Decoding Tourist Engagement in a Suzhou Classical Garden: A Methodological Triangulation of Self-Reports, Behavioral Observation, and Single-Channel Portable EEG

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Abstract

World Heritage sites are complex experiential environments in which visitors encounter architectural forms, water features, plants, rockeries, inscriptions, pathways and cultural narratives. Identifying visitors' points of interest is therefore important for heritage interpretation, route planning and sustainable tourism development. This study examined the use of BrainLink—a consumer-grade single-channel EEG headband reporting a proprietary attention-related index—as a supplementary tool for identifying dimensions of tourists' engagement in the Suzhou Classical Gardens, China. A mixed-methods design was adopted and has been approved by the Ethics Committee of the Silpakorn University. From December 2023 to March 2024, 497 participants aged 18 and above, including both Chinese and international tourists were recruited for this study. The research combines 408 responses from an online questionnaire, 64 responses from an on-site questionnaire, and 25 participants who completed on-site BrainLink tests and behavioral observation at the Master of Nets Garden in Suzhou. After artifact rejection, 183 valid spatial epochs across 101 Area of Interest observations were retained; attention peaks were defined as values exceeding one standard deviation above each participant's individual baseline, and 35 candidate peaks lacking spatial-behavioral convergence were excluded. The findings suggest that questionnaires are effective for identifying broad preference patterns, while portable brain-wave monitoring, when combined with behavioral observation, can capture momentary attention changes during actual heritage visits. This study proposes a methodological triangulation approach that combines self-reports, on-site observations, and attention-related physiological proxy indicators. It concludes that single-channel portable EEG should be utilized as a supplemental proxy measure, rather than a direct readout of tourists' visual or sensory attention, to aid in historical interpretation, visitor route design, and heritage tourism development.

Keywords: heritage visitor experience; Suzhou classical garden; single-channel portable EEG; visitor engagement; methodological triangulation

Introduction

World Heritage sites are rarely experienced as isolated visual objects. Instead, they operate as dynamic spatial, cultural, and social environments wherein visitors simultaneously encounter material forms, symbolic meanings, movement trajectories, and interpretive narratives. In the Suzhou Classical Gardens, the visitor experience is defined by continuous spatial movement, during which individuals interact with a complex arrangement of architecture, water features, flora, rockeries, poetic inscriptions, framed vistas, and winding pathways. Deciphering which specific environmental components attract and hold visitor attention is vital for heritage managers and local communities seeking to enhance interpretation planning, optimize route design, refine educational communication, and advance sustainable tourism development.

The Suzhou Classical Gardens represent an ideal empirical case for investigating these spatial attentional dynamics. Inscribed on the UNESCO World Heritage List, the gardens are celebrated as masterpieces of Chinese classical landscape design that compress natural scenery into miniature forms while embodying traditional aesthetic and philosophical values. Their intrinsic heritage value resides not only in their physical architecture, but also in the relationships among water, rockeries, vegetation, literary inscriptions, spatial sequencing, and traditional literati culture. However, this high density of aesthetic and cultural signifiers creates an interpretive threshold; first-time and international visitors, in particular, often struggle to decode the complex narrative landscape without structured guidance.

The Master of Nets Garden exemplifies this interpretive issue in practical terms. For example, the literati inscriptions and plaque couplets are so complicated that first-time and international visitors can't understand without assistance. For these challenges, heritage managers must make practical decisions—where to position interpretation, how to sequence paths, and how to spend limited resources.

Existing visitor studies within heritage contexts predominantly rely on self-report and observational approaches, including questionnaires, interviews, spatial route observations, photography, online reviews, and post-visit satisfaction surveys (Weiler & Ham, 2010). Although these methods yield valuable macro-level insights into general visitor preferences, they suffer from inherent methodological limitations. Self-report metrics depend heavily on post-hoc memory recall, language proficiency, and respondents' ability to articulate subjective experiences, whereas behavioral observation often conflates genuine visual engagement with external confounding factors such as physical fatigue, route confusion, crowding, or social interaction. Consequently, traditional methodologies leave a significant empirical gap in capturing real-time, in-situ attention during actual heritage visits (Lin et al., 2024). To address these limitations, recent tourism and experience research strongly encourages multi-modal, objective approaches capable of capturing

tourists' real–time attention, emotional responses, and embodied spatial experiences (Hadinejad et al., 2019).

Portable physiological devices offer a valuable approach to overcome these methodological constraints. Consumer–grade electroencephalography (EEG) systems have been validated across education, human–computer interaction, and applied cognitive research for recording attention–related neurophysiological indicators outside controlled laboratory environments (Sabio et al., 2024).



