University and some were young local artists. All of them had over three years of experience in art, engaging in artistic creation and appreciation activities weekly, with educational levels equivalent to a bachelor's degree or higher. Conversely, the non-experts were students from non-artistic design specialties at Jingdezhen Ceramic University. All participants were right-handed, possessed normal vision, and had signed written informed consent forms. No individual had a history of brain damage or a mental condition. This study received approval from the Jingdezhen Fifth People's Hospital. Upon the conclusion of the experiment, all participants were remunerated with a sum of 70 RMB.

2.2. Experimental Stimuli

Existing research has employed images of art pieces as neural experimental stimuli [76]. Building on this, researchers selected high-quality images of public sculptures as stimuli from the renowned image-sharing website www.Flickr.com (accessed on 17 August 2023). We invited professors from the Department of Sculpture and Environmental Art at Jingdezhen Ceramic University to select experimental stimuli based on the following criteria: (a) The content of the artwork typically depicts specific individuals or historical events, with proportions closely resembling those of real objects, and it possesses refined and abundant decorative techniques; (b) In terms of image specifications and scope, the selected pieces must be world-renowned public sculptures; there should not be significant discrepancies in the size and specifications of the artworks; the chosen images must be taken from similar frontal angles and must have high resolution to ensure clarity. After careful assessment by experts from Jingdezhen Ceramic University, 13 pictures were meticulously chosen from hundreds of images to serve as experimental materials for figurative public art (FPA).

Previous studies have seen scholars manipulate corresponding experimental materials through painting or technical means, such as Schwabe et al. [84], who implemented digital creation of abstract paintings by the same artist to study the aesthetic evaluation and perception of abstract art pieces. Guo et al. [85] abstracted the experimental materials within a specific framework and employed ERP methods to study the aesthetic evaluation of smartphones. In light of this, we synthesized abstract art-related descriptions within the literature and artistic experience summaries [37,84] and adhered to the following principles for artistic creation: (a) abandoning figurative forms such as realistic figures and themes; (b) simplifying or removing decorative details; and (c) utilizing abstract geometric shapes and lines to express the theme. By employing brushes and digital drawing techniques, we conducted abstract sculpture art creation using the selected 13 tangible sculptures as prototypes, thereby obtaining 29 abstract public art (APA) materials. Ultimately, 42 images were chosen for the subsequent research. Simultaneously, to minimize visual differences and eliminate the side effects brought about by irrelevant factors, all product images were preprocessed using Adobe Photoshop 2023 and converted into black-and-white high-definition images with uniform brightness, shadows, and a resolution of 2443 $\times$ 3338 pixels (Figure 1).

Additionally, Hou and Hu [86] employed a 5-point Likert scale to evaluate participants' familiarity with and the complexity of pictograms; similarly, Pelowski, Gerger, et al. [87] utilized a 7-point Likert scale to investigate the audience's classification of art types. Consequently, inspired by the studies, the present research also adopted a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree) and invited 28 art experts to partake in an online survey. The experts were prompted to respond to the inquiry "Do you consider the public sculpture in the picture to be abstract/figurative?" and to evaluate the photographs' degrees of abstraction and figuration online. The assessment criteria encompassed two dimensions: firstly, the average feature rating had to exceed 4; secondly, the percentage of ratings above 4 had to surpass 80%. Only if these two conditions were met could the selected public art be deemed to meet the standard in terms of their abstract and figurative levels (Table 1). Through scoring, 13 figurative sculptures and 11 abstract sculptures met the criteria. To ensure the reliability of the research data, we excluded 2 stimuli with relatively lower scores from the 13 figurative images, ensuring an equal number of experimental stimuli for both types. Ultimately, in accordance with the research objective, 11 figurative sculptures and 11 abstract sculpture images were singled out through rating, to serve as stimuli for the ERP experiment.

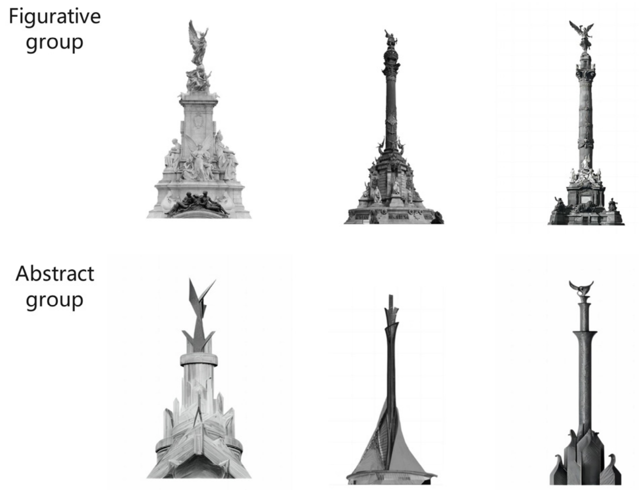

Figure 1. These are some instances of research stimuli.

Table 1. Rating table for the level of abstraction and figuration of experimental stimuli. The table includes two types of data: average feature scores and scoring percentages. Only experimental materials with an average score above 4 and a percentage over 80% meet the research standards.

