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The influence of academic background on the visual perception of heritage rural landscapes: an eye-tracking study of Tianluokeng Village

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ABSTRACT With growing emphasis on heritage conservation and rural tourism, heritage villages have become important resources for cultural landscape presentation. At the same time, antenna-enabled augmented reality, wireless guide systems, and electromagnetic spatial-interaction technologies require empirical understanding of how different audiences visually perceive heritage environments. This study takes Tianluokeng Village in Fujian, China, as a case study and combines eye-tracking experiments with semi-structured interviews to compare landscape-trained students and non-trained students in terms of visual attention distribution, visual behavior, and cognitive expression. Five categories of landscape photographs were selected as experimental stimuli: architectural landscape, agricultural landscape, natural landscape, folk cultural landscape, and tourism service landscape. The results show that the landscape-trained group exhibited more concentrated visual hotspots on core compositional elements, whereas the non-trained group displayed more dispersed scanning patterns. Significant differences were found in total duration of fixations, number of fixations, and number of visits. The non-trained group showed higher fixation engagement and revisit frequency, while the landscape-trained group demonstrated more efficient information acquisition. In cognitive expression, landscape-trained participants emphasized spatial structure and element relationships, whereas non-trained participants relied more on overall impressions. The findings provide empirical support for heritage conservation, tourism management, and the design of electromagnetic spatial sensing and interactive display systems for diverse audiences.

INDEX TERMS heritage village landscape, eye-tracking, visual perception, antenna-enabled interaction, electromagnetic spatial sensing

I. INTRODUCTION

AGAINST the backdrop of ongoing cultural heritage conservation and the sustainable development of rural tourism, heritage village landscapes have gradually become important carriers linking traditional agricultural civilization, local cultural memory, and contemporary rural tourism practices [1,2]. Compared with ordinary villages, heritage villages often embody richer historical legacies and cultural meanings, making them more distinctive and attractive within rural tourism systems [3]. In recent years, supported by designation systems such as cultural heritage and traditional village recognition, heritage village tourism has continued to gain momentum. In this context, modes of landscape presentation and the quality of visitor services have increasingly shaped tourists' overall perceptions of heritage value and destination image [4].

In heritage village tourism, visitors' understanding and evaluation of a destination often begin with visual perception [5]. The composition of landscape elements, together with the interaction between natural and human-made components, shapes visitors' immediate impressions of heritage villages. However, in many cases of tourism development and landscape planning, heritage villages still rely on relatively homogeneous forms of landscape presentation, with limited attention to differences in visitors' cognitive abilities and knowledge backgrounds. This tendency has led to the homogenization of landscape experiences [6–8]. To some extent, such homogenization weakens the regional distinctiveness and recognizability of heritage village landscapes and may also hinder the sustainable development of rural tourism. Therefore, incorporating the perspectives of diverse visitor groups into rural planning is of great importance for promoting the sustainable development of heritage village tourism.

In recent years, university students have gradually become an important group in rural tourism [9,10], showing distinct characteristics in travel motivation and experiential needs [11,12]. This group generally has a relatively high level of education and strong capacity for information acquisition. For them, heritage village tourism is not only a form of leisure and recreation but also an important setting for acquiring heritage-related knowledge. At the same time, as their aesthetic awareness and value cognition continue to develop, their perceptions of heritage village landscapes are relatively representative among young tourists and therefore worthy of scholarly attention.

Moreover, existing research suggests that academic background influences individuals' visual attention strategies and preferences [13,14]. For university students from different academic backgrounds, whether they observe and interpret heritage village landscapes in different ways remains insufficiently explored. Accordingly, this study focuses on university students and examines how academic background affects the perception of heritage village landscapes by comparing differences in visual perception among students from different disciplines. The findings are expected to enrich research on visual perception in heritage villages and provide targeted practical implications for the presentation and planning of heritage landscapes for younger audiences.

II. LITERATURE REVIEW

A. STUDIES ON RURAL LANDSCAPE PERCEPTION

Studies on rural landscape perception generally focus on the relationship between people and the environment, particularly on how individuals identify rural landscape elements and make value judgments. The research perspective has gradually expanded from an emphasis on visual preference [15] and landscape quality assessment [16] to broader concerns related to planning, management, and practical applications [17,18], with findings increasingly used to inform rural landscape optimization and improve tourism experiences. In terms of research methods, questionnaires [19] and photographbased preference evaluations [20] are commonly used to identify relationships between landscape attributes and preferences through statistical analysis. Building on this foundation, some scholars have further employed multivariate statistical methods, such as structural equation modeling, to assess rural visual quality and examine how landscape elements influence visitor satisfaction and experiential evaluations [21–23]. Although research methods have become increasingly diverse, such studies still rely primarily on subjective evaluation data, focusing mainly on attitudinal outcomes while providing relatively limited objective measurement of the perceptual process.

B. APPLICATION OF EYE-TRACKING TECHNOLOGY IN LANDSCAPE STUDIES

Compared with traditional approaches such as field surveys and questionnaire interviews, eyetracking technology can record the viewing process with less reliance on verbal analysis. It provides objective data and broadens the analytical scope of landscape perception research. Existing eyetracking studies on landscapes have primarily focused on urban and natural settings, including urban parks [24–26], historic districts [27–29], and forest landscapes [30–32], while rural landscapes have received relatively limited attention. The limited number of studies addressing rural contexts has mainly examined the visual assessment of rural landscapes [33], preferences for public spaces [34], and overall visual experience [35]. Some of these studies have also compared differences in landscape cognition among different social groups, such as residents and tourists [36,37]. However, within the same social group, perceptual differences associated with knowledge background or professional experience have received relatively limited attention.

C. STUDIES ON ACADEMIC BACKGROUND DIFFERENCES AND VISUAL PERCEPTION

In the field of eye-movement research, differences between experts and novices have been examined across multiple domains [38,39]. Studies on landscape and environmental perception indicate that professional training influences individuals' sensitivity to the structural complexity and spatial relationships of landscapes [40], and may lead to broader visual scanning patterns [41,42]. Moreover, individuals with different knowledge backgrounds exhibit differences in the distribution of fixation hotspots [43] and in restorative perception [44]. Knowledge background also affects the degree of attention paid to spatial order and cultural symbols [45], thereby shaping distinct modes of landscape understanding. However, existing research has primarily focused on natural landscapes or historical districts, while investigations into complex cultural landscapes such as heritage villages remain relatively limited.

Building on the above discussion, this study takes Tianluokeng Village as an empirical case of a heritage village and employs eye-tracking experiments together with semi-structured interviews to systematically compare differences in the visual perception of heritage village landscapes among university students with different academic backgrounds. The analysis is conducted from three dimensions: visual attention distribution, cognitive processing patterns, and patterns of perceptual expression, with the aim of exploring how professional knowledge background influences the perception of heritage village landscapes. In line with these objectives, the paper addresses the following three questions:

(1) At the spatial level, are there differences in the distribution of visual hotspots between the landscape-trained group and the non-trained group? Do their visual attention patterns reflect different spatial focusing modes and tendencies in element selection?

(2) At the behavioral level, do the two groups differ in key eye-tracking indicators? How do these differences reflect variations in fixation processing depth, visual scanning strategies, and information acquisition efficiency?

(3) At the level of cognitive expression, what differences do the two groups exhibit in their focus on landscape elements and evaluative perspectives? Does professional knowledge influence their interpretive approach to heritage village landscapes?

The findings are expected to provide empirical evidence and practical guidance for the conservation of heritage village landscapes, tourism management, and planning and design for diverse audiences.

III. MATERIALS AND METHODS

A. RESEARCH AREA

Tianluokeng Village is located in Shuyang Town, Nanjing County, Zhangzhou City, Fujian Province, China, at 24°35′ N and 117°04′E, with an elevation of approximately 787.8 m (Figure 1). The village is predominantly inhabited by Hakka people, and its settlement pattern centers on a cluster of Hakka tulou buildings. Constrained by the mountainous terrain, local traditional agriculture has long relied on terraced fields for grain production. Over time, this has given rise to a distinctive mountain village pattern in which tulou settlements are integrated with a terraced field system. In July 2008, the Tianluokeng tulou cluster was inscribed on the World Heritage List as an important component of "Fujian Tulou." Within the heritage conservation planning framework, the tulou complex has been designated as the core zone, while the surrounding terraced fields and forest landscapes are included in the buffer zone. Together, these elements form a cultural landscape system centered on architectural heritage and supported by agricultural and natural landscapes. As a result, the village has become an important representative of traditional vernacular architecture and cultural landscapes in China.