Figure 1 BrainLink Lite Device by Shenzhen Macrotellect. Image taken from the official site: www.macrotellect.com

Among these, the BrainLink headband (Figure 1)—a lightweight, forehead–mounted single–channel portable EEG device—enables non–invasive bio–signal acquisition during active mobility (Cheng et al., 2018). Prevalent neuro–cognitive literature demonstrates that such single–channel EEG devices can capture frontal cortical signals and translate them into real–time attention and relaxation metrics via embedded algorithmic processing (Tuckute et al., 2021).

This study is thus based on a single core proposition: institutionally authorized heritage significance does not always transfer into tourist involvement. Each measurement approach looks at this conversion process from a different angle: self–reports capture declared, retrospective values; behavioral observation captures visible engagement behaviors; and a single–channel portable EEG proxy captures momentary frontopolar arousal during navigation. This gives the convergence and divergence of the three techniques theoretical meaning, rather than just a methodological aspect. As a result, this study is organized around the idea that the three techniques measure various aspects of engagement. We explicitly examine their convergence and divergence rather than using single–channel portable EEG data as a measure of subconscious esthetic attention.

Objectives

1. To establish and operationalize the Master of Nets Garden's Areas of Interest (AOI) in accordance with the Chinese classical–garden design categories (architecture, water, rockery, vegetation, cultural inscriptions, and cultural artifacts), with the coding process and inter–coder agreement documented.

2. To estimate the pattern of visitor involvement for each data stream independently, using the appropriate unit and denominator (declarations per 408 or 64 respondents; episodes per 25 participants; behavioral events per AOI) and reporting interval estimations.

3. To assess the convergence and divergence of the three measurement streams across AOIs, employ a researcher–defined, pre–registered two–stream convergence rule whose sensitivity and stability are assessed in a sensitivity analysis.

Literature Review

1. Heritage visitor experience and Interpretation

Heritage tourism operates at the intersection of historic preservation and contemporary socio–cultural negotiation (Timothy & Boyd, 2003; McKercher & Du Cros, 2002). Rather than serving merely as a passive consumer encounter with physical artifacts, heritage engagement is fundamentally a process of constructing meaning, identity, and value (Smith, 2006). This conceptualization underscores a persistent theoretical debate within heritage management: balancing the preservation of tangible cultural assets with the economic and socio–cultural dynamics of tourism commodification (Shepherd, 2002). At UNESCO World Heritage sites, this tension necessitates holistic visitor management frameworks that simultaneously safeguard site integrity, facilitate meaningful interpretation, and deliver broad social value (Pedersen, 2002).

Concurrently, theoretical understandings of the visitor experience have evolved beyond simplistic post–consumption satisfaction metrics. Frameworks of tourist experience emphasize multi–dimensional engagements involving educational, aesthetic, entertaining, and escapist dimensions (Pine & Gilmore, 1998), which collectively shape memorable, novel, and meaningful encounters (Kim et al., 2012). In heritage contexts specifically, the essence of the experience resides in the emotional and cognitive relationship that visitors establish with the site, rather than the mere presence of historical artifacts (Poria et al., 2003). Consequently, identifying visitor points of interest extends beyond mapping spatial density; it serves as a lens for understanding how tourists actively decode and process cultural meanings.

Interpretation acts as the primary catalyst in bridging physical heritage space and cognitive experience. Effective interpretation transforms passive visitors into mindful, active processors of information (Moscardo, 1996), prompting personal meaning–making rather than the passive assimilation of factual data (Ham, 2013). In multi–layered, spatially dense heritage environments,

determining which specific visual and spatial elements capture, sustain, or lose visitor attention is essential for refining interpretive design and optimizing visitor education.

This study demonstrates that visitor engagement is an active meaning–making process rather than passive consumption, and that interpretation is spatial presence into cognitive and emotional participation. This finding establishes a theoretical foundation for investigating whether institutionally declared significant heritage items are perceived by visitors – a subject that cannot be fully addressed by post–hoc self–report measurement.

2. Suzhou Classical Gardens as Experiential Heritage

The Suzhou Classical Gardens offer an ideal empirical context for investigating spatial cognition and real–time visitor experience because their architectural layout relies on sequential movement. Designed around aesthetic principles of concealment, revelation, spatial rhythm, borrowed scenery (jiejing), and poetic association, these gardens require visitors to navigate a complex sequence of gates, corridors, pavilions, bridges, rockeries, and framed vistas. Scholars emphasize that Chinese classical gardens are not static visual compositions, but rather culturally coded, multi–sensory environments that seamlessly weave together architecture, natural elements, literature, and philosophy (Keswick et al., 2003).



Figure 2 A 360–degree panoramic photo of the inner garden of The Master of Nets Garden. Photographed by the authors.

The Master of Nets Garden (Figure 2) serves as an exemplar of this spatial paradigm. Its compact physical footprint, highly structured circulation pathways, and dense concentration of classic garden typologies—architecture, micro–topography, water bodies, vegetation, poetic inscriptions, and framed vistas—allow for controlled yet ecologically valid spatial tracking.

