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Combined Effects of the Visual–Acoustic Environment on Public Response in Urban Forests

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Abstract: Urban forests are increasingly recognized as vital components of urban ecosystems, offering a plethora of physiological and psychological benefits to residents. However, the existing research has often focused on single dimensions of either visual or auditory experiences, overlooking the combined impact of audio–visual environments on public health and well-being. This study addresses this gap by examining the effects of composite audio–visual settings within three distinct types of urban forests in Fuzhou, China: mountain, mountain–water, and waterfront forests. Through field surveys and quantitative analysis at 24 sample sites, we assessed visual landscape elements, soundscapes, physiological indicators (e.g., heart rate, skin conductance), and psychological responses (e.g., spiritual vitality, stress relief, emotional arousal, attention recovery) among 77 participants. Our findings reveal that different forest types exert varying influences on visitors' physiology and psychology, with waterfront forests generally promoting relaxation and mountain–water forests inducing a higher degree of tension. Specific audio–visual elements, such as plant, water scenes, and natural sounds, positively affect psychological restoration, whereas urban noise is associated with increased physiological stress indicators. In conclusion, the integrated effects of audio–visual landscapes significantly shape the multisensory experiences of the public in urban forests, underscoring the importance of optimal design that incorporates natural elements to create restorative environments beneficial to the health and well-being of urban residents. These insights not only contribute to the scientific understanding of urban forest impact but also inform the design and management of urban green spaces for enhanced public health outcomes.

Keywords: urban forests; audio–visual environment; physiological responses; psychological responses; public health; landscape design

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1. Introduction

Urban forests are invaluable components of city ecosystems, providing urban dwellers with a multitude of physical and psychological health benefits. A growing body of research suggests that the environmental features of urban forests [1], such as vegetation [2], water features [3], and soundscapes [4], can influence individuals' sensory experiences, thereby impacting their health and well-being.

Despite extensive research exploring the relationship between human perception and specific environmental factors in urban forests, investigations into the combined effects of different factors remain limited. Given that recreational activities in forest environments often involve multiple and interactive aspects, examining the influence of individual factors on human perception alone fails to fully capture their real-world experience. Therefore, it is essential to investigate the combined effects of multiple factors on public responses. The existing studies demonstrate that the combined effects of two or more sensory modalities can produce synergistic effects, either enhancing or diminishing individual experiences. For example, the thermal–acoustic effect (the combined influence of sound and temperature) in urban forests can impact people's comfort levels [5]. Hot environments can induce discomfort, while noise can exacerbate this discomfort. However, an appropriate thermal–acoustic environment can create a more comfortable and pleasant space. For instance, shade trees can reduce perceived temperature, and the sound of fountains or water features can provide a cooling sensation. Furthermore, the interaction of olfactory and auditory stimuli is also evident in urban public open spaces [6]. In gardens, the combination of floral scents and birdsong can create a tranquil and serene atmosphere. Research on audiovisual interactions in indoor environments [7] has also shown that in offices, the visual presence of plants and natural imagery can mitigate the impact of office noise, while background music can aid concentration. In addition, other researchers have found that in campus recreational areas and green spaces, there is a clear relationship between the perception of sounds and well-being. However, in some areas near the water, despite the reported higher noise levels, the respondents felt quite comfortable [8]. By optimizing the audiovisual characteristics of urban forests, we can create more livable and healthy urban environments that promote the physical and mental well-being of residents.

This study aims to address the gap in research on the impact of outdoor visual–acoustic interactions on public response. We selected three different types of urban forests in Fuzhou, China, as our research sites and measured visual environmental elements, auditory environmental elements, and the physiological and psychological responses of participants. Using a combination of deep learning techniques and quantitative analyses, we investigated the effects of visual–acoustic landscape features in different forest settings on the sensory experiences, health, and well-being of the public.

The findings of this study provide scientific evidence to optimize urban forest landscape design and management for promoting the health and well-being of urban residents. Our findings can assist planners, landscape designers, and policymakers in creating more livable and healthy urban environments.

2. Materials and Methods

2.1. Study Site Overview

In conducting scientific research, the selection of an appropriate study area is crucial to ensure the validity and reliability of the research findings. This study selects Fuzhou City as the research area. As the capital city of Fujian Province, Fuzhou is not only a pivotal city in the Haixi Economic Zone but also one of China's national historical and cultural cities, and it is at the forefront of economic development [9].

Fuzhou is renowned for its beautiful natural environment and abundant forest tourism resources. Its beautiful natural landscapes and ecological environment have been fully recognized by the state, and it has been successively awarded the honorary titles of "National Garden City" and "Provincial Forest City". These characteristics make Fuzhou an ideal place to study the ecosystem and social functions of urban forests.

After comprehensively considering factors such as the area of urban forests, the number of visitors, and accessibility, this study carefully selected three representative forests as research objects. These three forests are Jinniushan Sports Park (representing mountainous urban forests), Fuzhou National Forest Park (representing mountain and water urban forests), and Xihu Park (representing waterfront urban forests). As shown in Figure 1, these three forests are not only geographically representative but also cover the main types of urban forests, providing a rich comparative basis for the study.

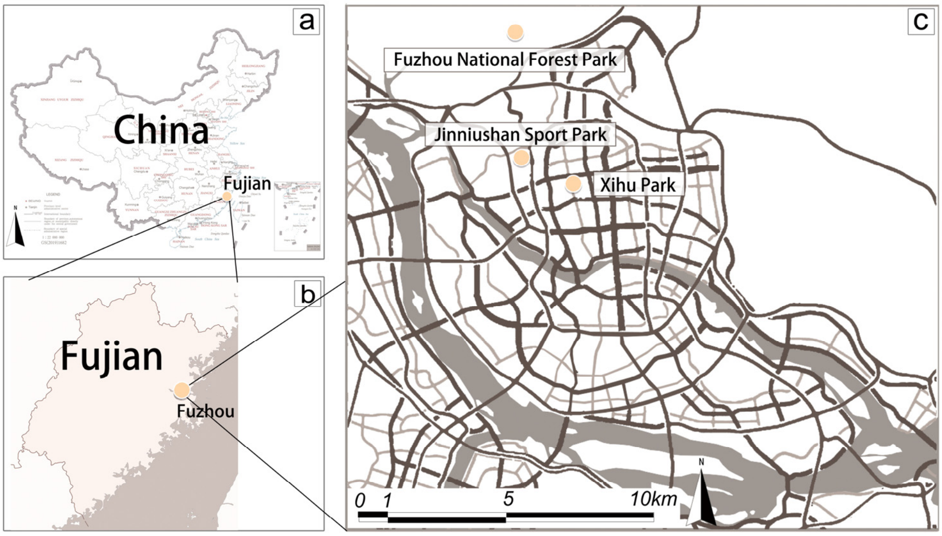


Figure 1. (**a**) Location of Fujian Province in map of China; (**b**) Location of Fuzhou City in map of Fujian; (**c**) Study site selection of urban forests in Fuzhou.

2.2. Forest Overview and Survey Point Layout

Table 1 provides an overview of the three urban forests in Fuzhou. Figures 2 and 3 show the position of the sites. The study divides them into 24 sample site scenes. Jinniushan Sports Park has 8 sample sites, denoted as S1–S8. Fuzhou National Forest Park has 9 sample sites, denoted as F1–F9. Xihu Park has 7 sample sites, denoted as X1–X7. Tables 2–4 provide an overview of the 24 sample sites.

Table 1. Overview of parks.

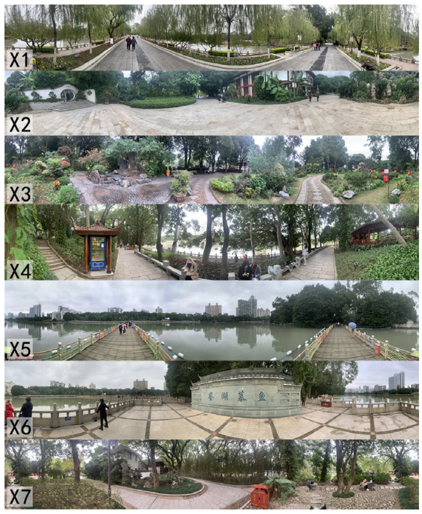
Park Name	Overview
Jinniushan Sports Park (Fudao Gate 3)	Characterized by undulating terrain and picturesque scenery, it is the largest community-type semi-hilly sports park in the heart of Fuzhou City and serves as the entrance at Fudao Gate 3.
Fuzhou National Forest Park	Fuzhou National Forest Park (also known as "Fuzhou Botanical Garden") is the first national-level forest park in Fujian Province, one of the top ten forest parks in China, and one of the six 4A-level scenic spots in the Fuzhou area. The total planned area spans 2891.3 hm^2, with a water catchment area reaching 13 km^2.
Xihu Park	Located in the northwest part of Gulou District in Fuzhou City, at the heart of the urban area, the current land area is 42.51 hm^2, of which the land area is 12.21 hm^2, and the water surface area is 30.3 hm^2.

(**a**) (**b**) (**c**)

Figure 2. (**a**) Study site selection of Jinniushan Sports Park; (**b**) Study site selection of Fuzhou National Forest Park; (**c**) Study site selection of Xihu Park.

(a)

(b)



(c)

Figure 3. (**a**) Plots of Jinniushan Sports Park; (**b**) Plots of Fuzhou National Forest Park; (**c**) Plots of Xihu Park.

Table 2. Overview of Jinniushan Sports Park plot.

Plot Number	Plot Name	Plot Introduction
S1	Entrance Square	Situated at the entrance of Jinniushan Sports Park (Fudao Gate 3), the terrain is level and expansive, with nearby amenities such as KFC, a sports gym, and the Shangfu Road Rotating Walkway.
S2	Mixed Coniferous and Broad-Leaved Forest	Nestled amidst the canopy of the boardwalk, adjacent to aerial resting platforms, the view is sequestered by both broad-leaved and coniferous trees.
S3	Broad-Leaved Forest	Situated along the hiking trail.
S4	Bamboo Forest	Nestled along the hiking trail, the surroundings are dominated by a verdant bamboo forest.
S5	Leisure Stone Table	Situated within a sylvan clearing, the centerpiece is a scenic vignette composed of a stone table and chairs, surrounded by a selection of broad-leaved trees.
S6	Bamboo Forest	Nestled amidst the canopy of the boardwalk, the view is partially secluded by bamboo groves to the left and right, with close proximity to the ground.
S7	Broad-Leaved Forest	Ensconced within the canopy of the boardwalk, the vista is partially secluded by broad-leaved trees on either side.
S8	Canopy Walkway	Perched above the forest canopy, the walkway is flanked on one side by a 20 m slope adorned with lush vegetation.

Table 3. Overview of Fuzhou National Forest Park plot.

Plot Number	Plot Name	Plot Introduction
F1	Entrance Square	Situated on the eastern edge of the entrance landscape zone, the main entrance plaza spans approximately 1.9 ha, featuring an asphalt surface adorned with tree pits.
F2	Shade-Grown Botanical Garden	Nestled beneath a nutmeg grove on the northern side of the park's eastern grand entrance, a gently sloping, fertile woodland has been selected for the creation of a diverse tapestry of flora. Over 100 species of high-value plants have been carefully arranged.