Abstract Public Sculpture									
									
4.00 (60.71%)	4.21 (85.71%)	4.32 (89.28%)	3.96 (75.00%)	4.32 (89.28%)	4.00 (75.00%)	4.39 (85.37%)	4.39 (92.85%)	4.07 (78.57%)	4.14 (78.57%)
									
4.14 (71.42%)	4.11 (78.57%)	4.07 (71.42%)	4.25 (82.14%)	4.07 (85.71%)	3.86 (71.42%)	4.00 (75.00%)	4.04 (71.42%)	4.00 (75.00%)	4.00 (71.42%)
									
4.11 (78.57%)	4.36 (85.71%)	4.14 (75.00%)	4.64 (96.42%)	4.32 (82.14%)	4.25 (89.28%)	3.54 (64.28%)	4.11 (71.42%)	3.79 (60.71%)	

Table 1. *Cont.*

Figurative public sculpture									
									
4.57 (96.42%)	4.68 (96.42%)	4.39 (85.71%)	4.32 (89.28%)	4.29 (82.14%)	4.71 (100.00%)	4.75 (96.42%)	4.36 (89.28%)	4.75 (100%)	4.21 (85.71%)
									
4.36 (89.28%)	4.75 (100.00%)	4.39 (89.28%)							

2.3. Experimental Procedure

The study was carried out in a controlled environment with consistent illumination, wherein participants were instructed to assume a comfortable seated position at around 70 cm from the display, maintaining a field of view of 31.5° × 18.9° (width × height). Moreover, the monitor boasted a resolution of 1920 × 1080 and measured 24 inches in size. The task for the ERP was programmed and presented through Eprime 3.0. Participants were instructed to observe 22 images (11 abstract and 11 figurative sculptures), each photograph repeated six times, resulting in a total of 132 trials. To mitigate any sequence effect, the images were arranged in a random order. The experimental process is illustrated in Figure 2. Initially, an introductory script appeared on the screen, outlining the essential aspects of the experiment. Subsequently, during the experimental procedure, a series of images were presented, and the subjects were required to respond according to their aesthetic preferences within the stimulus's appearance time; the numeral 1 denoted liking, and the numeral 2 indicated disliking. Through script design, we assigned the keypress behaviors of number 1 and number 2, as well as abstract and figurative stimuli, to corresponding response marks and stimulus marks. When a stimulus mark appeared, a corresponding response mark would only appear after the designated key was pressed. This approach prevented errors or repeated keypresses from interfering with the data results. Participants were advised to refrain from blinking or moving their heads during stimulus presentation. After the introductory script, a brief pre-experiment occurred. Pressing the spacebar then initiated the formal experimental phase. A grey crosshair cursor appeared at the center of the screen for 2000 ms, aiding participants in focusing their attention. The stimuli were displayed at intervals of 1500–1800 ms, lasting 3000 ms. The program was set to move on from the current screen immediately upon the participant's completion of a keystroke or automatically advance to the next stage after the stimulus's display time. During the interval between stimuli, a central crosshair cursor on a grey background was shown on the screen. The stimulus images were alternately presented until the conclusion of the experiment. The entire experiment lasted 40 min, with one break included within each experimental session.

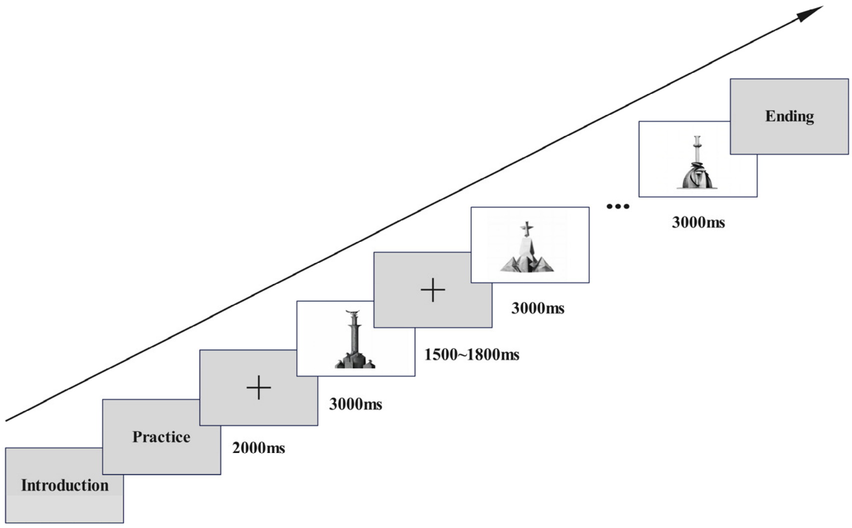

Figure 2. Experimental flow.