Despite rich study on the spatial syntax, cultural landscapes, and digital documentation of Suzhou Classical Gardens, traditional heritage research has predominantly prioritized physical spatial structures over the real-time, embodied experiences of visitors. Consequently, empirical research investigating moment-to-moment perceptual variations and attentional drivers in these settings remains scarce. Standard analytical frameworks frequently fail to capture how visitors dynamically perceive, process, or disregard elements of high aesthetic and cultural significance in situ (Zhang et al., 2026), creating a theoretical gap that limits the efficacy of interpretation planning. Although recent multidimensional frameworks—such as the "space-perception-behavior" model using mobile sensing and machine learning—have begun addressing landscape quality and crowding (Song et al., 2025), there remains a critical need to examine fine-grained cognitive interest and immediate attentional allocation during active site navigation.

Overall, the sequential, culturally encoded architecture of these gardens serves as a test setting for investigating attention while navigating dense historical spaces. The existing research gap is both methodological and theoretical: there is currently a shortage of empirical information on whether the heritage aspects judged most significant by experts are the ones that tourists notice on site.

3. Methodological Approaches to Measuring Visitor Interest

Empirical studies into visitor interest historically rely on self-reported survey instruments, semi-structured interviews, direct behavioral observation, spatial route tracking, online review scraping, and visual content analysis. While questionnaires efficiently capture macro-level preferences across large cohorts, self-report metrics are susceptible to recall decay, social desirability bias, post-hoc rationalization, and linguistic limitations (Larsen, 2007; Lin et al., 2024). Because tourist experiences are continuously reconstructed through memory and post-visit cognitive filtering, retrospective surveys often fail to capture real-time, momentary affective and cognitive fluctuations (Hadinejad et al., 2019).

Direct behavioral observation (e.g., measuring dwell times, camera triggers, or movement decelerations) offers valuable spatial evidence of visitor engagement. However, observational data alone remain methodologically ambiguous; physical pauses or photographic behaviors often stem from confounding external variables such as physical fatigue, spatial disorientation, crowding, or social interaction rather than genuine aesthetic interest (Sharp et al., 2019).

To overcome the diagnostic limitations of isolated methodologies, recent tourism scholarship strongly advocates for multi-modal methodological triangulation (Sun & Dong, 2022). Combining self-report evaluations, systematic behavioral tracking, and objective neuro-physiological sensing enables researchers to cross-validate subjective evaluations with real-time bio-behavioral indicators, thereby minimizing single-method bias and enhancing the diagnostic validity of spatial experience models.

Each method captures a different aspect of visitor involvement and has its own unique sources mistake. Methodological triangulation is therefore a cross–validation method, as opposed to just mixing different research tools. This logic directly justifies the construct–indicator framework, which will be explained in the following section and used in our research technique.

4. Single–channel Portable EEG and Neuro–Tourism Measurement

Electroencephalography (EEG) non–invasively records cortical electrical activity and represents a established methodology across cognitive neuroscience, psychology, and human–computer interaction (Britton et al., 2016; Sanei & Chambers, 2013). Historically restricted to laboratory environments, physiological metrics—including cognitive load, affective valence, and attentional focus—are increasingly utilized to measure real–time human responses in complex real–world settings (Kahneman, 1973; Paas et al., 2003). In tourism research, scholars highlight the transformative potential of portable physiological apparatuses for capturing authentic, unmediated tourist responses, while emphasizing the imperative for rigorous experimental design and contextualized data interpretation (Hadinejad et al., 2019; Li et al., 2015; Li et al., 2022).

It's worth noting that data collected from classrooms, programming activities, and controlled neurofeedback settings differs from heritage visits in terms of task structure, movement patterns, and sensory management. As a result, findings from those circumstances are solely presented here to illustrate the plausibility of our methodology, not to explicitly validate our field–based EEG metrics.

Advancements in micro–electronics have yielded portable, single–channel portable EEG hardware that significantly lowers operational barriers compared to laboratory–grade multi–channel systems, rendering field–based neuro–tourism studies viable (Lee et al., 2026). Single–channel frontopolar devices, such as the BrainLink headband, have been successfully applied in educational and applied cognitive settings to monitor attentional metrics and cognitive load dynamics relative to environmental stimuli (Cheng et al., 2018). Similarly, biofeedback and biometric studies confirm that lightweight frontopolar EEG sensors can capture reliable frontal cortical indicators related to mental focus and attentiveness (Girardi et al., 2020; Lin & Li, 2018).

Nevertheless, applied neuro–tourism research demands epistemological caution. Single–channel portable EEG devices do not directly measure higher–order construct variables such as philosophical appreciation or aesthetic judgment; rather, they yield proxy indicators of frontal cortical arousal and task–focused attention. Furthermore, field–based physiological data collection is vulnerable to signal artifacts, physical motion noise, individual baseline variability, and environmental interference (Lopez et al., 2020; Rogers et al., 2016). Therefore, single–channel portable EEG must be deployed as a complementary, non–clinical tool embedded within a broader triangulated framework, ensuring that physiological metrics are cross–validated against observational behaviors and self–reported subjective experiences.