With the continued development of tourism, Tianluokeng Village has gradually transformed from a traditional agricultural settlement into a composite development model that emphasizes both cultural heritage preservation and rural tourism. Driven by tourism activities, visitors' attention has expanded beyond the architectural forms of the Hakka tulou to include diverse elements such as terraced fields and Hakka folk culture, resulting in a more integrated landscape experience. Overall, Tianluokeng Village brings together multiple landscape components, including architectural heritage, agricultural landscapes, and folk cultural landscapes, with clear spatial hierarchies and diverse landscape types. These composite landscape characteristics give the village considerable analytical value for visual perception research, making it suitable both as a case study and as a source of visual stimuli for eyetracking experiments.

B. SELECTION OF EXPERIMENTAL PHOTOGRAPHS

This study employed static photographs as visual stimuli in the eye-tracking experiment. Previous research has shown that static photographs have been widely used as experimental stimuli in studies of landscape perception and visual attention [46–48]. Under controlled experimental conditions, photograph-based eye-tracking experiments can reliably capture the distribution and patterns of viewers' visual attention, thereby providing methodological support for the analysis of environmental perception. In October 2025, the research team conducted field investigations and photographic documentation in Tianluokeng Village. To minimize the effects of lighting variation on the visual stimuli, three researchers carried out the photography between 10:00 and 17:00, when natural light was relatively stable. A total of 697 photographs were collected.

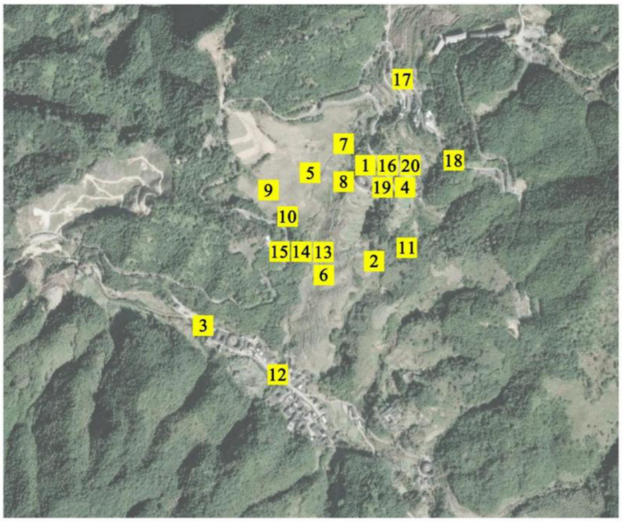
During the photograph screening stage, all photographs were preliminarily categorized according to the compositional elements and overall landscape characteristics of Tianluokeng Village. The village landscape was divided into five major types: architectural landscape, agricultural landscape, natural landscape, folk cultural landscape, and tourism service landscape. On this basis, each landscape type was further refined according to the specific features presented in the photographs. Each of the five major categories was subdivided into four representative subtypes to more accurately reflect the compositional differences among landscape elements.

Based on this classification framework, the selection of experimental stimulus photographs was carried out in two stages. In the first stage, three candidate photographs were preliminarily selected for each landscape subtype according to whether they clearly represented its typical characteristics. In the second stage, eight experts with more than ten years of research and practical experience in landscape architecture were invited to evaluate the candidate photographs for each subtype. The photograph receiving the highest number of votes in each subtype was selected, resulting in four representative photographs for each of the five major landscape categories. In total, twenty photographs were selected as the static visual stimuli for the formal eye-tracking experiment (Figure 2).

To reduce participants' anticipation and familiarity effects, two additional photographs were randomly selected and used as warm-up images. All experimental photographs were uniformly processed using Adobe Photoshop 2025 and adjusted to a resolution of 1600 × 900 pixels at 300 dpi to ensure consistency throughout the experimental presentation.

C. PARTICIPANTS

To examine how university students from different academic backgrounds perceive heritage village landscapes, this study recruited 49 undergraduate students from Fujian Jiangxia University. Recruitment was conducted among approximately 120 students enrolled in the landscape architecture program and a comparably sized pool of students majoring in finance, accounting, law, and other non-design disciplines. Among the participants, 25 majored in landscape architecture and 24 majored in other disciplines, forming the landscape-trained group and the non-trained group, respectively. To reduce potential confounding effects associated



1. Tulou
2. Ancestral Hall
3. Temple
4. Roads
5. Terraced Fields
6. Irrigation Channels
7. Rice Harvesting
8. Straw Burning
9. Mountain
10. Forest
11. Ancient Trees
12. Water
13. Buddhist Shrine
14. Incense Burner
15. Donation Stele
16. Lanterns
17. Guesthouse
18. Viewing Pavilion
19. Signage
20. Rest Platform

FIGURE 1. Study area and distribution of sampling points.

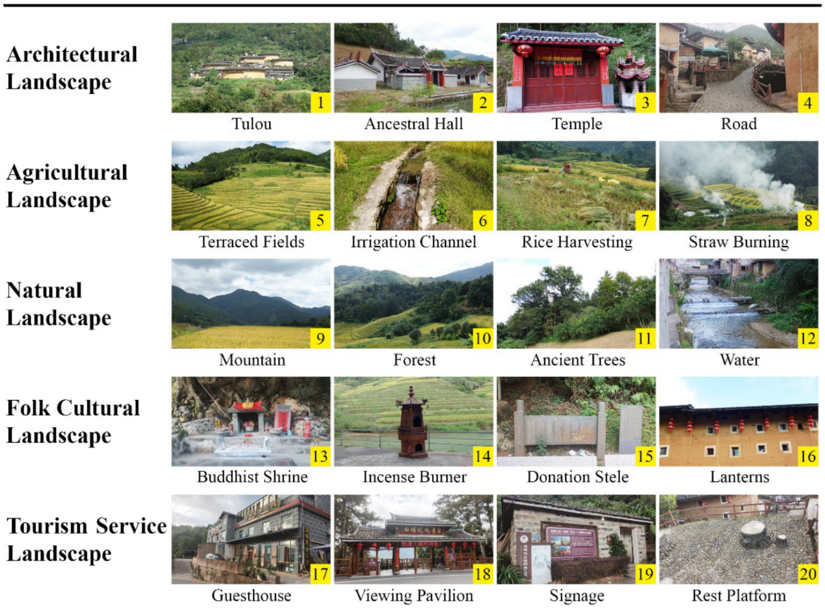


FIGURE 2. Photographs of the eye-tracking experiment.

with prior training, participants in the latter group were screened to ensure that they had not received formal education or training in art, aesthetics, or design. The male-to-female ratio was approximately 1:2 in both groups, indicating that their gender compositions were broadly comparable. Because female students constitute a relatively high proportion of both the university's undergraduate population and its landscape architecture program, the gender distribution of the sample generally reflects the demographic characteristics of the source population. A post-hoc analysis comparing male and female participants within each academic group did not identify statistically significant gender differences in the primary eye-tracking metrics ($p > 0.05$), suggesting that gender was unlikely to fully account for the observed between-group differences. Nevertheless, given the limited sample size and the relatively small number of male participants, possible gender-related effects cannot be excluded. Future studies should therefore recruit larger samples with a more balanced gender composition to further examine the respective effects of academic background and gender, as well as their potential interaction.

All participants met the following criteria: (1) normal uncorrected vision or mild myopia of less than 400 degrees, with no color blindness, color weakness, or other visual impairments; and (2) adequate verbal expression skills to clearly describe their perceptions of the experimental stimuli. This study was approved by the Ethics Committee of Fujian Jiangxia University, and was performed in accordance with the principles of the Declaration of Helsinki. Before the experiment, all participants were fully informed of the procedures and research content and signed informed consent forms.