2.4. Data Acquisition and Analysis

According to the standard International 10–20 system, electroencephalogram (EEG) data were continuously recorded using a Neuroscan Synamp2 Amplifier coupled with an electrode cap containing 64 Ag/AgCl electrodes. Figure 3 illustrates the primary process of data collection and handling in the study. The software employed for data collection was Scan4.5, and the recording sampling rate was calibrated at 1000 MHz. The reference electrodes were assigned to the left and right mastoids (M1, M2), while a grounding electrode was placed at the FCz position. Throughout the experimental process, the resistance at each electrode was meticulously maintained below 5 kΩ.

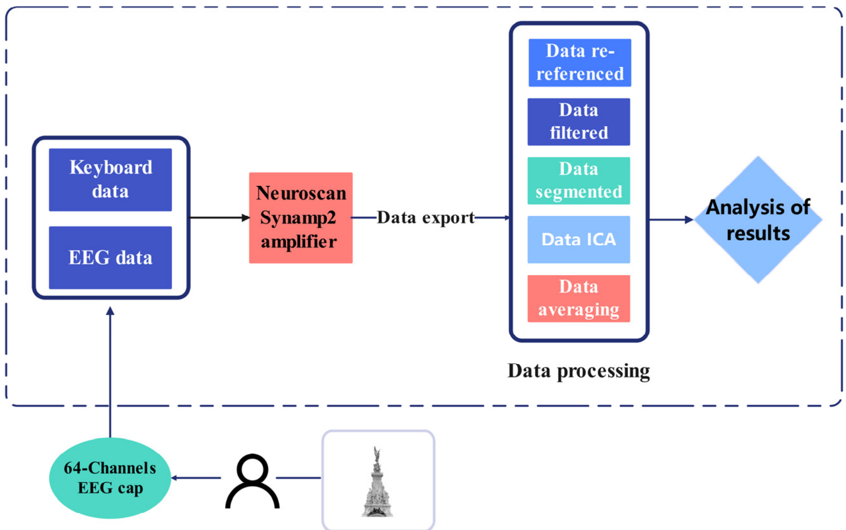

Figure 3. Data Collection and Processing Procedure.

We preprocessed the EEG data offline using the MATLAB 2023a EEGlab toolbox. The EEG data were analyzed, considering the means of the left and right mastoids, and then electronically filtered through a lowpass filter with a fixed cutoff frequency between 0.5 and 30 Hz. The first 200 ms of the EEG recordings were used as the baseline data, and sections between the 200 ms before stimulus commencement and the 1000 ms after it were recorded. Segments with a low signal-to-noise ratio were routinely eliminated through manual scanning, and ocular and electromyography (EMG) artefacts were removed using independent component analysis (ICA). Following the removal of the EEG artifacts, each subject's data was retained with over 80 segments. Based on this, we averaged the data across subjects, channels, and conditions, culminating in the crafting of waveform graphs and topographic maps.

In accordance with the objectives of this research, previous studies [57,74,78,88], and the whole-brain topographic and waveform features within this study, we elected to conduct statistical analyses on nine electrodes situated in the frontal (FZ, F1, F2), central (CZ, C3, C4), and parietal (PZ, P1, P2) lobes. The electrode distribution is shown in Figure 4. The selection of time windows was concentrated around the peak intervals of the ERP components. In general, the frontal and central areas of the brain show a stronger N100 component during visual perception [57,88]. However, in alignment with the waveform graphs of this study, the central region displayed no conspicuous N100 component. Consequently, we selected the frontal region (FZ, F1, F2) and analyzed the mean amplitude of the N100 in the 100–170 ms time window. During aesthetic perception, the P200 is active in the parietal region [74,78], leading us to choose the parietal area (PZ, P1, P2) for the analysis of the P200 mean amplitude in the 200–240 ms time window. Research indicates that the N200 is more vigorous in the frontal and central regions [83], yet the waveforms of this study showed no evident signs of the N200 in the frontal region. Therefore, we opted for the central region (CZ, C3, C4) to analyze the mean amplitude of N200 in the 240–280 ms time window.

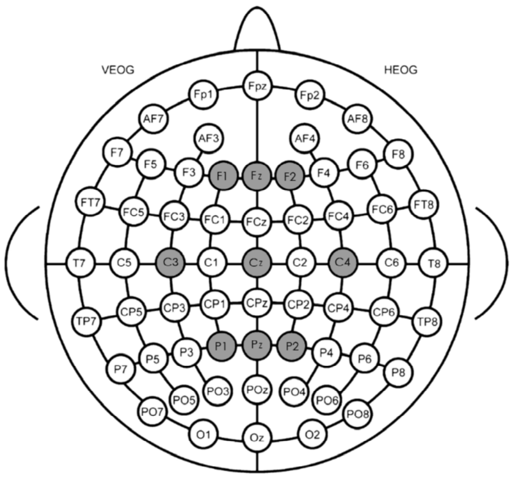

Figure 4. Selected Electrodes in the Study.

Ultimately, we extracted the mean amplitudes for all varying conditions and regions, employing IBM SPSS Statistics 26 to administer a two-way repeated-measures analysis of variance (ANOVA) on both behavioral data and ERP data, with the factors being two feature types (abstract, figurative) and two group types (experts and non-experts). In this analysis, the feature types were regarded as within-subject variables, while group types were considered as between-subject variables. Additionally, we conducted tests for normality and homogeneity of variance, describing the means and standard deviations in the descriptive statistics.