Table 3. *Cont.*

Plot Number	Plot Name	Plot Introduction
F3	Bamboo Grove	Positioned on an open expanse amidst a verdant tapestry of trees and bamboo, the site offers panoramic views and excellent ventilation. The ground cover is a harmonious blend of paved and grassy areas, creating a visually appealing and inviting space.
F4	Bamboo Grove	The garden is home to an extensive collection of approximately 215 bamboo species. The sample plot is strategically situated along a winding path that meanders through a tranquil bamboo grove.
F5	Log Platform	Perched beside the tranquil waters of August First Reservoir, a wooden platform invites visitors to immerse themselves in the picturesque surroundings. Flanked by a discreet security post and a charming kiosk, the platform centers upon a magnificent banyan tree. The reservoir's serene expanse and the captivating vista beyond create a captivating panorama.
F6	Riverside Walkway	Nestled alongside the picturesque August First Reservoir, the Waterfront Promenade offers a tranquil respite. Towering Alexander palms grace both sides of the walkway, their graceful fronds swaying gently in the breeze. Beneath their verdant canopy, vibrant bougainvillea and crimson Fraser's photinia add splashes of color, while a verdant expanse of lawn carpets the opposite side.
F7	Millennial Banyan Tree	The Millennial Banyan, a stately Ficus concinna Miq., stands as an iconic symbol of Fuzhou National Forest Park. Its ancient trunk soars majestically, its dense canopy casting a dappled shade upon the meticulously manicured understory. The tree's distinctive silhouette, with its elevated and uniform branches, has become synonymous with the park's enchanting beauty.
F8	Pavilion in the Center of the Lake	To the north lies the Hydrophilic Arboretum, a verdant sanctuary for moisture-loving trees. To the south, the Millennial Banyan District unfolds its ancient grandeur. The western horizon is graced by the serene waters of August First Reservoir, while the east offers a glimpse into the Banyan Garden Scenic Area. Within the lake's crystal depths, hundreds of vibrant red and gold koi dance gracefully, adding a touch of enchantment to the landscape.
F9	Hydrophilic Arboretum	Nestled at the southern edge of Banyan Garden, the Hydrophilic Arboretum is a verdant haven dedicated to moisture-loving trees. Scattered throughout the arboretum are three sets of stone tables and chairs, inviting visitors to pause and immerse themselves in the serene atmosphere.

Table 4. Overview of Xihu Park plot.

Plot Number	Plot Name	Plot Introduction
X1	Gateway Bridge	At the heart of the Bonsai Garden, where the terrain levels and opens up, lies a petite plaza flanked by the visitor service center.
X2	Bonsai Garden Entryway	Encircling the garden, a tapestry of verdant lawns and meticulously manicured bonsai shrubs unfolds, creating a serene and harmonious setting. A carefully crafted rockery, with its rugged peaks and cascading waterfalls, adds a touch of drama to the landscape, inviting visitors to contemplate the beauty of nature in miniature.
X3	Bonsai Garden	Flanked by banyan trees, the stone-paved path is the garden's main thoroughfare, thronged by passersby.
X4	Woodland Trail	A wooden footbridge spans the water, offering an unobstructed vista of the surrounding expanse.
X5	Timbered Floating Bridge	By the water's edge, an observation deck flanked by two banyan trees extends over the water, providing expansive views on three sides, while a stone wall forms the backdrop on the fourth.

Table 4. *Cont.*

Plot Number	Plot Name	Plot Introduction
X6	Waterfront Terrace	A recreational area is dominated by broadleaf and bamboo groves, with three sets of stone tables and chairs beneath the trees for visitors to rest upon. The ground is paved with a durable cement–pebble composite.
X7	Broadleaf and Bamboo Forest Intermix	At the entrance to the flat and expansive Bonsai Garden, a small plaza is surrounded by the visitor service center.

2.3. Overall Experimental Design

This study aims to investigate the impact of the audio–visual environment of urban forests in Fuzhou on the physiological and psychological perception of the public in order to reveal the sensory experience of green spaces in the urban environment and their mechanisms of action. To this end, we selected three urban forests in Fuzhou, with a total of 24 representative sample points for study. By quantitatively measuring audio–visual landscape elements and combining this with real-time monitoring of the public's physiological indicators and questionnaire survey data collection, this study comprehensively evaluates the effects of urban forests on people's sensory experiences.

2.4. Audiovisual Environment Measurements

2.4.1. Visual Environment

Evaluating landscape quality is a multidimensional process involving multiple constituent indicators. In the field of research on the evaluation of landscape quality based on visual landscape elements, scholars propose four categories of key elements [10]: landscape spatial scale elements [11], physical landscape elements [12], color elements [13], and comprehensive elements [14]. Furthermore, drawing on research related to mountain parks [15], this study further identifies vegetation elements, water body elements, spatial elements, and construction elements as the main factors affecting the landscape quality of mountain forests. A comprehensive analysis of these elements helps to deeply understand the characteristics of the landscape and their impact on the visitor experience. A detailed classification and description of the elements are shown in Table 5.

Table 5. Overview of landscape elements.

	Landscape Elements	Number	Scoring Criteria and Weightings
Plant elements	Plant proportion	Z1	The proportion of the plant in the panoramic scene
	Plant color	Z2	1 point for no apparent chromatic aberration, 2 points for green hues of varying brightness, 3 points for the presence of flowers or colored foliage
	Plant layers	Z3	1 point for the absence of layers, 2 points for a single layer of vegetation, 3 points for a double layer of vegetation, 4 points for the presence of trees, shrubs, and grass
Water elements	Water proportion	S1	The proportion of the water body in the panoramic scene
	Water presence	S2	1 point for presence, 0 points for absence

Table 5. *Cont.*

	Landscape Elements	Number	Scoring Criteria and Weightings
Spatial elements	Skyward proportion	K1	The proportion of sky coverage within the panoramic scene
	Enclosure	K2	Sum of tree, shrub, architectural structure, and fence coverage proportions within the panoramic scene
	Ground proportion	K3	The proportion of the ground in the panoramic scene
Architectural elements	Pavement presence	J1	1 point for presence, 0 points for absence
	Scene complexity	J2	1 point for negligible presence of weeds or fallen leaves on paved surfaces (roads, plazas, etc.), 2 points for moderate presence, 3 points for substantial presence and untidiness
	Structure proportion	J3	The proportion of buildings and structures (street lights, trash cans, etc.) in the panoramic scene

Landscape feature extraction is foundational work in landscape research, involving various techniques and methods. This study adopts the following two main methods for landscape feature extraction. The first is image segmentation. Image segmentation is a fundamental technique in the field of computer vision and is of great significance for improving computers' ability to understand images. As shown in Figure 4, this study performs image segmentation processing on panoramic images of selected sample sites to extract landscape features.

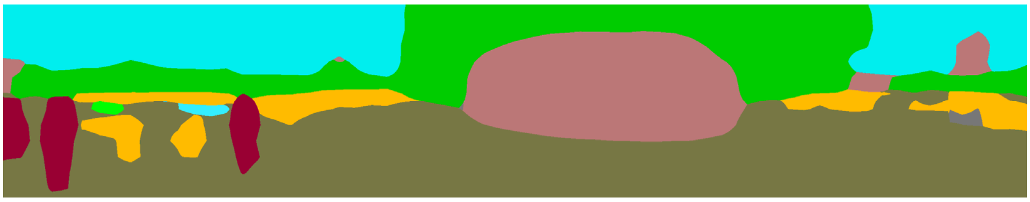


Figure 4. Scene image semantic segmentation graph.

The second is the ColorImpact color extraction method. This study uses ColorImpact 4.0.3 software to extract colors from the collected panoramic images to analyze the color characteristics of the landscape.

In this study, we collected panoramic images of 24 sample sites in three major urban forests in Fuzhou. Based on relevant research results in the field of mountain forest research, we identified four key factors that affect the landscape quality of mountain forests: vegetation, water bodies, space, and construction.

2.4.2. Acoustic Environment

In this study, we conducted sound environment monitoring of three urban forests in Fuzhou, using high-precision sensors and high-fidelity recorders provided by Weihai Gemho Digital Mining Technology Co., Ltd, Weihai, China, to record volume and real-time sound at the sample sites. The monitoring period was from October to December 2020. Each experiment was conducted from 7:00 a.m. to 7:00 p.m., ensuring comprehensive coverage of the daytime sound environment. The monitoring equipment was placed at a height of 1.5 m above the ground, and data were collected every 2 h, with the average of three readings taken as the final record.

2.5. Measurement of Physiological Data from the Public

When exploring physiological and psychological indicators, skin electricity, heart rate, and respiratory rate are important physiological indicators for assessing the level of emotional calmness of an individual. Although these indicators can reflect the level of physiological arousal, they often cannot accurately distinguish between specific categories of emotions. For example, the literature [16] points out that these indicators mainly reflect the physiological activation state and cannot directly reveal the category of emotions.

However, from a general physiological response perspective, skin electrical activity shows an upward trend when an individual is tense, as described in the literature [17]. Conversely, in an individual's relaxed state, the heart rate will show a downward trend. Heart rate, the number of pulse beats per minute, is a key indicator for assessing the health of the cardiovascular system [18]. Changes in heart rate can reflect an individual's stress level and physiological arousal state. Under calm conditions, the normal heart rate range is 60–100 beats/min. When an individual experiences emotional tension or increased stress, the heart rate rises accordingly.

The low frequency (LF) component in heart rate variability is usually associated with sympathetic nervous system activity, while the high frequency (HF) component is closely related to parasympathetic nervous system activity [19]. The LF/HF ratio, the ratio of the low-frequency to high-frequency components of the heart rate, can reflect the dynamic changes in sympathetic and parasympathetic nerve activity [20]. Changes in the LF/HF ratio can effectively indicate an individual's psychological state, such as changes in tension, relaxation, or comfort.

The skin galvanic response (EDA) signal changes significantly with changes in emotion [21,22] and is often used to study subjects' responses to specific emotionally arousing environments or stimuli [23]. When faced with environmental stress, the skin conductance value exhibits sensitive changes, becoming an effective indicator reflecting emotional changes.

Therefore, this experiment will monitor the physiological indicators of the participants, including skin electricity, heart rate, and heart rate variability. To reduce external interference, the participants will watch the surrounding landscape in a fixed position so that their physiological and psychological responses can be captured more accurately.

2.6. Questionnaire Survey

This study aims to evaluate the impact of landscape perception on mental health and selects mental vigor, stress relief, emotional calmness, and attention restoration as evaluation indicators of mental health [24].

The questionnaire survey is divided into three main parts. The first part focuses on demographic characteristics, including personal background information, such as gender, age, stress level, professional background, and frequency of visits to urban forests. The second part focuses on the frequency and intensity of perception of various sounds in the forests, using the research method of Liu Jiang [25] to evaluate 17 typical sound sources. The evaluation criteria include perception frequency (1 point for never perceived, 2 points for occasionally perceived, and 3 points for often perceived) and perception intensity (1 point for quiet, 2 points for general, and 3 points for very strong). By multiplying the frequency and intensity scores, the dominance score of each sound is obtained, and it is reclassified into a 5-level scale: 1 for very low (1~2 points), 2 for low (3 points), 3 for general (4~5 points), 4 for high (6~7 points), and 5 for very high (8~9 points). Since bicycle sounds and frog calls were not recorded in the actual survey, this study actually evaluated 15 sounds. The specific evaluation results are shown in Table 6.

The third part involves the evaluation of visitor psychological indicators, as shown in Table 7, referring to the research of many scholars [26,27], using a 7-point Likert scale to set questionnaire questions and using 7 points as the full score for quantitative evaluation. Through such a structured questionnaire design, this study aims to explore the specific impact of landscape perception on individual mental health and provide a scientific basis for future urban planning and environmental design.

Table 6. Typical sound source composition in the case forests.

Sound Type	Classification	Instruction
Artificial sound	The sound of human activity	Conversation, children’s laughter, footsteps
	Mechanical sound	Traffic, aircraft, construction, bicycle bell, lawn mower, sweeping, public announcements, music
Natural sound	Geophysical sound	Wind, wind blowing the leaves, water
	Biological sound	Bird call, frog call, insect call

Table 7. Meaning of Psychological Perception Questionnaire.

Measures of Psychological Perception	Basic Meaning
Spiritual vitality	The state of an individual’s mental vitality experienced within their environment
Stress relief	An individual can effectively release stress within their environment
Emotional arousal	After experiencing their environment, an individual alleviates and releases negative emotions, such as anxiety, leading to a more moderate emotional state
Attention recovery	Natural environments are conducive to the recovery of human attention and have the effects of promoting positive emotions, alleviating stress, and relieving mental fatigue; natural space environments that meet the four basic characteristics of being away, richness, fascination, and compatibility possess the function of attention restoration

2.7. Subjects

When conducting research related to visual stimuli, ensuring the representativeness of the participants and the adequacy of the sample size is crucial for improving the scientific nature and generalizability of the research results. Researchers such as Kaplan [28] have pointed out that the college student population can provide highly scientific and representative data in such experiments. Therefore, this study used G*Power 3.1 software to conduct a rigorous power analysis to determine the appropriate sample size to ensure that the experiment had sufficient statistical power.