D. EXPERIMENTAL PROCEDURES

This study employed a comprehensive research approach that combined an eye-tracking experiment with semi-structured interviews. Quantitative and qualitative analyses were used together to examine the perceptual characteristics of participants from different backgrounds toward the heritage village landscape. The experiment was conducted in a quiet and tidy studio with relatively stable lighting conditions to minimize external interference during data collection.

Eye-tracking data were collected using a Tobii Pro X3-120 screen-based eye tracker with a sampling rate of 120 Hz. The experimental photographs were presented on a Razer Blade Stealth 13 laptop with a 13.3-inch screen and a resolution of 1920 × 1080 (Figure 3). The procedure was as follows:

(1) The eye tracker was mounted below the display screen and its position was adjusted.

(2) Participants were introduced to the experimental procedure and key instructions and were asked to maintain a natural sitting posture, with their eyes approximately 65 cm from the screen.

(3) Participants' basic information, including name, gender, and group assignment, was recorded, followed by a standard nine-point calibration to ensure data accuracy.

(4) The formal experiment began with two test photographs to help participants become familiar with the procedure, after which twenty formal experimental photographs were presented in sequence. Each photograph was displayed for 10 s, with a 3 s black screen interval between photographs. The entire experiment lasted approximately 5 min.

After the eye-tracking experiment, semi-structured interviews were conducted with the participants. The entire interview process was recorded using a Sony ICD-UX523F voice recorder to obtain complete audio data. The interviews focused primarily on participants' viewing processes. The researchers presented the experimental photographs one by one and asked participants to recall their viewing experiences, describe the landscape areas and elements they focused on, explain the sequence in which they observed them, and clarify the reasons for their attention. These interviews were intended to address the limitations of eye-tracking data in explaining cognitive processes. By encouraging participants to review their viewing processes and express their personal impressions, the interviews helped reveal the focal points and attentional strategies underlying fixation behavior, thereby providing supplementary evidence for interpreting differences in fixation patterns and eye-tracking indicators. Each interview lasted approximately 20 min.

E. SELECTION OF EYE-TRACKING INDICATORS

To examine participants' visual attention during photograph viewing, this study selected eyetracking indicators from three dimensions: overall visual scanning, single-fixation processing, and spatial viewing patterns. Specifically, four indicators were analyzed: Total duration of whole fixations (TDF), Average duration of whole fixations (ADF), Number of whole fixations (NF), and Number of Visits (NV) (Table 1).

In the overall photograph analysis, TDF, ADF, and NF were statistically compared to assess the influence of academic background on overall visual attention intensity and processing characteristics. TDF and NF primarily reflect the level of visual engagement, whereas ADF indicates the depth of information processing during a single fixation. In the spatial-level analysis, the Area of Interest (AOI) method was introduced, and AOI segmentation of the experimental photographs was conducted using Tobii Pro Lab. The segmentation was based on a "main subject–surrounding environment" structure: landscape elements with the clearest visual expression and the greatest core significance were defined as the main subject area, while the remaining background or supporting landscape elements were classified as the surrounding environment area (Figure 4). By comparing NV values across different AOI regions, the study examined participants' viewing patterns across main and surrounding landscape elements and explored differences in visual selection strategies between the two groups. To avoid influencing participants' judgments, neither the AOI classification criteria nor the photograph names were shown to them.

F. DATA ANALYSIS

For the eye-tracking data, quality control was conducted after the experiment. Samples with an eye-tracking sampling rate below 70% were excluded, resulting in 40 valid participants, with 20 in the landscape-trained group and 20 in the non-trained group. After sample screening, the gender ratio in both groups remained approximately 1:2 (male: female), indicating no substantial change in the overall sample structure. The eye-tracking data were exported from Tobii Pro Lab, organized and preliminarily processed in Microsoft Excel 2021, and then statistically analyzed using SPSS 27.0. The Kolmogorov–Smirnov (K–S) test was used to assess the normality of each eye-tracking indicator. The results showed that some indicators did not meet the assumption of normal distribution. Given the relatively small sample size and to ensure consistency in the statistical analysis, the nonparametric Mann–Whitney U test was uniformly applied for between-group comparisons. This analysis examined differences in eyetracking indicators between the landscape-trained group and the non-trained group for both the full set

FIGURE 3. Experimental setup and environment.

TABLE 1. Definitions and explanations of eye-tracking indicators.

Metrics	Abbr.	Definition	Implication
Total duration of whole fixations (ms)	TDF	The total duration of the fixations inside this area of interest during an interval.	TDF reflects participants' overall attentional engagement with an image. A longer total fixation duration is generally associated with greater cognitive processing demands or a higher allocation of attentional resources [49].
Average duration of whole fixations (ms)	ADF	The average duration of the fixations inside this area of interest during an interval.	ADF reflects the amount of cognitive processing time invested during a single fixation. A longer average fixation duration is usually related to higher information-processing demands or more complex visual processing [50].
Number of whole fixations (count)	NF	The number of fixations occurring in this area of interest during an interval.	NF reflects the frequency of information sampling during viewing. A higher number of fixations usually indicates more frequent information acquisition [49].
Number of Visits (count)	NV	The number of Visits occurring in this area of interest during an interval.	NV reflects repeated entries into a specific area of interest (AOI) during visual search. A higher number of visits indicates that the area attracted repeated fixations during viewing, reflecting sustained attention allocation [51].

of photographs and the five categories of rural landscape photographs.

For the interview data, the research team first transcribed the interview recordings verbatim and merged synonyms in the transcripts to reduce the potential influence of semantic dispersion on the statistical results (Table S1). To maintain consistency, all subsequent analyses were conducted in the original Chinese linguistic context. KH Coder 3 was then used to perform word frequency analysis on the interview texts corresponding to each photograph. Developed by the Japanese scholar Koichi Higuchi, the software supports multilingual text analysis, including Chinese word segmentation, partof-speech tagging, and statistical analysis [52].

Regarding part-of-speech selection, participants' attention to rural landscapes was mainly reflected through nouns, whereas their subjective evaluations and attitudinal tendencies were more often expressed through adjectives. Therefore, the study first conducted statistical tests on both nouns and adjectives. The results showed that the overall frequency of adjectives in the interview texts for individual photographs was relatively low, with most appearing fewer than three times, making it difficult to establish stable statistical patterns. Accordingly, adjectives were excluded from the subsequent analysis, and only nouns were retained as the core analytical category for word frequency statistics. The total corpus consisted of 12,450 words for the landscape-trained group and 9,820 words for the non-trained group. To improve the stability of the results, only nouns with a frequency of five or more occurrences were included in the analysis. This threshold was determined based on a sensitivity analysis where lower cutoffs (e.g., 3 occurrences) introduced excessive idiosyncratic noise from individual participants, while higher cutoffs (e.g., 10) eliminated diagnostic technical terms such as 'eaves' or 'inscription'. This frequency filter ensures that the results reflect shared cognitive schemas rather than isolated personal observations, following established content analysis protocols. On this basis, differences in the composition of high-frequency

FIGURE 4. AOI division and description of photographs.

nouns in the interview texts of the landscapetrained group and the non-trained group were further compared to identify differences in their focal attention to landscape elements, thereby providing supplementary support for interpreting the eyetracking results.

Based on the analytical procedure described above, this study takes academic background as the core variable and examines how it influences participants' visual attention distribution, visual behavior characteristics, and cognitive expression. Figure 5 presents the overall analytical framework of the study.

IV. RESULTS

A. VISUAL HOTSPOT ANALYSIS

Analysis of the eye-tracking heat maps for the landscape-trained group and the non-trained group (Figure 6) showed that the two groups displayed different fixation distribution patterns when viewing the five categories of rural landscape photographs, as described below.

In the architectural landscape category, the visual hotspots of the landscape-trained group were mainly concentrated on key architectural elements, including facades, eaves, entrances, and spatial configurations. The high-intensity red and yellow areas were mostly located in the central part of the image or within the core of the building structure, extending along building interfaces and roads. This pattern indicates focused attention on the settlement's spatial structure and the architectural entity itself. In contrast, the hotspots of the non-trained group were more dispersed. In addition to the main buildings, their gaze tended to extend toward background elements such as surrounding vegetation, water, and the sky, suggesting a visual pattern that attended to the main subject while also scanning the broader environment.