3. Results

3.1. Behavioral Results

In the collection of behavioral data, we recorded responses for both Key 1 (Like) and Key 2 (Dislike). Since the aim of this study is to investigate people's aesthetic preferences towards public art, we excluded data related to Key 2 and invalid responses (where no selection was made). We calculated the proportion of presses for Key 1 (like) relative to the total number of keypresses, treating the response time and keypress ratio as behavioral data. Following a test for normality of the behavioral data, an ANOVA test was employed to examine the data for differences. Descriptive statistics for the response times and proportions among subjects, under varying feature-type conditions, can be found in Table 2.

Table 2. The descriptive statistics for behavioral results include the mean and standard deviation (Mean ± SD) of participants' response times and keypress ratios under different conditions. The total average (TA) of the condition categories in the table is the sum of the sub-conditional averages (SA), divided by the number of sub-conditions (*n*). The formula is TA = (SA_1 + SA_2 + . . . + SA_n)/n.

Feature	Group	Response Time (ms)	Keypress Ratio (%)
Abstract	Non-expert	1185.39 ± 460.05	40.02 ± 25.02
	Expert	1157.84 ± 376.71	30.59 ± 22.13
Figurative	Non-expert	1043.19 ± 606.52	40.48 ± 31.55
	Expert	1041.07 ± 380.15	61.10 ± 25.28

In the present study, we recorded the participants' response times and conducted an analysis of the data through a two-way ANOVA. The findings revealed that there was no significant difference in the participants' response times, regardless of whether the features were abstract or figurative (F = 2.596, p = 1.116, $\eta^2{}_p$ = 0.071). Moreover, no discernible distinction was observed between experts and non-experts in their response to the artistic features of the public art shown (F = 0.013, p = 0.912, $\eta^2{}_p$ = 0.000), and no significant interaction between the feature variables and the between-group variables was detected (F = 0.025, p = 0.875, $\eta^2{}_p$ = 0.001). Based on the statistical results of response times, participants across different groups bestowed equal attention to both APA and FPA.

In analyzing the participants' keypress proportions, this study conducted statistical analysis specifically focusing on the proportion of presses for Key "1" (indicating "like"). Analysis of variance (ANOVA) indicated that the feature conditions (F = 5.393, p = 0.026, $\eta^2{}_p$ = 0.137) had a significant impact on the participants' preferences for public art. Specifically, in comparison to APA, individuals tended to favor sculptures with FPA (35.30 ± 23.77% vs. 50.79 ± 30.06%). However, the main effect between different groups was not significant (F = 0.979, p = 0.329, $\eta^2{}_p$ = 0.028), but there was indeed an interaction between feature conditions and groups (F = 5.080, p = 0.031, $\eta^2{}_p$ = 0.130). Further simple effect analysis revealed that experts were more inclined to appreciate FPA (61.10 ± 25.28% vs. 30.59 ± 22.13%, p = 0.003), while the preferences of non-experts did not exhibit significant differences (F = 0.002, p = 0.962, $\eta^2{}_p$ = 0.000).

3.2. ERP Results

From this research, the data under each condition were separately averaged, and an analysis was conducted on the mean amplitude of the N100, P200, and N200 components through a 2 (feature type: abstract sculptures vs. figurative sculptures) × 2 (group type: experts vs. non-experts) repeated-measures ANOVA. Table 3 presents the descriptive statistics for the ERP results, while Table 4 displays the ANOVA results for the N100, P200, and N200 components.

Table 3. Descriptive statistics for the ERP results, including the time window of brain waves for each component under various conditions, the brain region involved, corresponding electrode points, and the average amplitude information (Mean ± SD).

Component	Time Window (ms)	Regions and Electrodes	Abstract (μV)		Figurative (μV)	
			Non-Expert	Expert	Non-Expert	Expert
N100	100–170	Frontal FZ,F1,F2	0.176 ± 2.32	−1.984 ± 1.88	0.476 ± 2.49	−2.361 ± 2.58
P200	200–240	Parietal PZ,P1,P2	6.056 ± 3.78	5.261 ± 2.80	5.223 ± 3.79	6.201 ± 2.73
N200	240–280	Central CZ,C3,C4	0.293 ± 2.84	0.842 ± 3.45	0.330 ± 2.76	1.912 ± 3.59

Table 4. The main effects, interaction effects, and simple effects of the ANOVA for N100, P200, and N200, incorporating variables "Feature" (Abstract and Figurative) and "Group" (Experts and Non-experts). Further simple effect analysis is conducted in cases where interaction effects are significant.