Through the calculations of G*Power software, we determined the minimum sample size required under the given effect size, α level (usually 0.05, indicating the significance level), and statistical power (usually 0.80 or higher). Based on these calculations, we selected 77 undergraduate students from different majors as the experimental subjects. This sample size not only meets the requirements of statistical power but can also effectively represent a wider young adult population.

The age of all the participants was under 30 years old, with an average age of 23.4 years old. The selection of this age range helps to ensure that the participant performance on cognitive and perceptual tasks is consistent and reduces the potential impact of age-related cognitive differences on the experimental results. During the screening process, we excluded individuals with a history of major physical or mental trauma, major surgery, or chronic diseases, such as heart disease and hypertension, to ensure that their health status would not bias the experimental results.

2.8. Experimental Procedure

This study was conducted from October to December 2020 in three forests in Fuzhou—Jinniushan Sports Park, Fuzhou National Forest Park, and Xihu Park in Fuzhou—for a period of 7 to 14 days. The experimental time was scheduled from 7:00 a.m. to 7:00 p.m. each day to cover different time periods during the day. Each day, we invited 3 to 5 participants to participate in the experiment, and each participant’s observation time in each forest was controlled between 1.5 and 3 h.

Before the experiment started, the project leader gave detailed face-to-face instructions to the 77 participants, introducing the basic concepts of visual and auditory landscapes, the purpose and significance of the experiment, and explaining, in detail, how to fill out the questionnaire, including the meaning of each question and answer option. The research team then led the participants to 24 selected sample sites for physiological index measurement. In addition, after reaching each site, the subjects had to rest for 5 to 10 min to ease the physical and psychological indicators.

As Figure 5 shows, in the specific physiological index detection experiment, the participants were equipped with calibrated physiological monitoring equipment, and while observing the sample site landscape and listening to the ambient sound for 3 min, they were required to refrain from talking, eating, or drinking to reduce man-made interference during the experiment. The researchers were responsible for recording the participants' physiological index data in real time. After the perception session of each sample site, the participants filled out the relevant questionnaire survey.

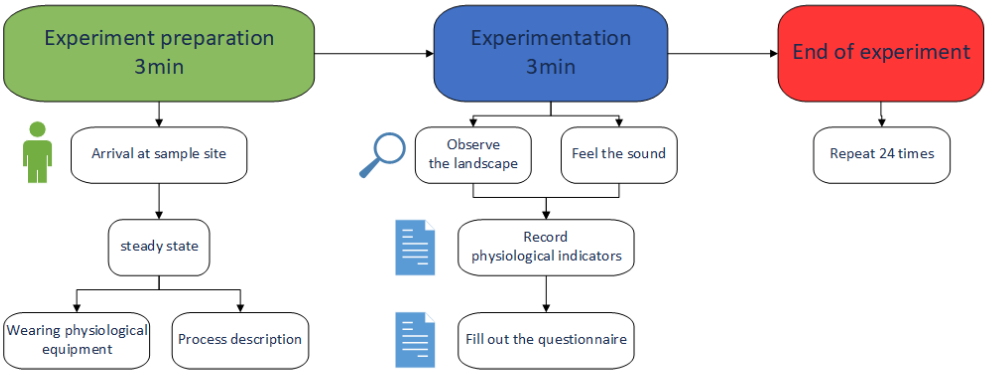


Figure 5. Procedure.

2.9. *Analytical Methods*

To explore the relationship between the audiovisual environmental elements in the scene and the physiological and psychological perception responses of the subjects to the studied scene and to identify their potential relationships, stepwise regression analysis was performed on the data to investigate whether there is a correlation between these elements and the strength and direction of the correlation to better understand the impact of the combined audiovisual effect on the public response.

3. Results

3.1. *Base Environmental Conditions*

In this study, we used advanced programming language technologies, such as Java and Python, to precisely segment the panoramic images taken of the selected sample sites to identify and extract different ecological patches. Through this image-processing method, we were able to analyze the landscape structure in detail, leading to a deeper understanding of the complexity of the ecosystem.

Furthermore, we carried out meticulous color extraction work on the generated patches. To ensure the accuracy and consistency of color recognition, we used professional ColorImpact 4.0.3 software to systematically analyze and recognize the extracted colors. Through the software's color scheme design function, we obtained detailed data on the color composition and distribution of the sample site landscape, which are organized and presented in Table 8. In addition, we conducted a detailed investigation and analysis of the soundscape dominance in the three forests in Fuzhou. The collected data reveal the uniqueness of the sound environment in each forest. Specifically, the soundscape indicators of the mountain forest are generally lower than the average level, indicating that the environment in this area is relatively quiet, with less noise generated by human activities.

In contrast, the data from the mountain–water forest show a higher dominance of conversation, children's play, and footsteps, which indicates higher foot traffic and frequent social interactions within the forest. The soundscape of the waterfront forest is obviously dominated by natural elements, especially the sound of water and birdsong, creating a stronger natural atmosphere. These results are clearly shown in Table 9.

Table 8. Quantitative analysis of plant landscape elements in different urban forests.

Type	Plant Proportion	Plant Color	Plant Layers	Structure Proportion	Pavement Presence	Scene Complexity	Skyward Proportion	Ground Proportion	Enclosure	Water Proportion	Water Presence
Mountain	57.78	2	2.62	16.12	0.50	2.50	8.07	18.02	73.90	0	0
Mountain–water	51.44	1.56	2.44	6.21	0.89	2.89	6.44	30.14	57.65	4.48	0.44
Waterfront	46.26	2.14	3.14	8.89	0.87	2.43	9.32	28.00	55.15	6.42	0.57

Table 9. Soundscape dominance analysis of forests.

Type	Conversation	Children's Laughter	Foot-Steps	Traffic	Aircraft	Construction	Lawn Mower	Sweeping	Public Announcements	Music	Wind	Wind Blowing the Leaves	Water	Bird Call	Insect Call
Mountain	2.26	1.96	2.08	1.58	1.20	1.39	1.18	1.30	1.83	1.58	1.92	1.95	1.23	2.24	1.94
Mountain–water	5.69	5.08	4.72	2.43	1.22	1.89	1.78	2.11	3.50	4.39	4.67	5.04	4.06	5.29	3.46
Waterfront	4.35	2.82	3.85	2.51	1.46	2.83	1.96	1.83	2.61	3.10	3.43	4.01	4.28	4.17	2.93

3.2. The Combined Effect of Visual–Acoustic Stimuli on the Physiological Indices of the Public

3.2.1. Effects on HR

- As shown in Figure 6, in the study of HR across three forests in Fuzhou, the mountain–water forest exhibited the highest average HR (81.82 beats per minute), followed by the waterfront forest (83.34 beats per minute), with the mountain forest recording the lowest average (69.55 beats per minute), all within the normal physiological range. Further analysis of HR variability reveals significant differences among the forests, with the mountain–water forest showing the greatest variation, followed by the waterfront forest and then the mountain forest. Statistical analysis, including analysis of variance (ANOVA) and least significant difference (LSD) post hoc tests, confirmed these differences to be highly significant. These findings suggest that the distinct landscape features and spatial experiences of the forests have varying impacts on the psychological and physiological well-being of visitors. The environments of the mountain and waterfront forests appear to be more effective in alleviating visitor stress, leading to more stable heartbeats and a trend toward decreased HR;

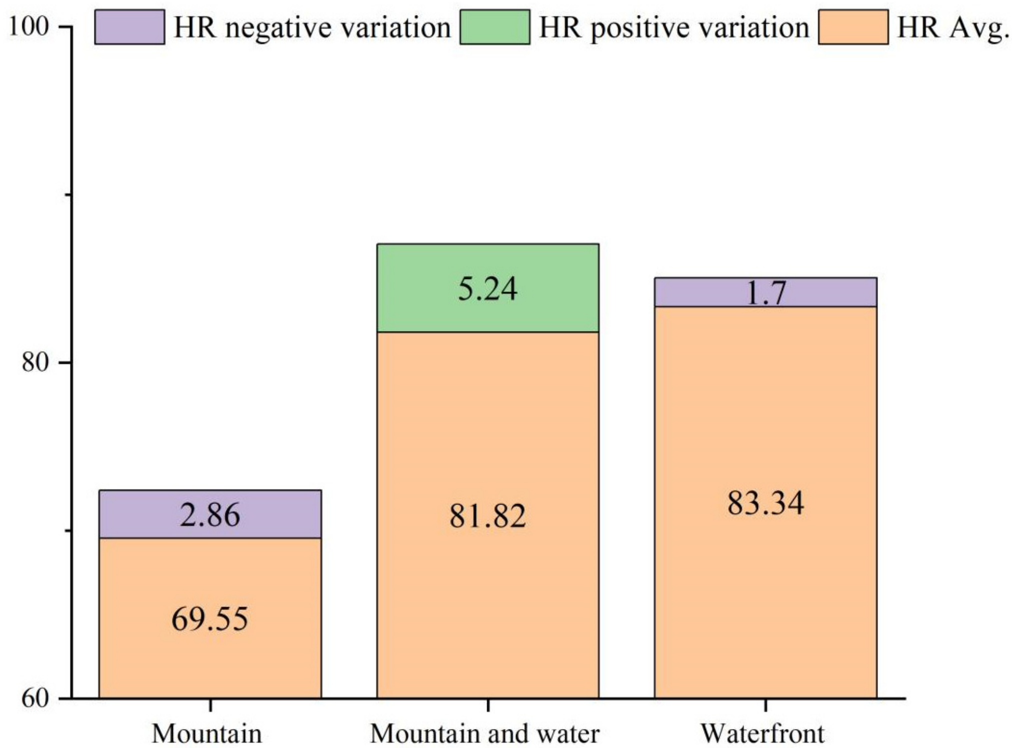


Figure 6. Average and change values of HR in Fuzhou urban forests.

- According to the research results shown in Figure 7, among the eight sample sites in the mountain forest, we observed positive changes in the subjects' HR values in the S3 and S4 sample sites, while negative changes occurred in the S1, S2, S5, S6, S7, and S8 sample sites. To further explore the impact of different sample sites on HR change values, we conducted an LSD multiple comparison test;
- The test results show that there were significant differences in HR change values between S3 and S8 (p = 0.046), S4 and S8 (p = 0.023), and S4 and S7 (p = 0.041). These findings indicate that most sample sites in the mountain forest can effectively reduce the stress levels of the subjects, leading to a decrease in HR values. It is particularly noteworthy that S8, located in an open field of vision, has a significant effect on reducing the heart rate of the public;

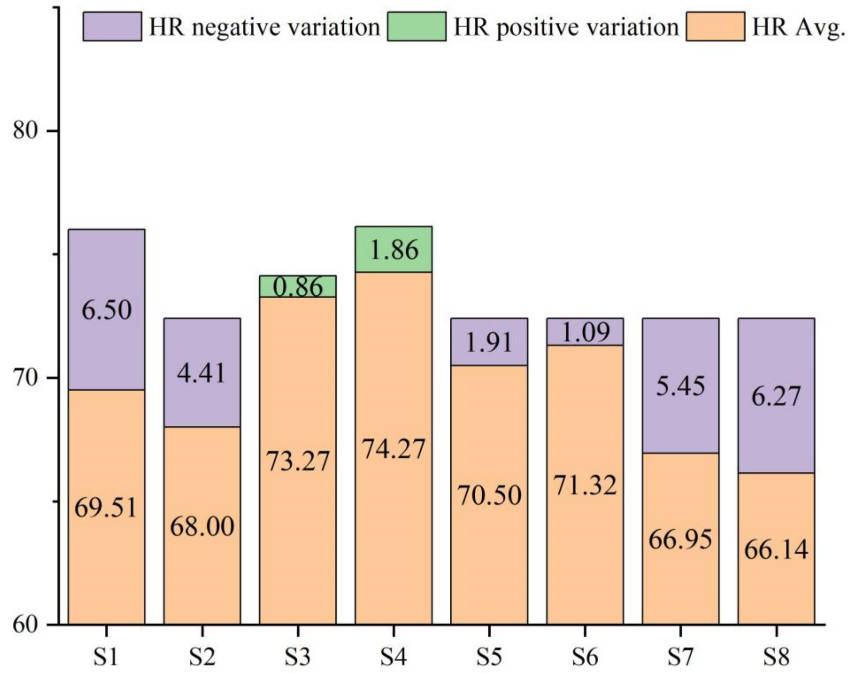


Figure 7. Average and change value of HR in mountain forest.