In the agricultural landscape category, the visual hotspots of the landscape-trained group were similarly concentrated on key structural elements such as terraced fields and irrigation channels, forming a relatively continuous distribution across these core components. In contrast, the non-trained group showed a more dispersed pattern of attention. Beyond the agricultural subjects, their gaze was more easily drawn to the surrounding environment or locally salient areas. In particular, in strawburning scenes containing strong visual stimuli such as smoke, the hotspots of the non-trained group appeared as scattered points in the surrounding bright areas, indicating a more dispersed visual scanning pattern.

In the natural landscape category, the hotspots of the landscape-trained group were mainly distributed across the middle ground and the transitional zones between the foreground and middle ground, focusing on elements such as mountains, forests, and water, as well as their intersections. Their spatial distribution was relatively concentrated, reflecting an emphasis on key spatial subjects and the hierarchical relationships among landscape elements. In contrast, the visual hotspots of the non-trained group covered a broader range. In addition to focusing on natural elements in the foreground and middle ground, their attention more readily extended to distant areas such as the sky, remote mountains, and bridges, showing a more expansive overall visual scanning pattern.

In the folk cultural landscape category, both groups showed a high degree of similarity in the overall distribution

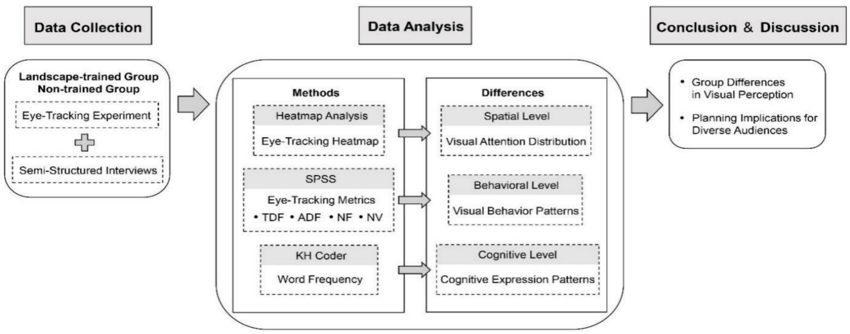


FIGURE 5. Research framework.

of visual hotspots, with concentrated attention on folk cultural facilities such as Buddhist shrines, incense burners, and donation steles. However, differences remained in their focal emphasis. The landscape-trained group tended to focus more on the core areas of these cultural elements, such as the center of the Buddhist shrine, the body of the incense burner, and the inscribed sections of the donation stele, with hotspots showing a clearer spatial concentration within the main subjects. Although the non-trained group also focused on the main subject, their attention more easily extended to the surrounding environment, resulting in a relatively broader overall hotspot coverage.

In the tourism service landscape category, the two groups showed generally similar overall hotspot distributions, with high-intensity red and yellow areas mainly concentrated on building bodies, plaques, and signage. However, despite this overall similarity, differences remained in the scope of visual attention. The landscape-trained group tended to focus on the core functional spaces of the facilities, such as the main body and front activity space of the guesthouse or the primary area of the rest platform. In contrast, the non-trained group was more likely to extend their attention to surrounding environmental elements, such as the forest around the guesthouse, trees near the viewing platform, and miscellaneous objects behind the rest platform, showing a scanning pattern that expanded from the facility itself toward the outer background.

B. ANALYSIS OF EYE-TRACKING INDICATORS

The comparison of overall eye-tracking indicators between the two groups across the five categories of rural landscapes showed that the landscape-trained group and the non-trained group differed significantly in their overall visual processing patterns (Table 2). Specifically, ADF did not reach statistical significance ($p > 0.05$), indicating that academic background had a relatively limited influence on individual fixation duration, that is, on the depth of immediate processing. In contrast, both TDF and NF showed significant differences ($p < 0.05$), suggesting that academic background was strongly associated with the overall level of visual engagement and scanning behavior. Among these indicators, the difference in NF was more pronounced ($p = 0.002$), indicating a clearer distinction between the two groups in fixation frequency. In terms of mean (M) values, the non-trained group showed higher averages than the landscape-trained group for all three indicators—TDF, ADF, and NF—suggesting that non-trained participants exhibited greater overall visual engagement and more frequent fixations when viewing rural landscape photographs.

A further comparison across the five categories of rural landscapes (Table 3) revealed significant between-group differences in TDF for all landscape types, indicating a consistent disparity in total fixation duration across different categories. The difference was most pronounced for tourism service landscape ($p = 0.006$). As shown in the overall trend (Figure 7), both groups exhibited the longest total fixation duration in the architectural landscape category, followed by a gradual decline, with the lowest level observed in tourism service landscape.

The between-group differences in ADF varied across landscape types. Significant differences in ADF were observed in the architectural landscape, agricultural landscape, and tourism service landscape, whereas no significant differences were found in the natural landscape or folk cultural landscape. This suggests that variation in single-fixation duration depended on landscape type rather than remaining consistent across all categories. As shown in Figure 8, both groups exhibited relatively longer average fixation durations in the agricultural landscape category and the shortest durations in tourism service landscape.

For NF, all five landscape types showed significant between-group differences ($p < 0.01$), suggesting stable differences in fixation frequency across landscape types. Among these categories, the difference was most pronounced in the architectural landscape ($p = 0.000$). As shown in Figure 9, both groups exhibited relatively high numbers of fixations in the architectural landscape category. The landscape-trained group recorded the lowest number of fixations in tourism service landscape, whereas the non-trained group recorded the lowest number in the agricultural landscape category.

At the AOI level, analysis of the NV indicator (Table 4) revealed significant differences between the two groups in their overall visual visitation behavior. The mean (M) values showed that, in both main and surrounding regions, the non-trained group had a higher number of visits than