The preceding to a unified conclusion: self–reports, behavioral observation, and portable each measure a different dimension of visitor engagement—declared preference, visible behavior, and frontopolar arousal, respectively—and the convergence of these dimensions must be tested rather than assumed. Table 1 fully defines what each method measures, its underlying mechanism, its projected convergence with other data streams, and the primary sources of measurement error. In this study, visual attention, cognitive effort, arousal, interest, and esthetic appreciation are regarded as separate constructs: our EEG proxy measures arousal and task–focused attention, not esthetic appreciation.

Table 1 Construct–indicator mapping of the three measurement streams

Stream	Construct measured	Mechanism	Expected convergence	Principal error sources
Self–report questionnaire	Declared preference; retrospective, memory–filtered evaluation	Post–hoc recall and verbal articulation of experience	Broad preference rankings should align with high–engagement AOIs	Recall decay, social desirability bias, post–hoc rationalization, language proficiency
Behavioral observation	Visible engagement (dwelling, photographing, pointing, discussing)	Overt spatial behavior logged against AOI boundaries and timestamps	Dwell/photo events should co–occur with EEG peaks at the same AOI	Fatigue, route confusion, crowding, social interaction confounds; event–based (not participant–based) counts
Portable EEG (BrainLink)	Frontopolar arousal / task–focused attention (proprietary eSense proxy)	Single–channel forehead electrode; embedded algorithm outputs 0–100 attention index	Peaks (>1 SD above individual baseline) should coincide with observed engagement at defined AOIs	Motion and muscle artifacts, ocular blinks, electrode displacement, baseline variability, proprietary algorithm opacity

Based on classified single–channel portable EEG as a supplemental, movement–sensitive indication, with interpretation reliability dependent on convergence with at least one independent data stream.

Conceptual Framework

The researchers established a multi–dimensional conceptual framework to systematically investigate visitor engagement within heritage environments. Grounded in a qualitative research design supported by mixed methodological triangulation, the framework connects environmental stimuli with cognitive and behavioral responses to achieve the core objective: the identification of cross–method corroborated visitor points of interest—where corroboration follows a researcher–defined, pre–registered convergence rule rather than validation against an independent external criterion (Figure 3).

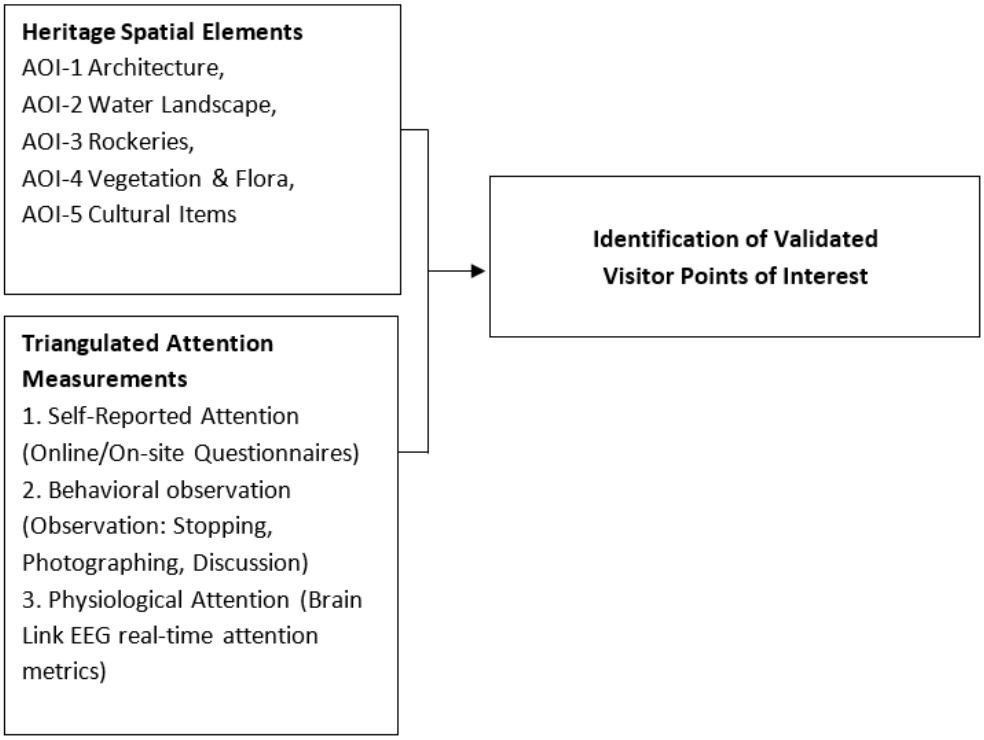


Figure 3 The Conceptual Framework

Research Methodology

Research Tools and Samples

To achieve methodological triangulation, this study deployed a mixed-methods empirical design comprising four distinct data collection streams across four sample cohorts: An online survey cohort (N = 408) capturing general visitor perception and heritage preferences; An on-site intercept survey cohort (N = 64) capturing immediate post-visit impressions; A wearable bio-sensing cohort (N = 25) capturing continuous real-time neural activity; and A behavioral observation cohort (N = 25) capturing spatial movement and engagement actions.