- According to the data presented in Figure 8, among the nine sample sites in the mountain–water forest, the HR of the participants generally showed a positive change; that is, the heart rate increased, and these changes did not show significant differences statistically. In terms of the change trend, the HR change value of F8 was the highest, followed by F1, while the HR change value of F5 was the smallest;
- This result indicates that the different sample sites in the mountain–water forest generally increased the stress levels of the participants, leading to a general increase in HR. In particular, F8 seemed to have the greatest stress impact on the participants, as evidenced by a significant increase in heart rate. In contrast, F5 had the least stress impact on the participants, with a relatively small increase in HR;

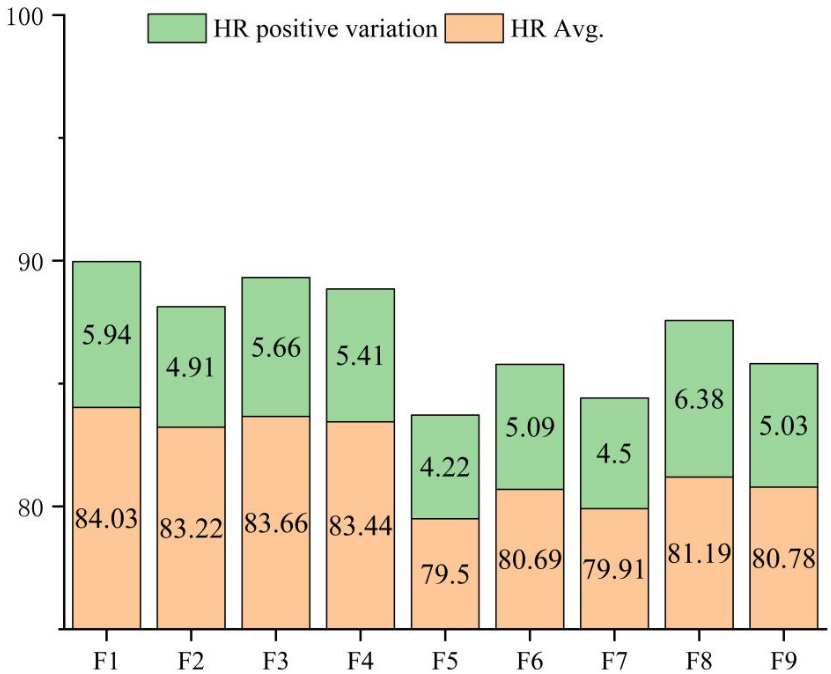


Figure 8. Average and variation of HR in mountain–water forest.

- According to the research results shown in Figure 9, among the seven sample sites in the waterfront forest, the HR changes of the participants showed varying degrees of negative changes; that is, the heart rate generally decreased. Specifically, the HR change value of X6 was the largest, followed by X2, then X4, X1, X5, X3, and X7. Despite this, these changes did not reach a significant level statistically;
- In the waterfront forest, all sample sites showed a stress-relieving effect on the participants, as evidenced by the decrease in HR. This phenomenon indicates that the landscape design of the waterfront forest has, to a certain extent, promoted relaxation and stress reduction among visitors. However, since the differences in HR change values between the sample sites were not significant, this may imply that the stress-relieving effects of different areas in the forest are relatively uniform or that further research is needed to explore the potential differences and the specific effects of specific landscape features on psychological relaxation. In summary, the sample sites in the waterfront forest generally had a mitigating effect on the psychological stress of the participants.

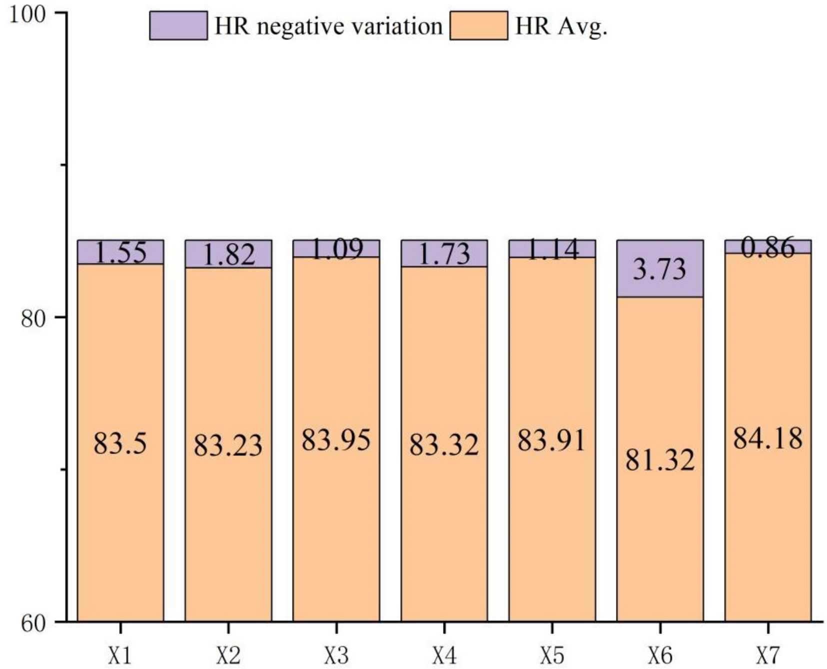


Figure 9. Average and change value of HR in waterfront forest.

3.2.2. Effects on the Heart Rate LF/HF Balance

- According to the data presented in Figure 10, the low-frequency-to-high-frequency heart rate variability ratio (LF/HF) of the mountain–water forest was the highest on average, followed by the mountain forest, while the average LF/HF of the waterfront forest was the lowest. This indicator reflects the tension level of the subjects in the three different forests and its impact on the activity of the autonomic nervous system. The research results show that all three forests led to an increase in the LF/HF values of the subjects; that is, they increased the activation level of the sympathetic nervous system, reflecting an increase in the tension level of the subjects. However, there were differences in the degree of influence, with the waterfront forest having the highest level of tension, followed by the mountain forest, and the mountain–water forest having the least influence. In the mountain–water forest, the sympathetic nerve arousal level of the subjects was relatively low, and the change in LF/HF value was also the most limited;

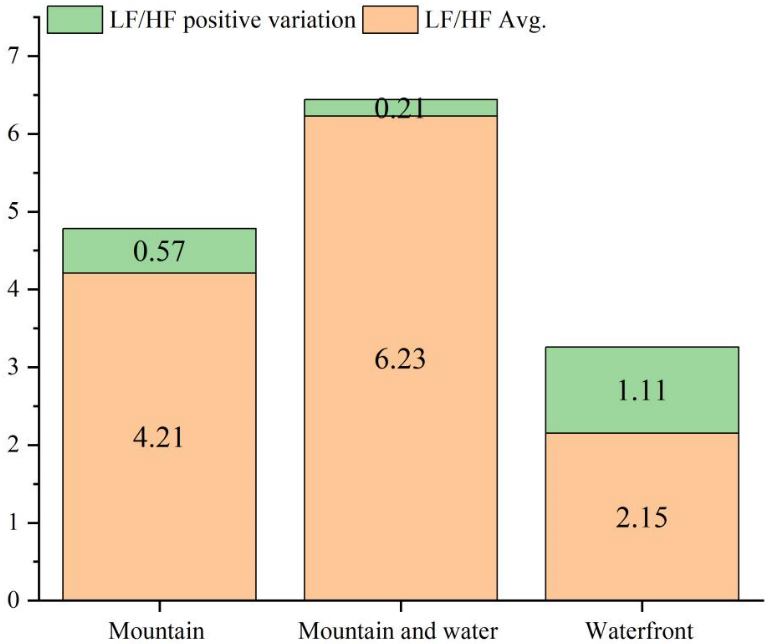


Figure 10. Average value and change value of heart rate balance ratio (LF/HF) in Fuzhou urban forests.

- According to the data analysis results in Figure 11, in multiple sample sites in the mountain forest, the heart rate balance ratio (LF/HF) of the participants showed varying degrees of positive and negative changes. Specifically, the LF/HF change value of S7 was the largest, followed by S1 and S8, followed by S5, S3, S4, and S6;
- By performing the LSD multiple comparison test, we found that there were significant differences in the LF/HF change values between S1 and S6, S3 and S7, S4 and S7, and S6 and S7. These results reveal the specific effects of different sample sites on the participants' autonomic nervous system activity;
- In particular, S3, S4, and S6 seem to be able to effectively reduce the anxiety level of the participants, as evidenced by enhanced parasympathetic nerve activity and decreased LF/HF values. However, in other sample sites, such as S1 and S7, the participants' anxiety and tension levels were relatively high, as reflected by an increase in LF/HF values;

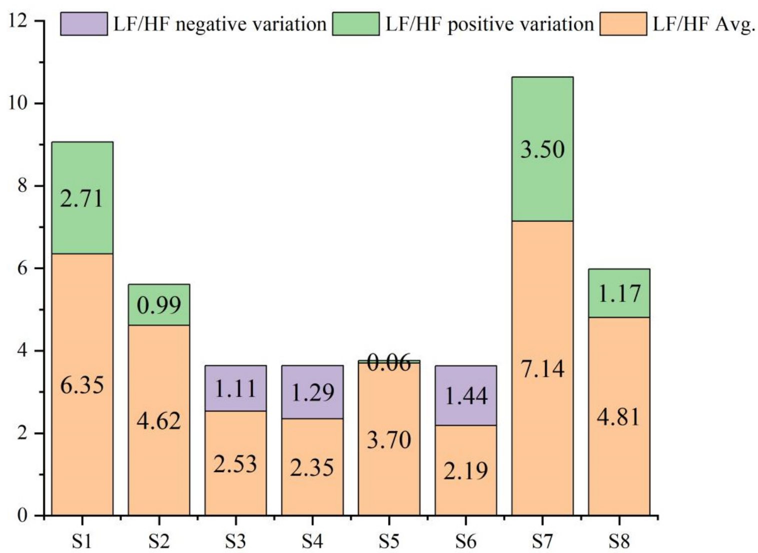


Figure 11. Average value and change value of heart rate balance ratio (LF/HF) in mountain forest.