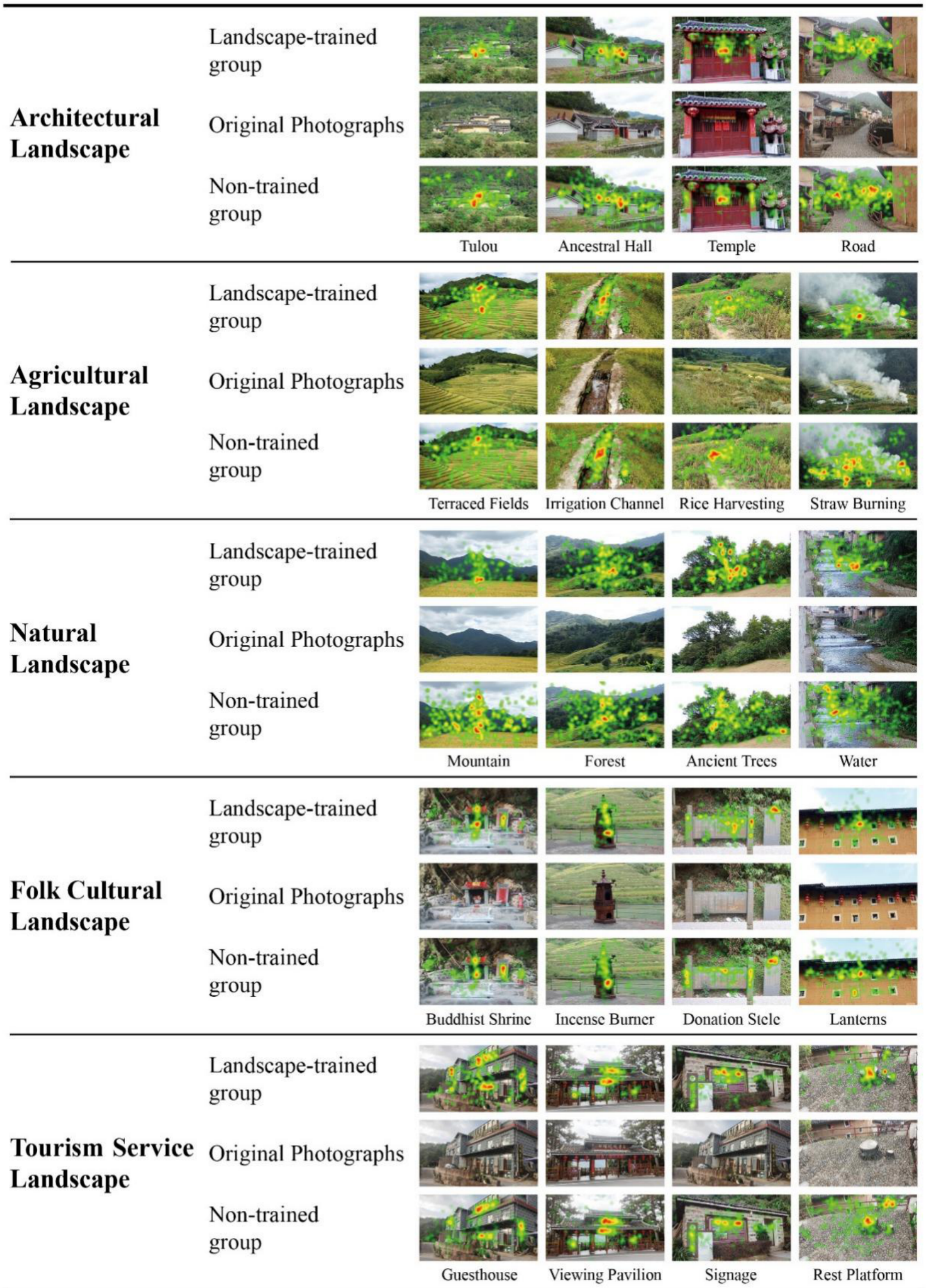


FIGURE 6. Eye-tracking heat maps of five categories of rural landscape photographs.

the landscape-trained group, suggesting that the former switched visual attention more frequently across different regions.

A further comparison across the five categories of rural landscapes (Table 5) showed that these differences were present in all landscape categories, although the levels of significance varied. Among them, the differences between the two groups were more pronounced in the agricultural landscape and tourism service landscape ($p < 0.001$), indicating that visual visitation behavior diverged more markedly in these two categories.

Further analysis by AOI type showed that, across the five categories of rural landscapes, the number of visits to the main AOI was generally higher than that to the surrounding

TABLE 2. Overall significance analysis of TDF, ADF, and NF.

Indices	Group	M	SD	Z	p	Effect Size (r)
TDF(ms)	Landscape-trained group	4158.335	2862.475	-2.407	0.016*	0.38
	Non-trained group	6473.380	1834.694			
ADF(ms)	Landscape-trained group	232.595	124.756	-1.812	0.070	0.29
	Non-trained group	277.115	89.798			
NF	Landscape-trained group	17.313	7.260	-3.152	0.002**	0.50
	Non-trained group	25.220	5.586			

*p<0.05, **p<0.01, ***p<0.001. Note: Effect size r is calculated as $Z/\sqrt{N}$, where r > 0.1 is small, > 0.3 is medium, and > 0.5 is large.

TABLE 3. Analysis of significant differences in TDF, ADF, and NF by landscape category.

Indices	Landscape Type	Group	M	SD	Z	p
TDF	Architectural Landscape	Landscape-trained group	4579.688	3072.222	-2.299	0.021*
		Non-trained group	7114.138	1691.832		
	Agricultural Landscape	Landscape-trained group	4477.600	2991.462	-2.191	0.028*
		Non-trained group	6786.350	1744.231		
	Natural Landscape	Landscape-trained group	4407.438	2802.473	-2.218	0.027*
		Non-trained group	6392.688	1900.924		
	Folk Cultural Landscape	Landscape-trained group	4149.388	2994.150	-2.083	0.037*
		Non-trained group	6296.488	1968.928		
	Tourism Service Landscape	Landscape-trained group	3177.563	2783.417	-2.732	0.006**
		Non-trained group	5777.238	2136.940		
ADF	Architectural Landscape	Landscape-trained group	227.450	111.977	-2.029	0.042*
		Non-trained group	272.538	73.473		
	Agricultural Landscape	Landscape-trained group	256.613	175.312	-2.245	0.025*
		Non-trained group	317.238	119.668		
	Natural Landscape	Landscape-trained group	252.075	175.399	-1.623	0.105
		Non-trained group	294.525	140.476		
	Folk Cultural Landscape	Landscape-trained group	234.625	137.464	-1.731	0.083
		Non-trained group	263.675	97.331		
	Tourism Service Landscape	Landscape-trained group	192.213	112.096	-2.137	0.033*
		Non-trained group	237.600	108.319		
NF	Architectural Landscape	Landscape-trained group	19.075	8.029	-3.518	0.000***
		Non-trained group	27.238	5.820		
	Agricultural Landscape	Landscape-trained group	17.463	6.880	-3.167	0.002**
		Non-trained group	24.100	4.714		
	Natural Landscape	Landscape-trained group	17.988	7.269	-2.652	0.008**
		Non-trained group	24.150	6.045		
	Folk Cultural Landscape	Landscape-trained group	16.963	8.245	-3.045	0.002**
		Non-trained group	25.025	6.526		
	Tourism Service Landscape	Landscape-trained group	15.075	9.445	-3.166	0.002**
		Non-trained group	25.588	7.612		

*p<0.05, **p<0.01, ***p<0.001.

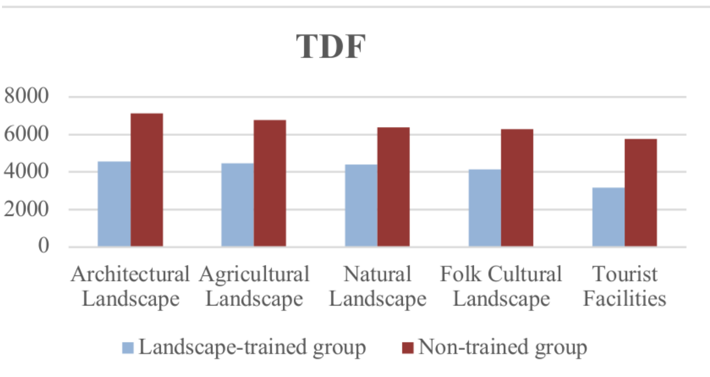


FIGURE 7. Mean distribution of TDF for the two groups of participants.

TABLE 4. Overall significance analysis of NV.

AOI	Group	NV M	SD	Z	p
AOI–Main Subject	Landscape-trained group	2.205	0.727	-3.320	0.001**
	Non-trained group	3.117	0.760		
AOI–Surrounding Environment	Landscape-trained group	1.358	0.514	-4.442	0.000***
	Non-trained group	2.268	0.469		

*p<0.05, **p<0.01, ***p<0.001.

AOI, suggesting that participants tended to focus their visual attention on core landscape elements. However, within the same AOI type, significant differences still existed between the landscape-trained group and the nontrained group. This

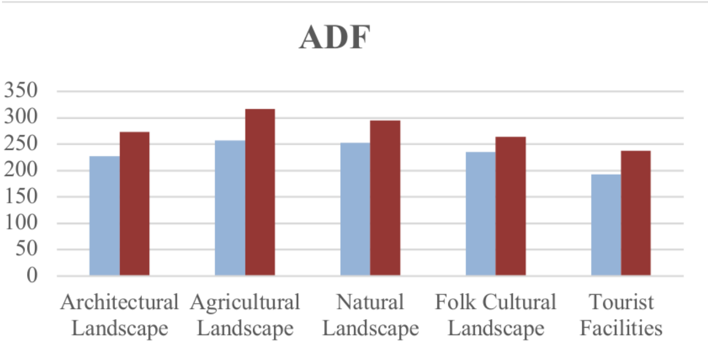


FIGURE 8. Mean distribution of ADF for the two groups of participants.