The sample size for the neuro-physiological experiment ($N = 25$) aligns with established sample size norms in exploratory field-based mobile EEG tourism research, balancing empirical validity with the operational constraints of on-site biophysical signal acquisition. Participants in the physiological cohort were concurrently monitored via systematic behavioral observation to enable direct data pairing and spatial synchronization. The EEG and behavioral-observation cohorts consisted of the same 25 participants, with paired sessions. Recruitment was conducted via intercept sampling at the garden entrance during the study period from March 1 to March 5, 2024. The inclusion criterion was an age range of 18–65 years, with no restrictions on participants' nationality, and the participants in this cohort are completely distinct from those who participated in the questionnaire survey. The study protocol was reviewed and approved by the Human Research Ethics Committee of Silpakorn University (approval no. REC 66.0913-131-8280).

All participants provided voluntary informed consent prior to data collection, and experimental protocols adhered to institutional ethical guidelines for non–invasive human subject research.

Data Collection Methods

Online and On–site Questionnaire

The research utilized two structured survey instruments. The online questionnaire gathered demographic profiles, prior knowledge regarding Suzhou Classical Gardens, visit motivations, preferred heritage attributes, interpretation requirements, and overall satisfaction rated on a 5–point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). The on–site intercept survey was designed as an abbreviated version optimized for post–navigation deployment at the exit of the Master of Nets Garden, prioritizing immediate cognitive impressions, affective responses, and salient spatial recall.

The Use of BrainLink for Physiological Data Acquisition



Figure 4 The Use of BrainLink to Collect Data

Real–time attentional dynamics were recorded using the BrainLink headband—a consumer–grade single–channel electroencephalography (EEG) device equipped with dry frontopolar electrodes (Figure 4). The device records neuro–electrical activity across the prefrontal cortex and converts raw bio–signals into a proprietary attention index (eSense Attention metric, scaled from 0 to 100) via embedded algorithmic processing. Prior to field trials, participants were briefed on the non–clinical, non–diagnostic nature of the study. Signal stability and electrode–skin impedance were verified using the device's diagnostic software before starting data acquisition. Participants navigated a standardized, self–paced visitor route through the Master of Nets Garden under naturalistic field conditions. To ensure data synchronization, researchers recorded continuous video and spatial timestamps corresponding precisely to the EEG recording timeline.

Technical and processing parameters were as follows: 512 Hz sampling rate; the hardware has a built–in filtering range of 3Hz–100Hz, and the research focuses on observing the fluctuation frequency of α waves (8–13Hz) and β waves (14–30Hz); 2–second epoch length; 2–minute eyes–open resting–baseline duration before the visit; electrode–skin impedance was maintained below 5 kΩ as indicated by the device diagnostic software.

Systematic Behavioral Observation

Concurrently with the EEG trials, trained observers executed unobtrusive, continuous behavioral mapping for each participant (N = 25). Observers recorded discrete spatial engagement markers using a standardized behavioral observation matrix. Specific observational indicators included:

– Deceleration & Dwell Time: Halting or slowing movement speed near specific garden features.

– Visual & Spatial Orientation: Turning body/head toward specific architectural or landscape assets, looking through framed views.

– Active Engagement: Pointing, taking photographs, or engaging in verbal discussion regarding specific site elements.

Data Processing, Signal Cleaning, and Triangulation Analysis

Quantitative Survey Analysis: Survey data were analyzed using descriptive statistics (frequencies, percentages, means, and standard deviations). Cross–tabulation analyses were conducted to evaluate preference variations between domestic and international visitor cohorts.

EEG Signal Processing & Normalization: Raw EEG data streams underwent rigorous signal cleaning. Artifacts resulting from facial muscle contractions, ocular blinks, physical motion noise, or electrode disconnection were systematically identified and removed. To account for baseline inter–individual physiological variations, attention values were normalized relative to each participant's individual mean and resting baseline, evaluating within–subject relative fluctuations rather than absolute cross–subject values.