- According to the data shown in Figure 12, the influence of different sample sites in the mountain–water forest on the heart rate balance ratio (LF/HF) of the participants showed positive and negative changes. Specifically, the LF/HF change values of F2, F5, and F6 were relatively large, while the LF/HF change values smaller for F3, F7, F8, F1, F4, and F9;
- The research results reveal that F1, F4, and F9 have a significant relaxation effect on the participants, resulting in a decrease in LF/HF values, among which the relaxation effect in F9 is the most significant. In contrast, in the other six sample sites, the participants generally experienced different degrees of emotional tension, which led to increased sympathetic nerve activity and a corresponding increase in LF/HF values;

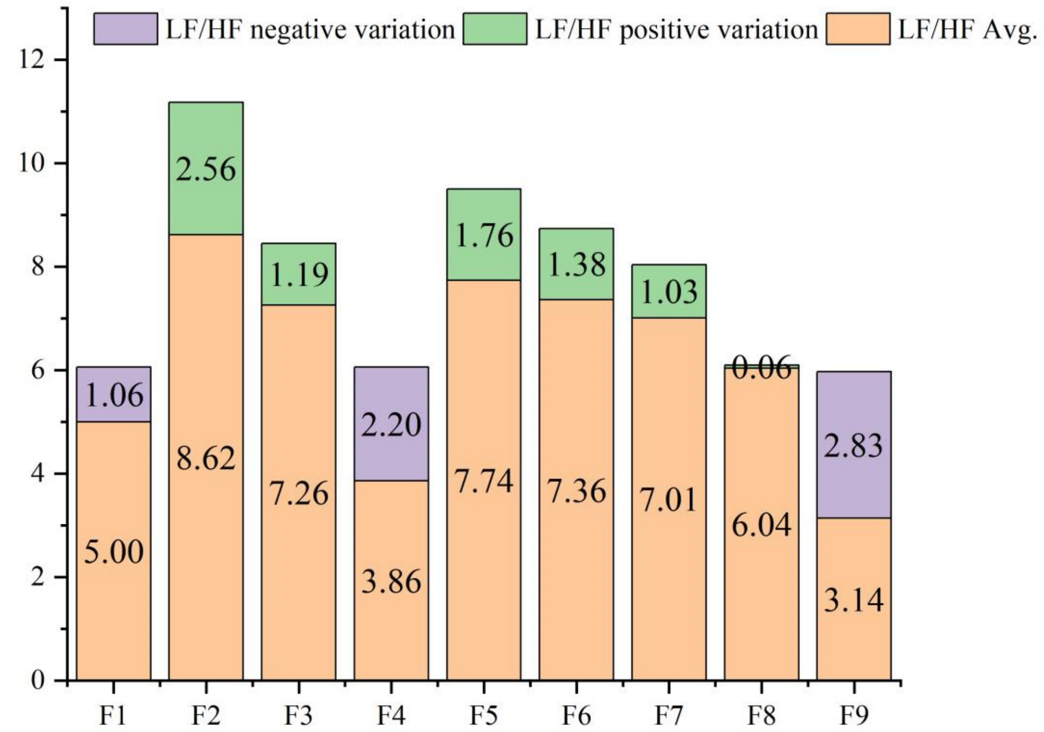


Figure 12. Average value and change value of heart rate balance ratio (LF/HF) in mountain–water forest.

- According to the data presented in Figure 13, the seven sample sites in the waterfront forest generally had a negative impact on the heart rate balance ratio (LF/HF) of the participants, indicating that the parasympathetic nervous system activity was relatively enhanced, and the participants' psychological state was effective. It has been soothed and relaxed. Among these sample sites, X6 has the most significant effect on reducing LF/HF values, while X5 has a relatively weak relaxation effect, although all sample sites show a tendency to promote relaxation;
- In terms of specific change values, the LF/HF change value of X6 is the largest, followed by X3 and X4, followed by X2, X1, and X7. These results reveal the specific effects of different sample sites in the waterfront forest on the participants' autonomic nervous system activity and point out the importance of landscape features that should be considered in park design for promoting visitor relaxation. In summary, the sample sites in the waterfront forest generally help to reduce the tension of the participants, among which specific areas, such as the waterfront platform, are particularly effective in promoting psychological relaxation.

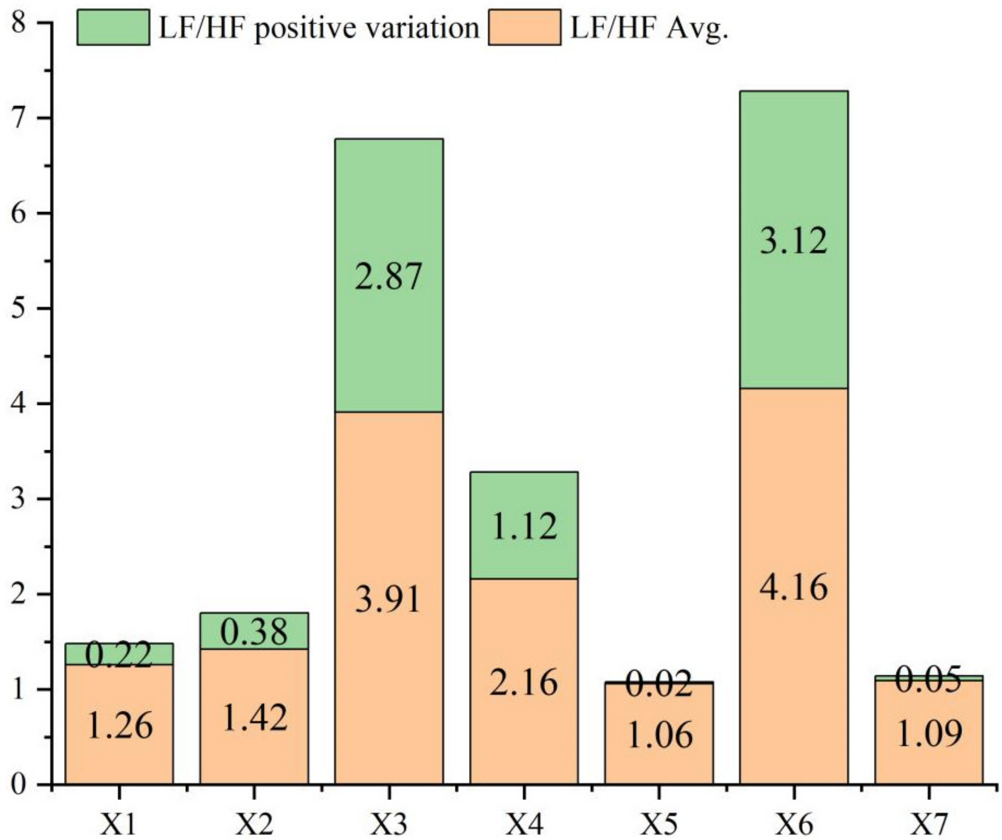


Figure 13. Average value and change value of heart rate balance ratio (LF/HF) in waterfront forest.

3.2.3. Effects on EDA

- According to the data analysis results in Figure 14, the EDA change values of the participants in the three forests showed different trends, with the change value in the mountain forest being the largest, followed by the mountain–water forest, and the change value in the waterfront forest was the smallest. Through an ANOVA test, we found that there was no significant difference in EDA change values among the three forests ($F(2, 615) = 1.029$, $p = 0.358$);
- The research results reveal that in the mountain forest and the mountain–water forest, the participants' mood fluctuated more, leading to an increase in the average EDA value. In contrast, in the waterfront forest, the participants' psychological states were relatively more stable, and the average EDA value showed a downward trend. This difference may be related to the geographical location and usage frequency of the waterfront forest. As a comprehensive forest located in the city center, Xihu Park has high accessibility and daily usage frequency, so for regular visitors, there may be a lack of novel experience;
- It is worth noting that many participants said that this was their first visit to Jinniushan Sports Park and Fuzhou National Forest Park. The novel experience of these two forests may have a greater impact on the participants' emotions, leading to an increase in EDA conductance;

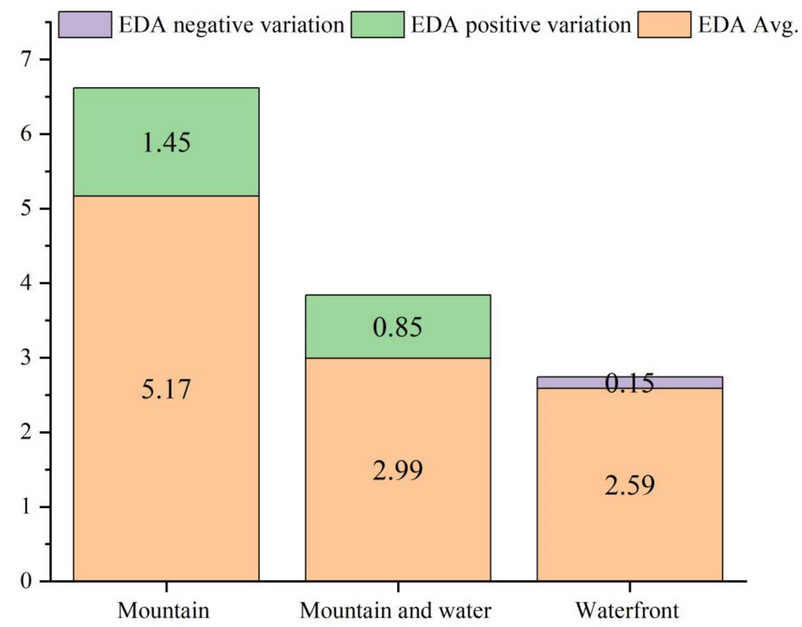


Figure 14. Average value of EDA in Fuzhou urban forests.

- According to the research results shown in Figure 15, among the eight sample sites in the mountain forest, the EDA of the participants generally showed positive changes, indicating an increase in emotional fluctuations. Specifically, the EDA change value of S7 was the highest, indicating that the area had the most significant impact on the participants' emotions. This was followed by S6, while the EDA change value of S1 was the smallest, indicating that its impact on emotional fluctuations was relatively weak;
- These findings indicate that different sample sites in the mountain forest differ in their ability to induce emotional fluctuations. S7 may have a stronger emotional arousal effect on the participants due to its specific environmental characteristics or atmosphere. In contrast, S1 and S5 were relatively calm, with less impact on the participants' emotional fluctuations;

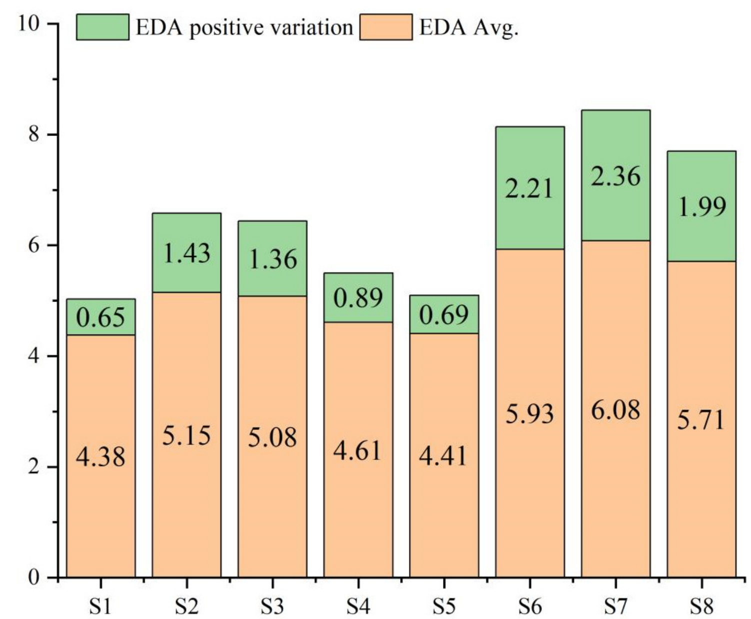


Figure 15. Average value and change value of EDA in mountain forest.