Analysis Type	Factors		N100			P200			N200		
			F	p	η^2_p	F	p	η^2_p	F	p	η^2_p
Main Effect	Feature		0.021	0.886	0.001	0.027	0.871	0.001	4.713	0.037	0.122
	Group		11.703	0.002	0.256	0.007	0.932	0.000	1.066	0.309	0.030
Interaction Effect	Feature × group		1.590	0.216	0.045	7.537	0.010	0.181	4.713	0.050	0.108
Simple Effect	Feature × group	Abstract × group	-	-	-	0.513	0.479	0.015	0.270	0.606	0.008
		Figurative × group	-	-	-	0.787	0.381	0.023	2.187	0.148	0.060
	Group × feature	Non-expert × feature	-	-	-	3.331	0.077	0.089	0.011	0.919	0.000
		Expert × feature	-	-	-	4.233	0.047	0.111	8.804	0.005	0.206

As illustrated in Figure 5, within the frontal region's 100–170 ms time window, we observed the N100 component, and the corresponding grand-averaged ERPs and topography map were delineated. The ANOVA results indicated a significant impact of different groups on the N100 amplitude (F = 11.703, p = 0.002, $\eta^2{}_p$ = 0.256), where experts (−2.173 ± 2.23 μV) elicited a greater N100 amplitude than non-experts (0.326 ± 2.37 μV). However, the influence of the feature factor (F = 0.021, p = 0.886, $\eta^2{}_p$ = 0.001) on the N100 component was not significant, and there were no meaningful interactions between features and groups (F = 1.590, p = 0.216, $\eta^2{}_p$ = 0.045).

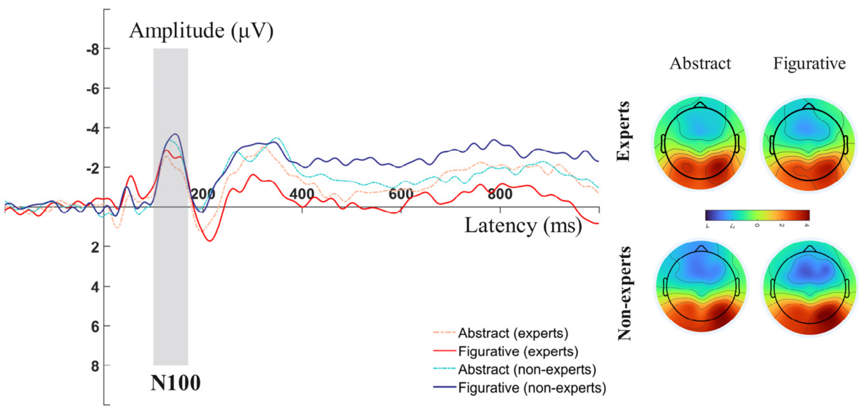

Figure 5. Under four situations, the parietal region's grand-averaged ERPs and topographical map.

Within the parietal region's 200–240 ms time window, we observed the P200 component, as depicted in Figure 6. The ANOVA analysis results indicated that the influence of the feature factor on the P200 component was not significant (F = 0.026, p = 0.871, $\eta^2{}_p$ = 0.001), and the different group types also failed to produce a significant effect (F = 0.007, p = 0.932, η^2_p = 0.000). However, there was indeed an interaction between the feature conditions and group types (F = 7.537, p = 0.010, η^2_p = 0.181). Further simple effect analysis revealed that experts' responses to FPA caused a higher P200 amplitude compared to responses to APA (6.201 ± 2.73 µV vs. 5.261 ± 2.80 µV, p = 0.047), while non-experts did not present a noticeable difference between the two (F = 3.331, p = 0.077, η^2_p = 0.089).

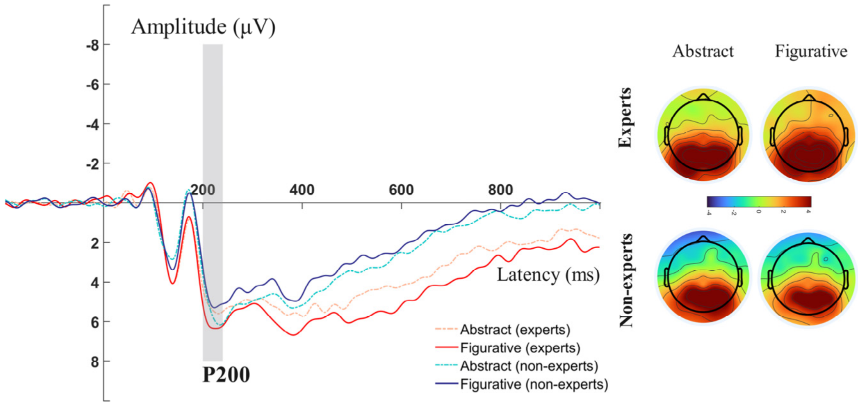

Figure 6. Under four situations, topography and grand-averaged ERPs were mapped in the parietal area.