Multi–Modal Data Triangulation: Spatial Areas of Interest (AOI) were delineated by integrating normalized EEG attentional peaks, spatial timestamps, and observational behavioral markers. A garden feature was confirmed as a validated Point of Interest (POI) only when at least two independent data streams (e.g., elevated EEG attention index + observational dwelling/photographing, or survey preference + EEG attention peak) converged. This rule is a decision strategy established by the researcher and it has not been evaluated against independent external criterion. Its sensitivity, specificity, and stability under different thresholds (e.g., 0.5 SD, 1.5 SD) are assessed in the sensitivity analysis in the Results section. To account for differential exposure time among AOIs, all engagement rates are presented per valid segment and per minute of exposure, and statistical comparisons are based on generalized linear mixed models

with participant random effects. Where discrepancies emerged between subjective self–reports and objective bio–signals, qualitative contextual analysis was applied to examine underlying confounding variables such as physical fatigue, crowd density, or spatial disorientation.

Research Results

Objective 1. The research results found that Spatial Coding of Areas of Interest (AOI) can be categorized into 5 types This classification (Table 2) synthesizes traditional Chinese classical garden design principles—which emphasize the harmonious integration of architecture, water landscape, rookeries, vegetation & flora, and cultural items. The coded map of the garden is shown in Figure 5.

Table 2 Suzhou Garden Area of Interest Coding

Code	Element	Examples
AOI–1	Architecture	Pavilions, covered corridors, stone bridges, halls, doorways
AOI–2	Water landscape	Pond
AOI–3	Rockeries	Huangshi/Taihu rockery formations, artificial grottoes
AOI–4	Vegetation & Flora	Trees, bamboo groves, seasonal floral arrangements
AOI–5	Cultural items	Calligraphic plaques, poetic couplets, stele inscriptions



Figure 5 The Master of Nets Garden Coded with Area of Interest Codes

Objective 2 and Objective 3: Research on Tourists' Attention to Areas of Interest Based on Measurement Methods

Respondent Profile

Data were gathered across two survey cohorts: an online cohort (N = 408) and an on–site intercept cohort (N = 64) deployed at the exit of the Master of Nets Garden (Table 3).

Online Participants

– Gender:53% male (215) and 47% female (193).

– Generation: Mostly concentrated between 1981–1996 (32%), followed evenly by 1997–2012 (24%) and 1965–1980 (24%), with smaller portions from 1928–1964 (12%) and 2013–2025 (8%).

– Visitor Type: Mostly international visitors at 99% (404), with domestic visitors accounting for 1% (4).

– Visit Experience: Composed of 13% repeat visitors (52) and 10% first–time visitors (40), with remaining data unstated. The visit–status was optional and was answered by 92 of the 408 online respondents; the remaining 316 responses were missing rather than a separate category. Similarly, the preference item allowed multiple selections, so the category totals in Table 3 exceed the number of respondents; percentages are therefore computed on the number of valid responses per item and are not additive.

On–site Participants

– Gender: 56% male (36) and 44% female (28).

– Generation: Primarily from the 1981–1996 generation (37%) and 1997–2012 generation (30%), followed by 1965–1980 (19%), 1928–1964 (11%), and 2013–2025 (3%).

– Visitor Type: Predominantly domestic visitors at 58% (37), while international visitors make up 42% (27).

– Visit Experience: Mostly first–time visitors at 67% (43), with repeat visitors making up 33% (21).

The demographic profiles reflect contrasting visitor samples. The online cohort was almost entirely composed of international respondents (99.0%), whereas the on–site intercept sample captured a balanced mix of domestic (57.8%) and international (42.2%) tourists. Furthermore, first–time visitors constituted 67.2% of the on–site sample compared to 9.8% in the online sample. This dichotomy is theoretically relevant: first–time visitors rely heavily on salient visual landmarks, whereas repeat visitors possess higher cognitive readiness to engage with subtle aesthetic details, spatial sequencing, and calligraphic inscriptions.

Questionnaire Findings: Preferred Heritage Elements

The questionnaire results show that visitors declared interests were concentrated in several major garden elements (Table 3). In the online questionnaire, Architecture was the most frequently selected element, chosen by 28 respondents and accounting for 7% of the valid sample. This was followed by Water landscape at 6%, Plants at 5%, Cultural stories at 4%, and Rockeries at 3%. Some participants who were unfamiliar with Suzhou Classical Gardens did not make the choice. In the on–site questionnaire, Water landscape ranked first at 36%, followed by Architecture and Cultural items.

Table 3 Visitors' Preferred Areas of Interest

Code	Online Questionnaire	Rank (Online))	On-site Questionnaire	Rank (On-site)
AOI-1	28 (7%)	1st	16 (25%)	2nd
AOI-2	23 (6%)	2nd	23 (36%)	1st
AOI-3	13 (3%)	5th	5 (8%)	5th
AOI-4	21 (5%)	3rd	9 (14%)	4th
AOI-5	18 (4%)	4th	11 (17%)	3rd

These results indicate that visually accessible elements such as Architecture and Water landscape were more frequently recognized by visitors. By contrast, culturally significant elements such as inscriptions, plaques or spatial naming received lower percentages, with 4% in the online questionnaire and 17 % in the on-site questionnaire. This pattern suggests that some heritage values may require stronger interpretation.