- According to the data shown in Figure 16, among the nine sample sites in the mountain–water forest, the participants' EDA all showed positive changes, indicating that emotional fluctuations increased. Among these sample sites, the EDA change value of F9 was the most significant, followed by F4, while the EDA change value of F5 was the smallest, indicating that its impact on emotional fluctuations was relatively weak;
- The research results reveal that different sample sites in the mountain–water forest have different effects on the participants' emotional fluctuations. F9 may have a more significant impact on the participants' emotions due to its unique environmental characteristics. In contrast, F1, F2, F3, F4, and F8 have a moderate and similar level of influence on the participants' emotions. F5 showed the least impact on emotional fluctuations, which may be related to the specific environmental design or atmosphere of the sample site;

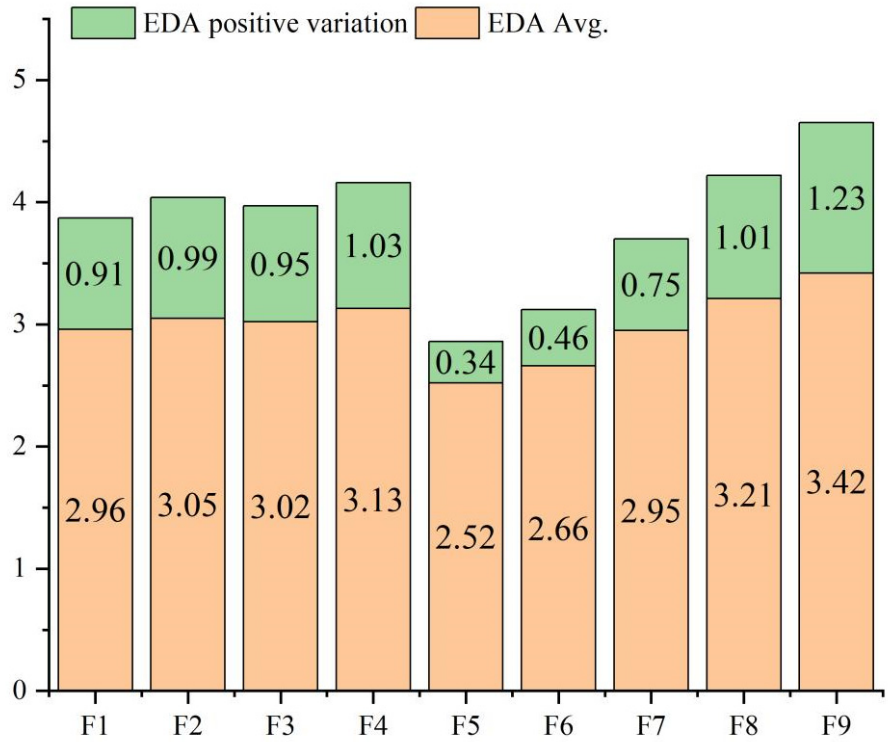


Figure 16. Average value and change value of EDA in mountain–water forest.

- According to the data shown in Figure 17, among the seven sample sites in the waterfront forest, the participants' EDA generally showed negative changes, indicating that emotional fluctuations were effectively relieved. Among these sample sites, the EDA negative change in X7 was the most significant, followed by X3, while the negative change in X4 was the smallest, indicating that its contribution to emotional relief was relatively weak;
- The research results show that different sample sites in the waterfront forest generally have the effect of mitigating the emotional fluctuations of the participants. In particular, X7 performed the best in reducing emotional fluctuations. X2, X3, X5, and X6 have similar effects on soothing emotions, with changes of about 0.15. In contrast, X4 has a relatively weak effect on soothing emotions.

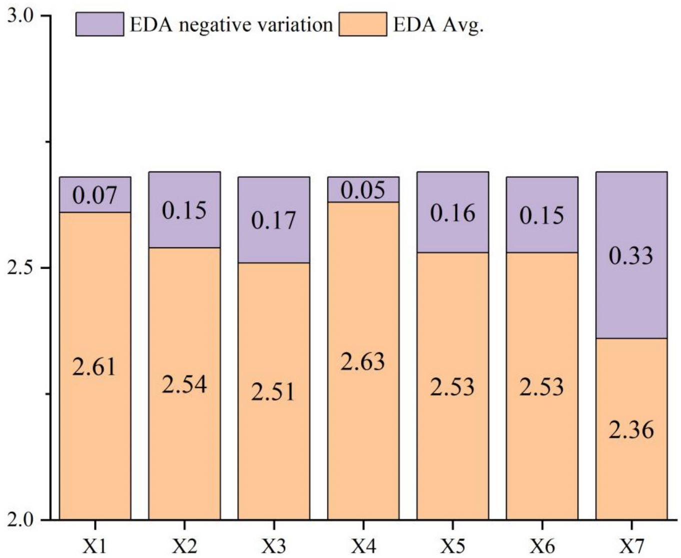


Figure 17. Average value and change value of EDA in waterfront forest.

3.3. The Combined Effect of Visual–Acoustic Stimuli on the Psychological Indices of the Public

3.3.1. Spiritual Vitality

- Figure 18 shows the results of a comparative analysis of the participants' mental energy levels in three different forest settings: a mountain forest, a mountain–water forest, and a waterfront forest. The analysis shows that the participants in the waterfront forest had the highest mental energy level, followed by the mountain–water forest, while the mental energy level of the mountain forest was relatively low. However, through statistical tests, it was found that the differences between the three were not statistically significant (p = 0.193), indicating that the three forests were similar in their ability to improve the participants' mental energy;
- The waterfront forest scored the highest in terms of mental energy level, which may be attributed to its beautiful natural environment and rich cultural atmosphere, which may have had a positive psychological impact on the participants. In comparison, Jinniushan Sports Park featured a suspended walkway, which may have had a certain impact on the participants' sense of psychological security and, in turn, had a certain negative impact on their mental energy;

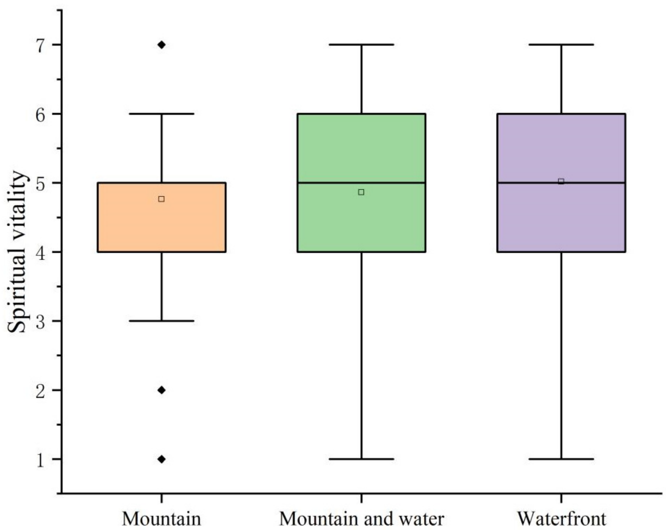


Figure 18. Comparative analysis of spiritual vitality in forests. Note: ◆ mild outlier.

- Figure 19 shows the mental energy of each sample site in the three forests. For the mountain forest, the mental energy score of S1 was relatively low, which may be related to the area's hard ground and urban characteristics. These factors may diminish the comfort of the natural environment, thereby adversely affecting people's mental energy. In contrast, S5 received the highest score, suggesting that its rich landscape types and clean site environment may be more conducive to improving the participants' mental energy;
- In the mountain–water forest, F7 received the highest mental energy score, which suggests that natural landscapes with historical and cultural value may have a significant positive effect on people's mental energy. At the same time, F1 received the lowest score, which may be related to disturbing factors, such as noisy crowds and traffic, which may have a negative impact on the participants' mental energy. Additionally, the higher scores of F9 and other forest recreation areas such as F2 and F4 indicate that a quiet natural environment and beautiful scenery have a positive effect on mental energy;
- In the waterfront forest, X3 received the highest score, which may reflect the importance of a well-designed landscape in enhancing mental energy. The relatively low scores of X1 and X6 may be related to their geographic location and surrounding environment, suggesting that these areas may need further improvement and optimization to enhance people's mental energy.

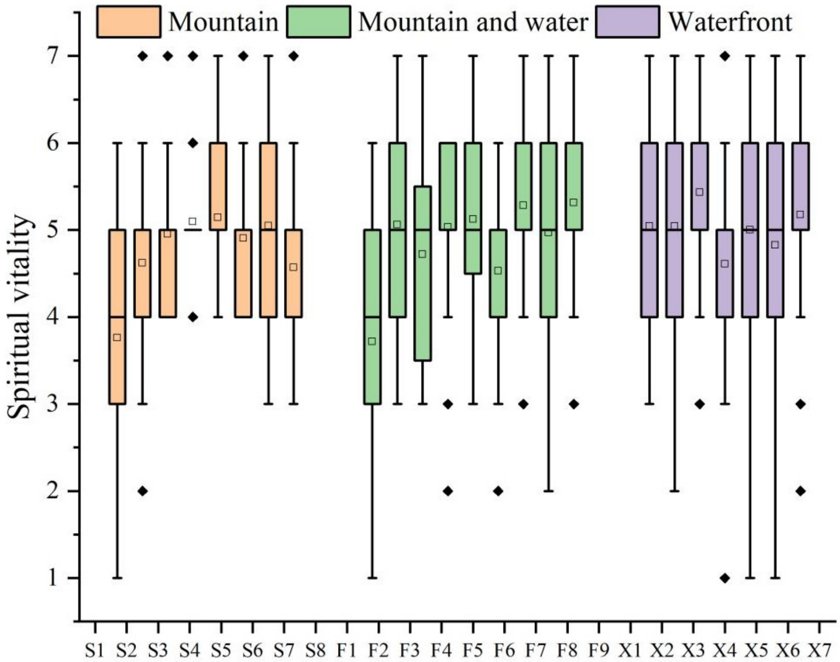


Figure 19. Comparative analysis of spiritual vitality in sample sites. Note: ◆ mild outlier.

3.3.2. Stress Relief

- Figure 20 provides the results of a comparative analysis of a mountain forest, mountain–water forest, and waterfront forest in terms of stress relief. The analysis shows that the waterfront forest has the highest score in terms of stress relief, followed by the mountain–water forest, while the mountain forest ranks third. However, through statistical tests ($p = 0.413$), we found that the differences in stress relief effects among the three forests were not statistically significant, indicating that they all have certain effects in mitigating visitor stress. It is worth noting that the stress relief scores of the three forests are all close to 5 points, which indicates that these forests all play a positive role in providing a relaxing and de-stressing environment for visitors;

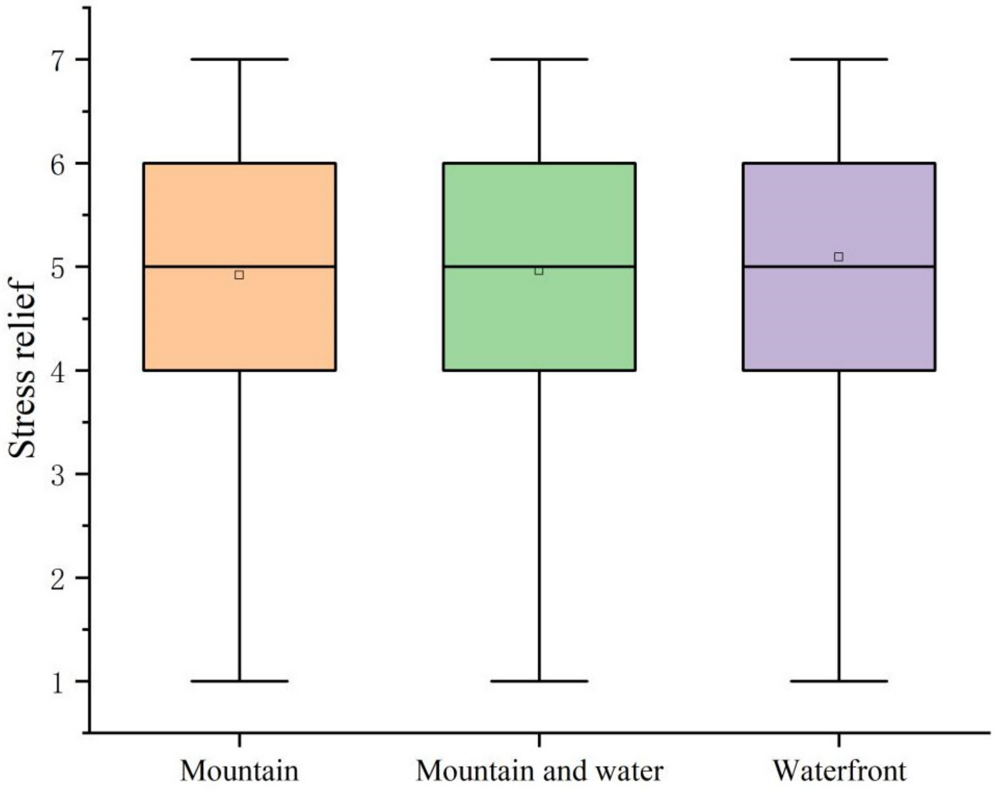


Figure 20. Comparative analysis of stress relief in forests.