As shown in Figure 7, we explored and extracted the average amplitude corresponding to the N200 component within the 240–280 ms time window in the central region. Through a 2 × 2 repeated-measures ANOVA, we discovered that the characteristic factor (F = 4.713, p = 0.037, η^2_p = 0.122) significantly influenced the amplitude of the N200 component, with APA (0.568 ± 3.13 µV) inducing a higher N200 amplitude relative to FPA (1.121 ± 3.26 µV). However, the main effect of group type was not significant (F = 1.066, p = 0.309, η^2_p = 0.030), although there was an interaction between characteristic condition and group type (F = 4.102, p = 0.050, η^2_p = 0.108). Further simple effect analysis revealed that experts' perception of APA elicited a higher N200 amplitude than that of FPA (0.842 ± 3.45 µV vs. 1.912 ± 3.59 µV, p = 0.005). Non-experts' perception of APA likewise slightly induced a higher N200 component than that of FPA (0.293 ± 2.84 µV vs. 0.330 ± 2.76 µV, p = 0.919), but under circumstances where $p > 0.05$, this difference did not yield statistically significant effects.

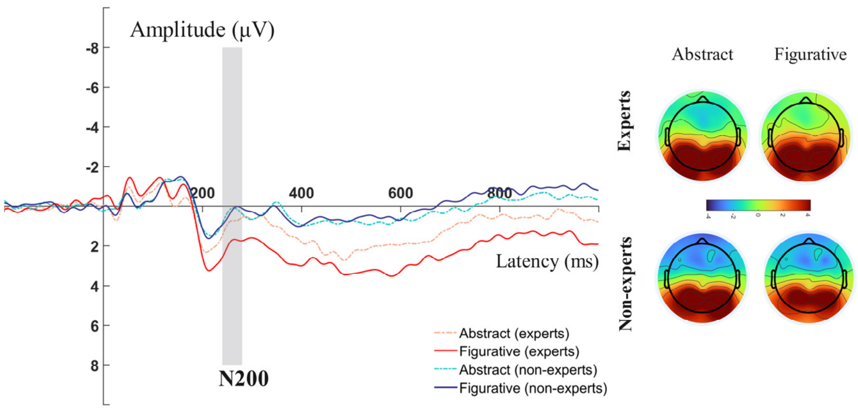

Figure 7. Grand-averaged ERPs and topography map under four conditions in the central region.

4. Discussion

This study aims to investigate the aesthetic preferences and corresponding neural responses of groups (experts and non-experts) towards different artistic characteristics of urban public art, serving as evidence of the influence of style and expertise on people's aesthetic mechanisms. By presenting participants with a series of abstract- and figurative-style urban public art images, the behavioral data and corresponding brain signals of the subjects during the experiment were recorded, utilizing the theory and technology of event-related potentials for data analysis.

4.1. Aesthetic Preferences of Public Art

The analysis of reaction times in behavioral outcomes revealed no significant differences between experts and non-experts when viewing public art with various characteristic levels. This contrasts with the findings of Bölte et al. [21], who discerned a slower response from experts in assessing the aesthetics of web pages. This discrepancy may stem from the artistic features of the experimental materials and the distribution of attention within the stipulated time. Nevertheless, despite the absence of differences in reaction times, experts and non-experts manifested divergent aesthetic preferences when confronted with landscape art of various characteristic types. This discovery may imply that aesthetic preferences are unrelated to cognitive processing speed and are more intimately connected with an individual's artistic experience and knowledge.

In this study, we presented participants with various images of abstract and figurative urban public art, guiding them to respond with keypresses according to their personal preferences. The findings revealed a significant preference for FPA over APA (50.79 $\pm$ 30.06% vs. 35.30 $\pm$ 23.77%, $p = 0.026$). This discovery aligns with previous research, as numerous studies have already substantiated that representations of tangible entities in paintings or images elicit higher aesthetic evaluations and preferences than abstract images that do not denote any specific content [20,89,90]. We further explored the disparities in preferences between experts and non-experts, and the results disclosed a more pronounced preference among experts for different artistic characteristics. Specifically, experts exhibited a leaning towards figurative art, while non-experts manifested no significant preference between the two kinds of art pieces. However, some research has found that individuals with specialized knowledge and an artistic background tend to favor abstract art [91,92], a finding that is inconsistent with our study. This inconsistency might be attributed to the artistic features of the experimental stimuli within our research. Specifically, FPA, through its lavish decorations and intricate craftsmanship, vividly showcases more elements drawn from reality, facilitating easy comprehension and evoking a sense of familiarity among individuals. In contrast, APA necessitates a more substantial contextual and artistic emotional interpretation, which is challenging to achieve under experimental conditions [47]. Moreover, people are generally inclined towards meaningful artistic works [93], and the expertise and perceptual abilities of experts further amplify this trend [49,94]. In conclusion, preference towards urban public art is not solely related to artistic characteristics but is also influenced by level of expertise. Experts with specialized knowledge tend to appreciate the craftsmanship and decorativeness of FPA more, while non-experts are unable to make a distinct preferential choice between the two characteristics [49].