Domestic and International Visitor Differences

A comparison between domestic and international respondents (Table 3) indicates potential differences in interest patterns. Domestic visitors demonstrated greater interest in the Water landscape, with 33% selecting it. In contrast, international visitors showed a stronger preference for Architecture, with 25% selecting it. Furthermore, international visitors were less likely to select Cultural stories, accounting for only 14%, compared to 26% among domestic visitors. These survey-level differences are exploratory: the two groups are drawn from different sampling frames (online vs. on-site), and no inferential test was pre-specified for this comparison

Physiological (BrainLink EEG) and Behavioral Observation Analysis

The researchers used the wearable EEG experiment to capture neural data across N = 25 participants during active garden navigation (Table 4). Following strict artifact rejection (removing epochs contaminated by ocular blinks, masseter muscle activity, motion noise, or electrode displacement), 183 valid spatial recording epochs across 101 discrete AOI observations were retained for analysis. Physiological attention peaks (eSense Attention index > 1.0 standard deviation above individual baseline) were mapped against concurrent spatial timestamps and behavioral observation logs. To guard against physiological over-interpretation, 35 candidate EEG peaks were excluded due to lack of spatial convergence or missing behavioral validation.

Table 4 BrainLink Data and Observed Behavior During the Garden Visit

Code	Valid BrainLink data segments n	Attention-related metrics improved n (%)	Observed behavior n
AOI-1	63	39 (62%)	54
AOI-2	36	26 (72%)	47
AOI-3	26	8 (31%)	15
AOI-4	31	16 (55%)	31
AOI-5	27	11 (41%)	13

Note. Valid BrainLink data segments refer to cleaned signal segments retained for each AOI after removing invalid or unstable recordings. "Increased attention–related value" indicates that the segment showed a higher attention–related value than the participant's baseline or immediately preceding route segment. Observed engagement events include stopping, photographing, pointing, reading, discussing, or looking back. The counts are event–based and should not be interpreted as the number of individual participants. The percentages in column 3 are segment–level (improved segments / valid segments per AOI); participant–level agreement is reported separately in the text.

The highest proportion of attention–related increases appeared at AOI–2, where 26 of 36 valid segments showed an increase (72% at segment level), and where 24 out of 25 participants showed an increase at least once (96% at participant level). Behavioral observation at this AOI also recorded 18 instances of stopping, 22 of photographing, and 7 of discussion. This convergence suggests that AOI–2 may be a potential point of interest. The prominence of AOI–2, which focuses on the Water landscape, indicates that this feature is particularly effective at capturing and sustaining visitor engagement. This could be due to the visual appeal, cultural significance, or experiential qualities of the water area. The two denominators—segments and participants—are now stated explicitly and consistently throughout the text and tables.

However, not all BrainLink peaks were treated as evidence of visitor interest. We excluded cases in which attention–related peaks did not occur during time frames when participants were located at a defined AOI, when the quality indicators flagged unreliable signals, or when there was no observable behavior to support engagement. Specifically, 'corresponding behavioral evidence' referred to visible actions such as stopping, photographing, or discussing, as recorded by observers at the AOI. A 'clear AOI context' meant that both the EEG peak and the relevant behavior occurred within the boundaries of a predefined area of interest, as mapped in our observational protocol. In total, 35 cases were excluded from strong interpretation according to these criteria. This procedure reduced the risk of over–interpreting physiological data.

Triangulation of Questionnaire, Behavior and BrainLink Data

Triangulating self–report preferences, behavioral mapping, and prefrontal EEG metrics yields a comprehensive model of visitor spatial attention (Table 5).

Table 5 Triangulation of Visitors' Areas of Interest

Code	Questionnaire report (Online /On–site)	Behavioural observed	BrainLink evidence	Interpretation
AOI–1	7%/25%	54	62%	Strong
AOI–2	6%/36%	47	72%	Strong
AOI–3	3%/8%	15	31%	Weak
AOI–4	5%/14%	31	55%	Moderate
AOI–5	4%/17%	13	41%	Potential

The triangulated findings demonstrate a consistent pattern of high convergence across all three data streams for Water Landscapes (AOI–2) and Architecture (AOI–1), suggesting that

visually open, structurally salient features consistently capture and sustain both conscious preference and frontopolar arousal–related responses measured by the EEG proxy index.

Conversely, a critical "Aesthetic–Cognitive Disconnect" emerges regarding Cultural Inscriptions (AOI–5) and Rockeries (AOI–3). Despite their central significance in classical garden design theory and heritage management literature, these elements elicited low behavioral dwelling and minimal frontopolar EEG arousal—particularly among international cohorts. This divergence indicates that high cultural value does not automatically translate into spontaneous visitor engagement. Rather, it highlights a key empirical gap where implicit spatial design fails to communicate heritage meaning without structured, multi–sensory interpretive guidance.