- In the comparative analysis of the stress relief effects of sample sites in mountain, mountain–water, and waterfront forests, as shown in Figure 21, we observed significant differences between sites;
- For the mountain forest, S5 showed significant advantages in providing stress relief compared to other sites. This result may be attributed to the relatively natural and quiet environmental characteristics of S5, which helps promote psychological relaxation for visitors. In contrast, as a heavily trafficked entrance area, S1 had a relatively weak stress relief effect. The stress-relieving effects of other sites in the forest showed no significant differences, indicating that the forest may have met the relaxation needs of visitors in a relatively balanced manner in its overall design;
- In the mountain–water forest, F7 received the highest score for stress relief due to its unique natural landscape and historically significant ancient trees. This suggests that landscapes with ecological and cultural value may have a stronger appeal to visitors, thus enhancing their connection to and immersion in the natural environment. F1, also as an entrance area, may be negatively affected by traffic and noise, resulting in its poor stress relief effect. In contrast, forest plots, such as F9 and F4, despite providing a relatively quiet environment, did not show significant differences in stress relief effects;
- The analysis of the waterfront forest shows that X3 is slightly superior due to its exquisite landscape design, which may provide visitors with a visual feast and psychological relaxation. The stress relief effect of X7 is significantly better than that of plot X4, which may be related to the natural sounds and tranquil environment it provides, which together promote the psychological restoration of visitors. Although waterfront plots, such as X5 and X6, provide water-related landscapes, their stress-relieving effects did not show significant differences.

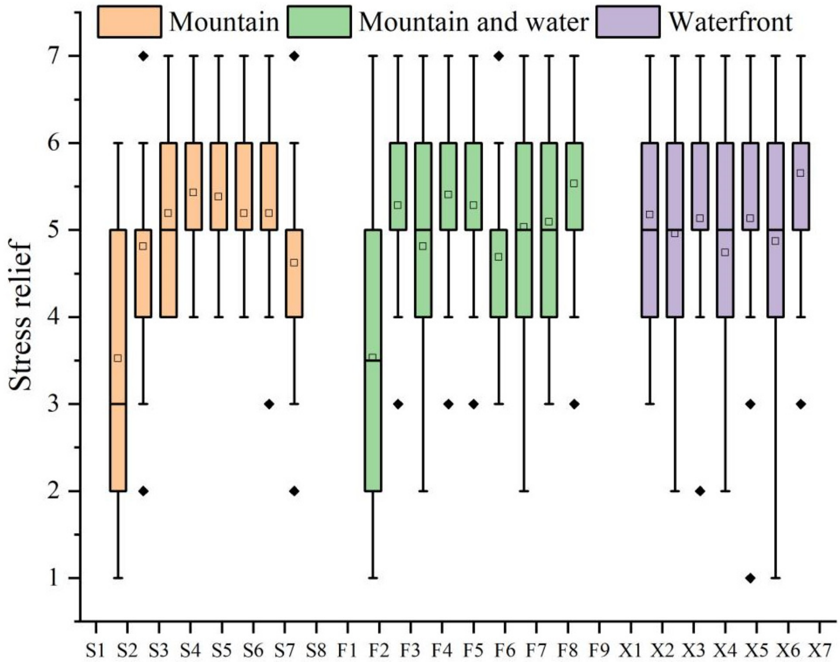


Figure 21. Comparative analysis of stress relief in sample sites. Note: ◆ mild outlier.

3.3.3. Emotional Arousal

- When comparing the emotional calming effects of mountain, mountain–water, and waterfront forests, we refer to the data in Figure 22. The analysis results show that the waterfront forest has the highest score in terms of emotional calming, followed by the mountain forest, and the mountain–water forest ranks third. However, through statistical tests (p = 0.368), we found that there is no significant difference in the emotional calming effects of the three forests. It is worth noting that the emotional calming scores of the three forests are all close to 5 points, which indicates that these forests can effectively promote emotional stability and arousal to some extent.

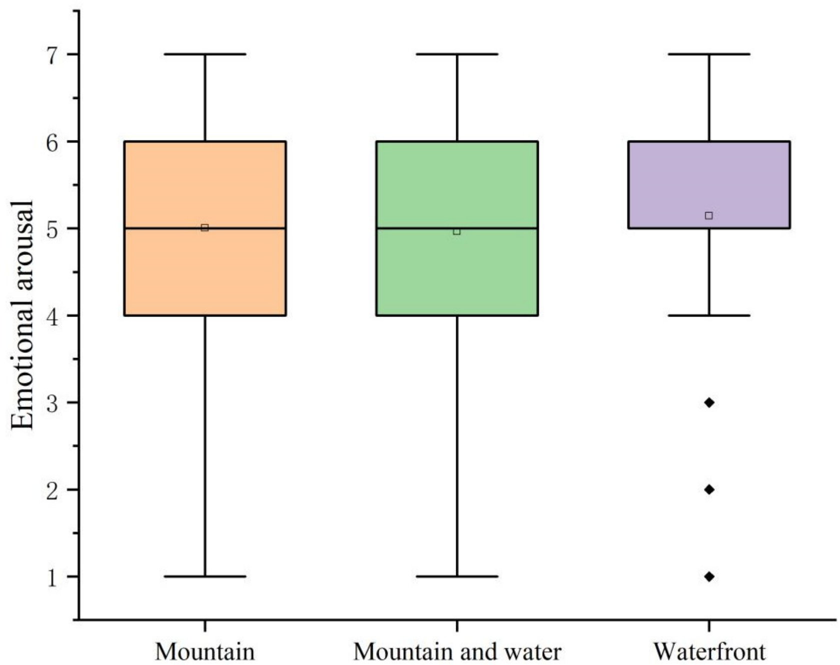


Figure 22. Comparative analysis of emotional arousal in forests. Note: ◆ mild outlier.

- As Figure 23 shows, among the sample sites in the mountain forest, S5 showed a better emotional calming effect compared to other sites, which may be related to the quiet environment it provides. In contrast, S1, being close to a major urban traffic road, may have a negative impact on emotional calming due to the noisy sound environment. In addition, there was no significant difference in the emotional calming effect between S4 and S3, while S6 was slightly better than S7, S2, and S8 in emotional calming, which may be related to the specific environmental characteristics of S6;
- The analysis of the sample sites in the mountain–water forest shows that the emotional calming effect of F7 is the most significant, while the emotional calming effect of F1 is relatively low due to the heavy traffic flow as an entrance area. F4 and F9 have similar effects in emotional calming and are both better than F2, but this difference is not statistically significant. Among the waterfront sample sites, the emotional calming effect of F5 is significantly better than F8 and F6, which may be related to the resting space and landscape quality provided by F5;
- Among the sample sites in the waterfront forest, X3 and X7 perform better in emotional calming, which may be due to their peaceful environment and beautiful natural scenery, which provide visitors with a space conducive to emotional recovery. In comparison, the emotional calming effect of X4 is relatively weak due to the large flow of people and the noisy environment. The waterfront plots X5, X1, and X6 are similar in emotional calming effects, with no significant difference, indicating that these plots may have common benefits in promoting emotional stability;
- Overall, the sample sites in the three forests have a certain effect in emotional calming, but the specific degree of effect may vary depending on the environmental characteristics of the site.

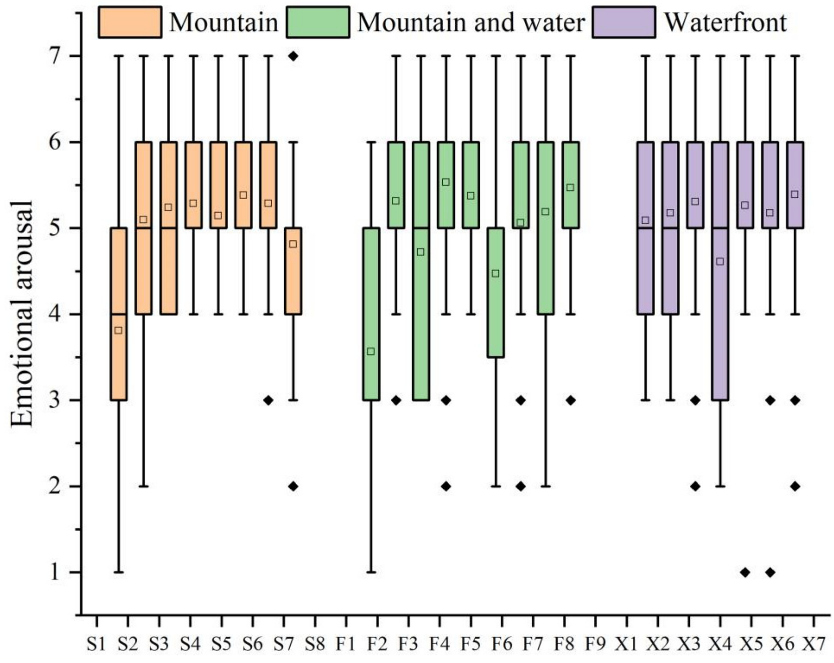


Figure 23. Comparative analysis of emotional arousal in sample sites. Note: ◆ mild outlier.

3.3.4. Attention Recovery

- In comparing the attention restoration effects of sample sites in mountain, mountain–water, and waterfront forests, we refer to the data in Figure 24. The analysis results show that the waterfront forest has the highest score in terms of attention restoration, followed by the mountain–water forest, and the mountain forest ranks third. Despite this, the differences in attention restoration effects among the three forests did not reach statistical significance (p = 0.102);

- It is worth noting that the attention restoration scores of the three forests are all concentrated around 5 points, which suggests that these forests can all promote the attention restoration of visitors to a certain extent. The waterfront forest received the highest score, which may be related to its beautiful natural landscape and rich cultural environment. The comprehensive and functional landscape planning of the waterfront forest may have had a certain positive impact on the attention restoration of visitors;

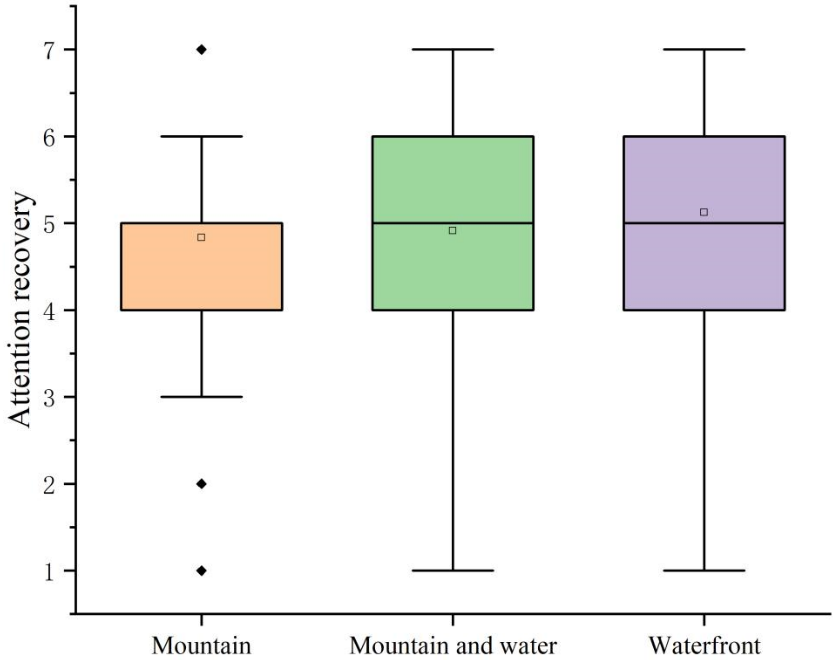


Figure 24. Comparative analysis of attention recovery in forests. Note: ◆ mild outlier.