4.2. Neural Mechanisms of Aesthetic Perception in Public Art

The visual N100 is closely associated with the early visual processing stage of emotional stimuli and is considered a vital indicator of selection and resource allocation [71,95]. According to previous research, the N100 is related to the activation of early visual areas in the brain triggered by visual stimuli, an activation principally elicited by low-level properties of stimuli such as contours, shapes, and colors [71]. Moreover, the N100 is also connected to the allocation of attention in aesthetic preferences. For instance, Chen et al. [96] discovered that lighter tiles with higher preference scores could induce a larger N100 amplitude compared to darker tiles with lower preference scores. However, differing from the above studies, our statistical results demonstrate that the art's characteristic types did not induce a main effect on the frontal N100. This finding suggests that during the primary stage of perceptual processing, individuals are unable to differentiate between different feature levels of urban public art. This may be due to the specificity of the experimental material, causing participants to focus solely on low-level attributes during the initial visual stage, without completing the mental reconstruction of APA or FPA, which requires higher-level visual processing. As Bimler et al. [89] found, the aesthetic experience is regarded as a cognitive process where objects are decomposed into lower-level features such as color, brightness, lines, light points, etc., and gradually develop into higher-level processing through the interpretation of artworks, systematically reconstructing them into intricate forms. This process might require individuals to observe for a more extended period to achieve full completion [45]. Furthermore, the statistical results also reveal that experts elicit more N100 components than non-experts, indicating that while appreciating public artworks, the brain's visual regions of experts are more active, and their professional knowledge prompts them to allocate more attentional resources [49]. This discovery aligns with prior research [49,97]. Therefore, our research results are consonant with Hypothesis 1.

According to research, the P200 functions as a neural correlate during the initial stages of processing visual aesthetics, associated with the processing of emotional stimuli, reflecting the automatic allocation process in the early stage of emotional stimulus processing [76,98]. It is well recognized that emotions (both positive and negative) constitute one of the essential elements in aesthetic preference, and both positive and negative stimuli can elicit variations in P200 amplitude [99]. According to the results of this study, people's preference for FPA leads to a greater P200 response. Existing research indicates that a larger P200 response is elicited when individuals are exposed to positive and preferred stimuli [74,77,78]. Our correlational analysis also supports this finding. The reason that FPA could elicit a larger P200 might be that, compared to the distinctive and novel APA, the FPA offering content imbued with real-life significance is more capable of resonating positively with aesthetic emotions and cultural harmony, one of the characteristics of urban public art [8,32,94]. These findings demonstrate that emotional processing has a role in the initial aesthetic assessment of urban public art, with individuals generating more positive emotions towards preferred urban sculptures, thereby inducing a greater P200 response. This study's findings concur with Hypothesis 2. Additionally, the results reveal that this preference instigated by emotional arousal appears only in the expert group, as Else et al. [49] discovered that artists, when facing figurative art, evoke more P200 responses compared to non-artists. This illustrates that experts invest more emotional resources into the aesthetic processing of art, rendering their evaluation of artworks more affirmative than novices. While the attention of non-experts wanes quickly, experts maintain a sustained sense of engagement [49].

The N200 component reflects a preferential selection of attention towards stimulus-related attributes, while also revealing differences in emotional stimuli [100,101]. Moreover, compared to stimuli with a high preference, those with a low preference have been found to evoke a greater N200 amplitude [82,83,96]. The ERP results are consistent with the aforementioned studies, demonstrating that participants exhibit a higher N200 amplitude in response to low-preference APA as opposed to FPA with a higher preference. Reber et al. [48] propounded a theory of fluency, suggesting that the aesthetic appeal of a piece of art is determined by the ease or difficulty with which it can be understood or perceived. Due to the often elusive and difficult-to-interpret content of APA [47], people tend to generate a more pronounced negative reaction to low-preference APA. This reflects a negative stimulus-driven selection of attention, and the research findings lend support to Hypothesis 3. In addition, during further analysis, experts elicited a greater N200 response to abstract art, signifying that those trained in the arts exhibit a more precise recognition and categorization of artworks. Their information processing is more profound [102], thereby enhancing their selective attention driven by emotions. In contrast, non-experts are found to be in a state where attentional resources are diffused.

4.3. Theoretical Implications and Insights into Urban Landscape Design

This study carries the following research implications: Firstly, it broadens the research methods in urban landscape aesthetics by introducing the neuroscientific approach of ERP, providing an objective assessment method and neuro-level data support for the landscape design field. Secondly, the study also reveals the preferences and neural mechanisms of the public regarding art style and expertise, further enriching the research perspectives in landscape visual assessment. Ultimately, this study employs neuroscience theories to offer a fresh interpretation of the research on urban landscape perception, providing new evidence to foster the development of urban landscape theory.

We provide the following insights into urban landscape design:

1. This study emphasizes the potential of utilizing neurophysiological measurement methods (such as ERPs) to objectively evaluate aesthetic preferences. This approach opens the possibility for guiding urban designers in making landscape art design decisions based on objective criteria. For instance, through the analysis of different ERP components, one can understand people's attention allocation and emotional responses when facing various landscape elements. These aesthetic perception indicators can be integrated into consideration during the design process;
2. By studying abstract- and figurative-style features, urban designers can better understand preferences for different styles of landscape art, assisting designers in making the correct choices when faced with various design requirements;
3. Recognizing that the public has limited interpretation of public art can also encourage designers to adopt appropriate methods to enhance the public's appreciation ability for art aesthetics. This would help in creating urban public spaces that are both aesthetically pleasing and inclusive of different tastes.