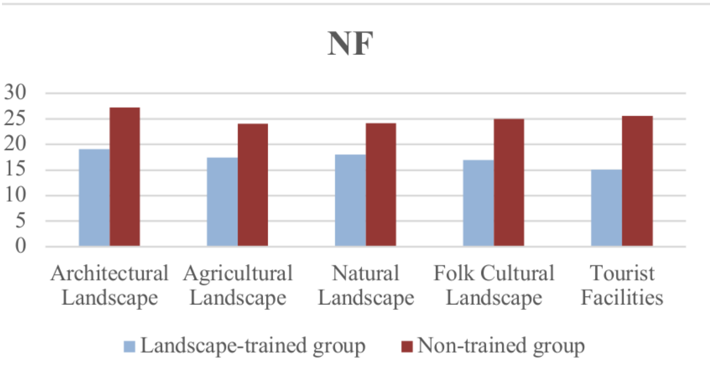


FIGURE 9. Mean distribution of NF for the two groups of participants.

TABLE 5. Analysis of significant differences in NV by landscape category.

Landscape Type	AOI	Group	NV M	SD	Z	p
Architectural Landscape	AOI–Main Subject	Landscape-trained group	2.025	0.903	-2.512	0.012*
		Non-trained group	2.713	0.922		
	AOI–Surrounding Environment	Landscape-trained group	1.300	0.812	-2.810	0.005**
		Non-trained group	2.030	0.691		
Agricultural Landscape	AOI–Main Subject	Landscape-trained group	2.563	0.866	-3.622	0.000***
		Non-trained group	3.863	1.047		
	AOI–Surrounding Environment	Landscape-trained group	1.620	0.810	-3.663	0.000***
		Non-trained group	2.770	0.785		
Natural Landscape	AOI–Main Subject	Landscape-trained group	2.750	1.156	-2.619	0.009**
		Non-trained group	3.788	1.148		
	AOI–Surrounding Environment	Landscape-trained group	1.508	0.714	-3.629	0.000***
		Non-trained group	2.525	0.722		
Folk Cultural Landscape	AOI–Main Subject	Landscape-trained group	2.190	0.855	-2.106	0.035*
		Non-trained group	2.890	1.071		
	AOI–Surrounding Environment	Landscape-trained group	1.720	0.712	-3.375	0.001**
		Non-trained group	2.710	0.914		
Tourism Service Landscape	AOI–Main Subject	Landscape-trained group	1.500	0.568	-3.704	0.000***
		Non-trained group	2.388	0.829		
	AOI–Surrounding Environment	Landscape-trained group	0.425	0.335	-3.883	0.000***
		Non-trained group	1.000	0.493		

*p<0.05, **p<0.01, ***p<0.001.

difference was more pronounced in the surrounding AOI, indicating a clearer divergence between the two groups in their visual revisits to background elements.

C. WORD FREQUENCY ANALYSIS

As shown in Tables 6 and 7, in the architectural landscape category, the descriptions provided by the landscape-trained group focused primarily on building types, structural details, and spatial organization. The frequent occurrence of words such as "tulou", "ancestral hall", "temple" and "roads" in their interviews indicates that they were able to identify and distinguish the core subjects depicted in the photographs with relative accuracy. At the same time, the repeated use of descriptive terms such as "layout", "form", and "structure" suggests that the landscape-trained group placed greater emphasis on the spatial relationships and structural features of buildings, showing a clear tendency toward more professionalized expression. In contrast, the non-trained group rarely engaged in interpretation at the level of specific structures or spatial dimensions, and instead remained largely at the level of overall impressions and intuitive perceptions. In addition, the frequent occurrence of surrounding environmental terms such as "water", "trees", "sky" and "spring couplets" indicates a stronger sensitivity to surrounding environmental elements.

In the agricultural landscape category, both groups paid considerable attention to the local terraced field system, but their focal points differed. The landscape-trained group focused more on the structural characteristics of the terraced fields, as reflected in the high frequency of words such as “hierarchy” and “structure”, which highlight their concern with the spatial and morphological composition of the terraces. In contrast, although the non-trained group also attended to the terraced fields themselves, terms referring to non-productive environmental elements such as “roads”, “sky” and “weeds” also appeared frequently. This suggests that their perception extended beyond agricultural production features to include surrounding environmental components, resulting in a broader range of attention.

For the natural landscape category, both groups primarily identified natural elements such as “mountains”, “terraced fields”, “forests” and “water”, showing a generally similar understanding of the main subjects. However, their specific expressions differed. The landscape-trained group placed greater emphasis on the spatial hierarchy and types of landscape elements. In addition to the core natural features, high-frequency words included spatial orientation terms such as “middle”, “back”, “surrounding” and “part”. Ecological terms such as “plants”, “ancient trees” and “tree species” further indicate their tendency to analyze the landscape in terms of ecological element types. By contrast, the non-trained group focused more on direct natural scenes and overall environmental impressions. Their high-frequency words centered on “mountains”, “terraced fields”, “sky”, “clouds”, “forests” and “water” with descriptions focusing on the natural scenery itself and showing fewer distinctions in spatial structure or typological classification.

In the folk cultural landscape category, the landscape-trained group placed greater emphasis on intrinsic cultural elements and their structural details. Their high-frequency words centered on core facilities such as Buddhist shrines, incense burners, donation steles, and lanterns, with additional attention given to the “inscriptions” and “details” on these facilities. The non-trained group, while also focusing on the main subjects, frequently mentioned surrounding elements such as “QR codes”, “fire extinguishers”, “surroundings” and “weeds” indicating a relatively high level of attention to surrounding environmental features.

In the tourism service landscape category, the two groups showed a marked difference in the richness of perceived content. Overall, the landscape-trained group produced a significantly greater number of high-frequency words across the rural landscape photographs than the non-trained group, and this difference was particularly evident in the tourism service landscape category. Their highfrequency words included terms such as “design”, “form”, “modeling”, “style”, “color”, “material” and “space,” all of which relate to spatial composition and design elements. This suggests that the landscape-trained group tended to adopt a more analytical perspective based on design attributes. At the same time, the frequent occurrence of words such as “local”, “distinctive”, “environment” and “village” indicates that they tended to interpret tourist service facilities within the broader context of the village’s regional environment. The interview data further showed that most participants in the landscape-trained group critically evaluated the design of existing tourist facilities and proposed improvements that emphasized local characteristics and harmony with the overall environment. In contrast, the non-trained group expressed themselves more simply in this category, with their attention focused mainly on the facilities themselves. Although terms such as “design” and “form” also appeared, the interview data showed that most non-trained participants were more accepting of the facility design. Their descriptions also contained fewer detailed comments on the relationship between facility design and the village environment.

V. DISCUSSION

A. ACADEMIC BACKGROUND AND DIFFERENT MODES OF UNDERSTANDING THE HERITAGE VILLAGE LANDSCAPE

Landscape is not merely a physical entity, but a spatial form continuously constructed and endowed with meaning through social and cultural practices [53–55]. Within the layered context of a heritage village, historical architecture, agricultural landscapes, and cultural symbols together constitute a complex visual environment. Participants’ viewing behavior is therefore not a passive reception of multiple elements, but a selective and organized process guided by prior knowledge and cognitive frameworks. Accordingly, the influence of academic background on visual perception is reflected not only in the distribution of visual attention, but also in the different ways in which landscapes are understood.

By integrating visual hotspot distributions, eye-tracking indicators, and semi-structured interview findings, this study shows that university students with different academic backgrounds followed distinct cognitive pathways when perceiving the heritage village landscape. Cognitive psychology research suggests that individuals in complex contexts tend to select and integrate information on the basis of existing knowledge structures [56]. Related studies further indicate that professional experience shapes how individuals recognize and process information, leading them to focus more on key elements in complex visual tasks and thus display more selective patterns of visual attention [57]. Similar patterns were also observed in the heritage village context of this study.

Specifically, the landscape-trained group demonstrated a cognitive pattern characterized by structural orientation. In terms of visual hotspot distribution, their gaze was mainly concentrated on the key structural components of the principal elements, showing a clear pattern of spatial focus. This finding is consistent with previous research on the influence of professional experience on attention allocation [58], which suggests that individuals with domain-specific

TABLE 6. Word frequency of interview content from the landscape-trained group.