- As Figure 25 shows, in the mountain forest, there were significant differences in the attention restoration effects among the sample sites, with some sites, such as S5, providing significantly better restoration effects than others. This may be related to the environmental characteristics of S5, such as its higher canopy cover and natural atmosphere, which may be more conducive to the attention restoration of visitors. In contrast, areas with more noise, such as S1, have a lower effect on attention restoration;
- The sample sites in the mountain–water forest also showed different attention restoration effects, with F7 performing the best. This could be because F7 has a unique natural landscape, providing visitors with a more immersive environment, thus facilitating attention restoration. On the other hand, F1, as an entrance area, may require visitors to disperse more attention to the surrounding environment due to the heavy traffic flow, resulting in its restoration effect being lower than that of other sample sites;
- The analysis of sample sites in the waterfront forest shows that while the attention restoration effects of all sample sites are not much different overall, the score of X7 is significantly higher than that of X4. The natural environment of X7 is beautiful, and its rich natural sounds and the combined effect of the landscape may have had a positive impact on the attention restoration of visitors. On the other hand, X4, as a main traffic route in the forest, may have been affected by its high traffic flow and noise level, affecting the attention restoration of visitors;
- In summary, the sample sites in the three forests show different effects in promoting the attention restoration of visitors, and these differences may be related to factors such as the natural characteristics of the site, canopy cover, noise levels, and pedestrian density.

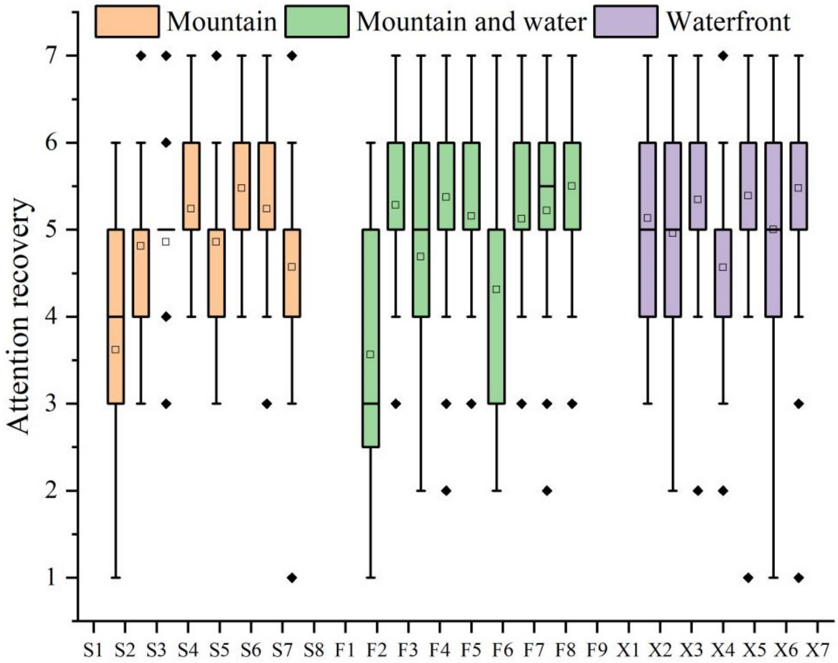


Figure 25. Comparative analysis of attention recovery in sample sites. Note: ◆ mild outlier.

3.4. Regression Analysis between Sensory Elements and the Public's Physiological and Psychological Responses

According to the standardized regression coefficient results presented in Table 10, we can summarize some meaningful findings. Firstly, the impact of the acoustic environment on physiological and psychological indicators exhibits a complex pattern. Certain sounds, such as children's laughter, airplane noise, and the sound of mowing, can increase the body's level of physiological arousal and elevate the skin conductance response value, and this could be because these sounds are perceived as stressors or unpleasant. In contrast, other sounds, such as footsteps and sweeping, may have the opposite effect, reducing the state of physiological activation, and this could be because these sounds are perceived as innocuous or pleasant. Notably, there is a correlation between broadcast sounds and heart rate (HR), potentially increasing an individual's stress level, as they are often associated with uncertain or important information. In comparison, the sound of water is not only associated with a lower LF/HF ratio but may also lead to positive psychological experiences, such as enhancing mental vitality, alleviating stress, and restoring attention, as water is often perceived as calming and restorative.

Secondly, the characteristics of vegetation in the visual environment have a significant impact on psychological experiences. The diversity of plant layers is significantly positively correlated with positive psychological experiences, such as enhanced mental vitality, stress relief, emotional calming, and attention restoration, and this could be because vegetation diversity provides a more complex and engaging environment, which can promote exploration and cognitive functioning. This result supports a wealth of prior research on the role of visual exposure to vegetation in promoting individual psychological health [29]. However, the richness of plant color is significantly negatively correlated with positive psychological experiences, such as stress relief, emotional calming, and attention restoration; this could be because too much plant color richness can be overwhelming or distracting. Another noteworthy finding is that the higher the level of scene clutter, the worse an individual's ability to relieve stress, calm emotions, and restore attention, and this could be because scene clutter can be overwhelming or difficult to process.

Table 10. Standardized regression coefficients between different audio–visual environmental indicators and physiological–psychological indicators.

	EDA	HR	LF/HF	Spiritual Vitality	Stress Relief	Emotional Arousal	Attention Recovery
Conversation	-	-	-	-	-	-	-
Children's laughter	0.09 *	-	-	-	-	-	-
Footsteps	−0.154 **	-	−0.448 *	-	−0.064 *	−0.063 *	−0.062 *
Traffic	-	-	-	-	-	-	-
Aircraft	0.201 *	-	-	−0.092 *	-	-	-
Construction	-	-	-	-	-	-	-
Lawn mower	0.182 **	-	-	-	-	-	-
Sweeping	−0.164 *	-	-	-	-	-	-
Public announcements	-	−0.449 *	-	-	-	-	-
Music	-	-	-	-	-	-	-
Wind	-	-	-	-	-	-	-
Wind blowing the leaves	-	-	-	-	-	-	-
water	-	-	−0.359 *	0.084 **	0.08 **	0.077 **	0.071 **
Bird call	-	-	-	-	-	-	-
Insect call	-	-	-	-	-	-	-
Plant proportion	-	0.17 **	-	-	-	-	-
Plant color	-	-	-	-	−0.504 **	−0.465 **	−0.454 **
Plant layers	-	-	-	0.245 *	0.361 **	0.275 *	0.261 *
Skyward proportion	-	−0.807 *	-	-	-	-	-
Ground proportion	-	−0.769 *	-	-	-	-	-
Enclosure	-	−0.922 **	-	-	-	-	-
Structure proportion	×	×	×	×	×	×	×
Pavement presence	-	-	3.224 *	−0.455 **	−0.506 **	−0.565 **	−0.581 **
Scene complexity	-	3.132 **	-	-	−0.271 *	−0.293 *	−0.264 *
Water proportion	-	−0.775 *	-	0.09 *	0.111 *	0.128 **	0.13 **
Water presence	-	-	-	-	-	-	-

Note: * and ** denote $p < 0.05$ and $p < 0.01$, respectively. - indicates that the audio–visual environment had no significant relationship with physiological–psychological indicators. × indicates that the metrics were not considered in the final model.

Lastly, the openness of the environment and the characteristics of water bodies are also important factors affecting an individual's physiological and psychological responses. For instance, a higher degree of environmental enclosure, larger sky-to-ground ratios, and other factors may trigger higher levels of physiological stress, as they can restrict an individual's field of view and freedom of movement. While the presence of pavements, the proportion of water areas, and so on, are significantly associated with the LF/HF ratio and psychological experience indicators, such as attention restoration, this could be because these factors influence an individual's spatial experience and connection with nature, thereby affecting their physiological and psychological states. These findings provide valuable insights for future environmental design optimization to improve human health conditions.

4. Discussion

4.1. The Combined Effect of Visual–Acoustic Environment on the Public's Physiology and Psychology

The results of this study support the Stress Recovery Theory (SRT) [30] and Attention Restoration Theory (ART) [31] in environmental psychology, both of which emphasize the significant role of natural environments in restoring mental health and improving attention. Through quantitative analysis, we found that urban forests, especially waterfront forests, have a significant effect on reducing stress levels and improving mood, which is consistent with the findings of Qiu's team (2021) [32]. They pointed out that natural environments can serve as a "psychological refuge", helping individuals recover from cognitive fatigue.

A further literature review reveals the potential health impacts of different types of urban forests (such as mountain forests, waterfront forests, etc.) in various regions around the world. These studies typically report positive psychological and physiological health benefits [33–38]. For example, a study by Hartig et al. (1991) [39] showed that regular contact with forests and other natural environments can significantly reduce stress and overall symptoms of poor health. This further confirms our findings that the visual and auditory elements of natural environments are significantly related to improving the physiological and mental health of the public. In line with our findings, mountain forests, characterized by their unique topography and vegetation, may offer enhanced psychological restoration benefits. These forests are often characterized by tranquility and remoteness from urban noise and disturbances, thereby facilitating greater stress reduction for visitors. In contrast, waterfront forests are particularly significant for psychological restoration due to their open vistas and the natural sounds of water bodies. Water bodies not only provide cooling environmental benefits but also enhance the aesthetic value and diversity of the surroundings. Additionally, the sounds of water can act as a natural white noise, masking urban noise pollution, while the visual effects of water reflections and light patterns provide additional relaxation. Hence, waterfront forests can offer even more profound stress reduction and psychological restoration experiences.

Furthermore, the impact of disturbances cannot be overlooked. Studies have shown that the restorative benefits of forests can be compromised by anthropogenic disturbances such as high visitor traffic and noise pollution. Therefore, it is crucial to consider the minimization of such disturbances in the design of forest entrances and along major walking trails. For example, buffer zones can be established to reduce the intrusion of external noise, or trail designs can be adjusted to avoid direct entry from noisy urban areas into the serene forest environment.

In terms of methodology, this study employed multiple regression analysis to quantitatively assess how different types of urban forests impact mental health indicators, ensuring the rigor of the analysis [40]. However, we also recognize certain limitations of this study, such as the limitation of sample size and the seasonal impact of data collection, which may affect the universal applicability of the results.

Based on these findings, we recommend that urban planners and landscape architects prioritize increasing vegetation coverage and water bodies while minimizing noise pollution when designing urban green spaces. This will not only provide a tranquil resting environment but also promote the psychological recovery and physiological health of residents.

4.2. Shortcomings and Prospects

This study also has some limitations. First, the sample size is mainly concentrated in three forests in Fuzhou, which may not fully represent other regions or types of urban forests. Second, the study mainly focuses on the physiological and psychological responses in the short term, and future research could explore the effects of long-term exposure to these environments. Finally, the study mainly relies on self-report questionnaires, which may be subject to subjectivity, and these findings could be verified by more extensive survey methods in the future.

Future research could explore the responses of groups with different cultural backgrounds, ages, and genders to the audiovisual environment of urban forests and how to meet the needs of different groups through design. In addition, other aspects of urban forests, such as community engagement, educational programs, and recreational activities, could be studied, and how they interact with the park's audiovisual environment to jointly promote the health and well-being of the public. Through these studies, we can better understand the complex role of urban forests and provide guidance for creating healthier and more sustainable urban environments.

5. Conclusions

This study was conducted in three different types of urban forests in Fuzhou City, systematically assessing the impact of the visual–acoustic environment of urban forests on the physiological and psychological well-being of the public and making a significant contribution to the scientific research and practical application of urban forests. Our findings clearly indicate that natural elements in urban forests have a markedly positive effect on enhancing residents' mental health and physiological relaxation. This discovery is of great importance for guiding the design and management of urban forests.

Our research emphasizes the need to prioritize the integration of natural elements in urban forest planning, such as vegetation, water bodies, and natural soundscapes, to promote psychological recovery and stress relief for residents. Furthermore, our study provides a basis for the classified management of urban forests, revealing the differences in providing psychological and physiological benefits among various types of urban forests. This helps decision-makers and planners to develop more precise management strategies based on the specific characteristics of the forests.

Through this study, we provide empirical support for the potential benefits of urban forests to public health, which is significant for promoting the role of urban forests in enhancing the quality of urban life. Future research can further explore the differentiated impacts of urban forests on different population groups and how innovative urban forest designs can meet a broader range of social needs. Our work provides a scientific foundation and practical guidance for achieving a greener, healthier, and more sustainable urban living environment.

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