Furthermore, we acknowledge the incredible diversity within the fields of art and design, with abstract art and various innovative styles (like the Bauhaus School) holding significant value and influence. It is crucial to note that our research findings do not advocate for a restrictive or normative approach to artistic creation. Instead, our goal is to reveal certain public preferences, providing insights for artists and designers to consider, integrate, or challenge in their work. Art styles should not merely cater to popular taste but should also attract, challenge, and expand the public's understanding and appreciation of art. Designers must consider the needs of individuals with different perceptual and cognitive conditions, ensuring that public art is experienced and appreciated by as many viewers as possible.

4.4. Limitations of the Study

This study has several limitations. Firstly, most participants were young students and artists. Future research needs to include subjects from various age groups to enhance the generalizability and representativeness of the results. Secondly, the study did not consider the impact of cultural background on the aesthetic appreciation of public art. Cross-cultural comparisons, such as those contrasting Eastern and Western cultures, can be conducted in the future. Different cultural backgrounds might foster different aesthetic patterns for public art, which is worth further exploration. Moreover, this study primarily focused on abstract- and figurative-style characteristics, potentially overlooking the influence of other style elements and artistic forms on aesthetic preferences. Future studies can undertake a broader exploration to gain a more comprehensive understanding of the aesthetic preferences for landscape public art. Lastly, to avoid data interference, this study eliminated the influence of complex variables such as the environment. In upcoming experiments, more environmental factors should be considered to restore the complexity and diversity of urban landscapes.

5. Conclusions

This study employs the event-related potential (ERP) method, aiming to examine aesthetic preferences and their neurological mechanisms in groups with diverse artistic backgrounds (experts and non-experts) while viewing abstract and figurative public art. The research findings indicate that, based on behavioral test results, people generally tend to appreciate artworks rich in concrete content. Specifically, experts tend to appreciate FPA more, but the preferences of non-experts do not show significant differences. Based on the ERP data analysis, experts generate a higher N100 amplitude when viewing stimulus pictures of all types, indicating that they are more sensitive in allocating attention to physical properties. When experts encounter FPA, they generate a higher P200 amplitude in the parietal cortex, indicating that compared to APA, FPA more readily arouses positive emotions. In the N200 component, experts trigger more N200 responses towards disliked APA, further suggesting that APA incites more negative biases. However, non-experts exhibit almost no noticeable changes in P200 and N200 responses under various conditions. The research results demonstrate that, compared to non-experts, experts have a more intense and sensitive response to artistic stimuli in terms of aesthetic cognition and emotional experience. This difference is primarily reflected in the allocation of attentional resources, the intensity of positive emotional experiences, and negative emotional responses, but it does not alter the general tendency of people toward preferring representational art. For non-experts, their neural responses to both types of public sculptures are weaker, reflecting a slow and complex aesthetic appreciation for public art. The article concludes as follows:

1. The difficulty level of visual perceptual processing plays a significant role in the preference for landscape public art. As per the fluent processing theory, representational public art that is easy to recognize tends to be favored more by people, eliciting corresponding positive emotions. Figurative public art with rich content characteristics more readily induces positive emotional responses from individuals, whereas vague-yet-creative abstract art draws selective attention resource allocation from people, primarily due to the negative biases resulting from recognition difficulties. The present research results also highlight the importance of perceptual indicators during the aesthetic processing phase, revealing people's emotional perception and acceptance level of design features. Therefore, in subsequent related designs, designers should fully consider perceptual indicators like emotions and perceived difficulty;
2. From the perspective of the aesthetic cognitive process of landscape art, individuals first notice the low-order physical attributes of public art, and stylistic characteristics belong to a higher level of visual processing, requiring the participation of specialized knowledge. In the initial cognitive stage (N100), individuals observe primary physical attributes such as the contour and shape of objects, forming a first impression of them. In subsequent higher-order visual aesthetic processing (P200, N200), stylistic features are identified, generating corresponding emotions and aesthetic evaluations;
3. Expert knowledge plays a positive role in the aesthetic appreciation of landscape art. Professional art training allows individuals to invest more attention and positive evaluations into the allocation of attention resources, positive emotional experiences, and the intensity of negative biases. Therefore, cultivating the ability to appreciate art is also one of the aspects that designers need to focus on.

In conclusion, this study has offered insights into the aesthetic research of urban public art, enabling designers and researchers to gain a deeper understanding of the aesthetic mechanisms of landscape art, albeit with certain limitations. We hope that future studies can adopt a more enriched perspective and research paradigm to delve deeper into the relevant scientific issues. This will support the establishment of a more systematic theoretical framework in this field.

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Institutional Review Board Statement: This study was conducted in accordance with the Declaration of Helsinki and approved by the Jingdezhen Fifth People's Hospital (WY2023012).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

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