Architectural Landscape			Rice Harvesting	Terraced Fields	22	Buddhist Shrine	Facilities	5	Viewing Pavilion	Design	13
Tulou	Tulou	39		Rice	22	Incense Burner	Incense Burner	24		Local	12
	Architecture	15		Background	7		Upper	5		Styling	10
	Eaves	10		Water	6		Detail	5		Exit	7
	Center	8	Straw Burning	Smoke	47	Donation Stele	Donation Stele	23		Color	5
	Overall	8		Terraced Fields	28		Inscription	16	Signage	Signage	37
	Scene	8		Background	8		Upper	11		Character	10
	Layout	7		Color	7	Lanterns	Windows	25		Location	9
	Form	7		Visual Interest	5		Lanterns	20		Styling	8
	Structure	6		Water	5		Wall	13		Overall	7
	Surroundings	5		Scene	5		Architecture	6		Local	6
Ancestral Hall	Color	16	**Natural Landscape**			**Tourism Service Landscape**			Rest Platform	Space	16
	Ancestral Hall	16	Mountain	Mountain	24	Guesthouse	Architecture	40		Overall	15
	Roof Ridge	14		Terraced Fields	23		Guesthouse	32		Seating	14
	Door	11		Color	7		Character	18		Ground	13
	Architecture	9	Forest	Terraced Fields	23		Local	16		Railing	12
	Red	6		Forests	21		Overall	15		Rest	12
Temple	Incense Burner	21		Mountain	9		Wall	11		Stump	11
	Temple	20		Center	6		Design	11		Platform	10
	Surroundings	10		Background	5		Form	11		Quantity	10
	Architecture	8		Landscape	5		Plaque	10		Tulou	8
	Door	6		Vegetation	5		Environment	9		Form	7
Road	Road	48		Part	5		Color	9		Tables	7
	Traditional Houses	17	Ancient Trees	Trees	23		Element	8		Architecture	6
	Rear	8		Ancient Trees	16		Surroundings	8		Design	6
	Surroundings	5		Tree Species	6		Village	7		Paving	6
	Architecture	5	Water	Water	29		Styling	7		Stool	5
Agricultural Landscape				Road	13		Rural	6		Background	5
Terraced Fields	Terraced Fields	39		Stone	8		Clutter	6		Chairs	5
	Layers	18		Surroundings	7		Style	6		Stone	5
	Structure	11		Bridge	6		Tulou	5		Facilities	5
	Center	5		Center	5		Landscape	5			
	Mountain	5		Traditional Houses	5		Vegetation	5			
	Nature	5	**Folk Cultural Landscape**			Viewing Pavilion	Viewing Pavilion	24			
Irrigation Channel	Irrigation Channel	26	Buddhist Shrine	Buddhist Shrine	25		Plaque	18			
	Water	23		Surroundings	10		Overall	17			
	Surroundings	10		Center	8		Entrance	13			
	Center	8		Donation box	8		Character	13			

knowledge tend to prioritize structural and task-relevant information in complex visual tasks. In terms of eye-tracking indicators, Table 2 shows that the non-trained group had higher ADF means (277 ms vs. 232 ms) with a p-value of 0.070. While this does not meet the traditional threshold for significance, the strong trend suggests that academic background may indeed influence fixation duration. Given the sample size (n=20 per group), this near-significant result potentially reflects higher processing difficulty or scene complexity for the non-trained group, rather than simply a lack of influence. Previous studies have similarly noted that the duration of individual fixations can be sensitive to the viewer's expertise in decoding complex visual information [59]. By contrast, both TDF and NF showed significant differences, suggesting that academic background influenced the intensity of visual exploration and the frequency of scanning. Professional training may therefore contribute to a more selective distribution of fixations. At the linguistic level, the word frequency analysis showed that the landscape-trained group predominantly used high-frequency terms related to compositional elements and spatial hierarchy. This suggests that professional training may lead participants to prioritize the identification of core structural units and their spatial relationships during perception [60], or-

TABLE 7. Word frequency of interview content from the non-trained group.

Architectural Landscape			Straw Burning	Terraced Fields	10	**Tourism Service Landscape**		
Tulou	Tulou	14		Pond	8	Guesthouse	Guesthouse	20
	Center	10		Forests	7		Overall	14
	Architecture	9		Background	5		Plaque	10
	Scene	7	**Natural Landscape**				Design	9
	Visual subject	6	Mountain	Mountain	15		People	8
	Visual Interest	6		Terraced Fields	11		Architecture	7
	Time	5		Sky	6		Environment	5
	Windows	5		Clouds	5		Styling	5
Ancestral Hall	Water	10		Color	5		Color	5
	Roof Ridge	9	Forest	Terraced Fields	8	Viewing Pavilion	Viewing Pavilion	26
	Trees	9		Mountain	7		Overall	11
	Architecture	8		Forests	5		Plaque	7
	Sky	7	Ancient Trees	Trees	9		Design	7
	Color	7		Ancient Trees	6		Styling	6
	Eaves	6	Water	Water	22		Scenic Area	5
	Door	6		Bridge	6	Signage	Signage	28
	Visual Interest	5		Surroundings	5		Restroom	7
Temple	Incense Burner	11		Traditional Houses	5		Overall	7
	Chinese couplet	9	**Folk Cultural Landscape**				Location	6
	Surroundings	6	Buddhist Shrine	Donation box	13		Styling	5
	Overall	6		QR Code	9	Rest Platform	People	9
Road	Road	18		Buddhist Shrine	9		Chairs	9
	Traditional Houses	8		Fire Extinguisher	9		Ground	8
Agricultural Landscape				Surroundings	8		Overall	7
Terraced Fields	Terraced Fields	18	Incense Burner	Incense Burner	18		Platform	6
	Forests	7		Terraced Fields	13		Railing	6
	Road	6		Water	9		Tables	6
	Sky	5		Background	7		Life	6
Irrigation Channel	Water	16		Upper	6		Tulou	5
	Irrigation Channel	7		Inscription	5		Space	5
	Weeds	5	Donation Stele	Donation Stele	22			
Rice Harvesting	Rice	10		Inscription	11			
	Ponded water	8		Weeds	6			
	Terraced Fields	6		Surroundings	5			
	Surroundings	5	Lanterns	Lanterns	23			
Straw Burning	Smoke	27		Windows	21			

ganizing landscape information through categorization and relational description. Overall, the landscape-trained group exhibited a more structured mode of landscape perception by prioritizing key elements and integrating information within relatively localized spatial ranges.

In contrast, the non-trained group exhibited a cognitive pattern characterized by environmental integration. Their visual hotspots covered a broader range, and their fixation distribution tended to extend from primary elements toward the surrounding environment, making them more susceptible to overall environmental cues or locally salient stimuli. In terms of eye-tracking indicators, the non-trained group showed higher values of TDF, NF, and NV, indicating a stronger exploratory scanning pattern and more frequent revisits to specific regions during viewing. Related studies have suggested that scene perception depends to a large extent on the constraints imposed by existing knowledge structures on attentional allocation [61]. In the absence of such background knowledge, participants are more likely to rely on exploratory scanning to construct scene understanding. At the linguistic level, the non-trained group tended to use vocabulary associated with the overall environment and intuitive impressions. Their descriptions remained primarily experiential and focused on the visual scene itself, with fewer professional expressions related to spatial structure. Vocabulary choice and modes of description can, to some extent, reveal participants' focal concerns and organizational logic during information extraction and structural construction [62]. The non-trained group therefore tended to establish a more holistic perception of the heritage village landscape through broad visual scanning and the integration of environmental cues.

In addition, a synthesis of the eye-tracking indicators and semi-structured interview results suggests a correspondence between visual organization patterns and linguistic expression structures. We acknowledge that the landscape-trained group's more structured verbal descriptions may be partly attributed to their professional vocabulary and familiarity with disciplinary norms. However, because their linguistic focus on structural elements (e.g., "spatial hierarchy") directly correlates with the concentrated fixation hotspots observed in the eye-tracking data, it suggests that professional training shapes both the internal visual prioritization and the subsequent cognitive reconstruction of the scene, rather than merely affecting verbal output. Structured visual focus patterns were generally associated with more structured verbal expressions, whereas exploratory scanning paths were more likely to produce broader and more dispersed descriptive content.

B. PLURALISTIC VIEWING CHARACTERISTICS OF HERITAGE LANDSCAPES

The heritage village landscape does not have a single fixed mode of viewing. Rather, it exhibits pluralistic viewing characteristics shaped by the knowledge, experience, and cognitive frameworks of different observers. Previous studies have shown that the visual structure of a landscape is not entirely determined by its physical form, but is gradually shaped through the interaction between the viewer's knowledge and experience and the contextual information of the scene [63,64]. For viewers with different knowledge backgrounds, the same heritage village landscape may therefore be perceived differently within distinct cognitive frameworks. The visual differences identified in this study suggest that, under different knowledge conditions, heritage landscapes generate diverse interpretive pathways, leading to multiple modes of viewing.

From this perspective, the value of heritage landscapes lies not only in their physical forms and historical meanings, but also in the diversity of interpretations developed by different groups. The differences in visual perception revealed in this study do not simply indicate variations in viewing preference; rather, they reflect the differentiated cognitive structures through which different groups understand heritage landscapes [65,66]. Under the influence of diverse knowledge experiences and cognitive frameworks, the same heritage village landscape may be interpreted either as a system composed of core elements or as an integrated environmental scene. This suggests that heritage landscapes may be understood through multiple interpretive pathways within different cognitive systems, and that their visual structure may take different forms under different cognitive frameworks. The heritage village landscape therefore displays a marked multiplicity of viewing characteristics.

C. IMPLICATIONS FOR HERITAGE VILLAGE TOURISM MANAGEMENT

The findings indicate that, even within the same age group, differences in knowledge and experience can shape how observers understand the heritage village landscape. In the planning and tourism management of heritage village landscapes, it is therefore necessary to adopt a multi-audience perspective and optimize heritage landscape presentation and management in a more integrated way. Such an approach may improve both understanding of and experience quality across different visitor groups.

In terms of heritage landscape presentation, spatial organization and visual guidance may be used to strengthen the recognizability of core heritage elements. The results suggest that the visual attention of non-trained university students was more easily drawn to surrounding environmental elements, which to some extent diverted attention from the core heritage features. Accordingly, in the design of landscape presentation and tour routes, the arrangement of sight corridors, spatial sequences, and key landscape nodes may help create clearer visual guidance toward core heritage elements within the broader environment. This may, in turn, enhance the legibility of key elements within complex landscape information and help non-trained young visitors form a more effective spatial understanding of the heritage village landscape.

At the level of landscape conservation and planning design, greater attention should be given to the coordination between core components and the surrounding environment. The landscape-trained group repeatedly referred in interviews to the relationship between facility design and the village environment, indicating that individuals with relevant academic backgrounds placed greater emphasis on spatial integrity in landscape evaluation. In the planning and renewal of heritage villages, it is therefore important to strengthen the expression of regional cultural characteristics while meeting the functional requirements of tourist facilities, and to maintain the coherence of the landscape environment through integrated design.

In terms of visitor services, diversified approaches to landscape interpretation may enhance understanding of heritage landscapes among different visitor groups. For young visitors who lack relevant background knowledge, appropriate informational guidance may help them better understand the cultural meanings embedded in the landscape. Digital navigation systems, immersive exhibitions, and interactive media may therefore provide more accessible forms of interpretive support for young visitors, helping them understand the connotations of heritage landscapes and further enriching their overall travel experience.

D. RESEARCH LIMITATIONS AND FUTURE PROSPECTS

Although this study systematically examined differences in visual perception among university students with different academic backgrounds in heritage village landscapes by combining eyetracking experiments and semi-structured interviews, several limitations remain. First, regarding the sample structure, the gender ratio of participants was approximately 1:2 (male: female). Although this proportion generally reflects the actual composition of the university and disciplinary groups involved and therefore has a certain degree of representativeness, the uneven gender distribution may still have influenced the results. Future studies could further optimize the gender structure during participant recruitment or include gender as a covariate in the analysis to improve the robustness and explanatory power of the findings. Second, regarding the experimental materials, this study used only static photographs as visual stimuli and did not include videos or other forms of dynamic visual content. As a result, it was difficult to fully simulate the dynamic experience of real tourism settings. Future research could combine mobile eye-tracking devices or virtual reality technology to further test the findings in real-world or immersive environments. Third, regarding AOI division, this study classified areas of interest into only two types, namely “main subject” and “surrounding environment”. This approach simplified the complex spatial hierarchies and relationships among elements in the photographs to some extent and may therefore have overlooked differences among more specific subelements. Fourth, the fixed 10-second viewing duration for each photograph may have differentially impacted the two groups. Professional training often allows experts to extract structural information more efficiently, potentially leaving them with "surplus" time, whereas non-experts may have required more time to complete their exploratory scanning. The higher TDF and NF observed in the non-trained group might partly reflect an incomplete information-processing cycle that was truncated by the 10- second limit. Future research should employ self-paced viewing tasks to determine the natural time-tosaturation for different expertise levels. Future studies may adopt a more refined and multi-level AOI segmentation approach to improve the precision and depth of analysis.

VI. CONCLUSIONS

Based on eye-tracking experiments and semi-structured interview data collected from university students with different academic backgrounds in relation to Tianluokeng Village, this study examined three dimensions of heritage village landscape perception: visual attention distribution, cognitive processing patterns, and perceptual expression structures. The main conclusions are as follows. First, at the spatial level, the landscape-trained group and the non-trained group showed different distributions of visual hotspots. The landscape-trained group tended to focus more on the core compositional elements of the heritage village landscape, and their visual hotspots were more concentrated. In contrast, the non-trained group showed a broader range of visual attention, with gaze tending to extend from the main subject toward the environmental background. Second, at the behavioral level, academic background was associated with overall patterns of visual exploration. The two groups differed in the TDF, NF, and NV indicators. The landscape-trained group demonstrated a relatively more efficient mode of information acquisition, whereas the non-trained group showed a higher overall level of visual fixation and more frequent visual revisits. Third, at the level of cognitive expression, the semi-structured interviews indicated that the landscape-trained group placed greater emphasis on spatial structure and relationships among elements in their verbal descriptions, which were more hierarchical and systematic. In contrast, the non-trained group tended to focus more on overall impressions and intuitive perceptions. Overall, academic background exerted a clear influence on both visual attention characteristics and modes of verbal expression, revealing systematic differences that extended from visual processing patterns to the content of cognitive expression.

These findings suggest that university students’ perception of the heritage village landscape, as potential tourists, is shaped to some extent by their academic background. The differences in visual organization and linguistic expression between groups with different disciplinary training indicate that the presentation and management of heritage villages should not rely on a single visual logic. In terms of landscape presentation, strengthening the spatial guidance and visual representation of core heritage elements may help non-trained young visitors establish a clearer cognitive framework for understanding the landscape. In landscape conservation and planning design, greater attention should be given to the coordination between core components and the surrounding environment, while reinforcing the expression of regional characteristics to maintain the overall visual integrity of the heritage landscape. In terms of visitor services, understanding of the value and significance of heritage landscapes among different visitor groups may be enhanced by diversifying interpretive approaches.

SUPPLEMENTARY MATERIAL

The following supporting information can be downloaded at: https://doi.org/10.5281/zenodo.19103735, Table S1: Synonym merging scheme for semantic analysis.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee of Fujian Jiangxia University, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

AUTHOR CONTRIBUTIONS

Conceptualization – Zhen Yang, Tingfeng Xue, Longyi Cai, Ming Liu and Yiboni Chen; methodology – Zhen Yang, Tingfeng Xue, Longyi Cai, Ming Liu and Yiboni Chen; investigation – Zhen Yang, Tingfeng Xue, Longyi Cai, Ming Liu and Yiboni Chen; writing-original draft preparation – Zhen Yang, Tingfeng Xue, Longyi Cai, Ming Liu and Yiboni Chen. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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