Discussion

The primary objective of this study was to evaluate visitor attentional allocation within complex World Heritage micro–landscapes by triangulating self–report survey instruments, systematic behavioral observation, and portable frontopolar electroencephalography (EEG). By deploying this multi–modal framework at the Master of Nets Garden, the empirical findings contribute to the growing discourse on neuro–tourism, embodied spatial cognition, and heritage interpretation design.

A central theoretical contribution of this research lies in demonstrating how self–report questionnaires and wearable EEG bio–sensors capture fundamentally different layers of the tourist experience. Post–visit questionnaires measure retrospective, declarative cognitive recall and subjective preferences (Larsen, 2007; Weiler & Ham, 2010). In contrast, single–channel portable EEG (BrainLink) captures real–time, prefrontal neuro–cortical arousal and immediate attentional allocation during active site navigation (Cheng et al., 2018; Girardi et al., 2020).

Our findings indicate a clear structural divergence between these two data streams, confirming warnings in recent neuro–tourism literature regarding the limitations of relying on single–method evaluations (Hadinejad et al., 2019; Li et al., 2022). While strong preferences for Architecture and Water Landscapes (AOI–1 AOI–2) in post–visit surveys, EEG monitoring indicated attention–related changes during navigation that were rarely addressed in retrospective self–reports. This disparity highlights the fact that post–hoc surveys largely measure conscious, memory–filtered esthetic enjoyment, whereas in–situ EEG records a movement–sensitive proxy of frontopolar arousal that requires behavioral validation (Sabio et al., 2024).

Furthermore, the data reveal a pronounced "Aesthetic–Cognitive Disconnect" regarding Cultural Inscriptions and Poetic Plaques (AOI–5). Although emphasizes that calligraphic and poetic aspects have concentration of literati cultural relevance (Keswick al., 2003; Zhang et al., 2026), these traits induced limited brain arousal and low behavioral dwelling. This confirms Moscardo's (1996) mindfulness theory and Ham's (2013) interpretation framework: physical presence and

cultural value do not automatically translate into spontaneous visitor engagement unless the environment actively stimulates cognitive processing.

There are two cautions worth mentioning. First, arousal, attention, and esthetic appreciation are independent conceptions: the BrainLink index best serves as a proxy for frontal arousal and task–focused attention, and our findings do not distinguish between these categories and esthetic appreciation. Second, alternative explanations for reported EEG–behavior patterns must be considered, such as movement artifacts (which inflate the index during turns and stops), novelty effects, crowding, varying exposure durations across AOIs, and cultural familiarity with inscribed text. These options support, but do not eliminate, the convergence interpretation, and they serve as the basis for the conservative two–stream corroboration rule adopted in this work.

New knowledge from Research

The study's main conceptual contribution is the "Aesthetic–Cognitive Disconnect," which is characterized as a systematic divergence: historic elements with high institutionalized cultural relevance have poor perceptual accessibility, resulting in low spontaneous visitor involvement. Based on this concept, the following knowledge can be drawn:

1. Cultural objects and Rockeries had the weakest triangulated engagement, whereas visually open elements such as architecture and water scapes exhibited the strongest engagement.

2. Cultural familiarity moderates this relationship—the survey–level findings (difference in preference between domestic and international tourists) support the familiarity advantage theory. Our data only suggest a moderating effect, as the nationality of the EEG cohort was not recorded.

3. Structured interpretation converts latent cultural value into observable engagement, aligning with Moscardo's (1996) mindfulness framework.

From a methodological standpoint, this study also proposes a triangulated protocol for identifying visitor–interest patterns: questionnaires are effective in capturing broad, explicitly stated preferences, while BrainLink–assisted observation provides additional real–time evidence, assuming that the proprietary index is strictly used as a corroborated proxy. All of the propositions presented above are separate from neurocognitive assertions, which are limited to findings supported by the proxy arousal index.

Conclusion

The triangulated findings point to Water Landscape (AOI–2) and Architecture (AOI–1) as preliminary attentional anchors—features that captured declared preference, observable behavior, and elevated EEG proxy values all at once—while Cultural items (AOI–5) and Rockeries (AOI–3) failed to engage visitors spontaneously, consistent with the Aesthetic–Cognitive Disconnect. The

two–stream convergence rule, while conservative, has only been tested for sensitivity and stability at various thresholds in an exploratory sensitivity analysis and should not be considered a proven diagnostic. As a result, all managerial applications are provisional: water bodies and architecturally framed views may be used with caution as candidate locations for interpretation and wayfinding interventions, but firm recommendations should be held until replication using mobile eye–tracking, research–grade validated EEG measures, or controlled within–subject designs.

Methodologically, this study reinforces the necessity of strict data triangulation rules when utilizing consumer–grade bio–sensors in field settings (Lopez et al., 2020; Rogers et al., 2016). Single–channel frontopolar EEG devices are inherently susceptible to motion artifacts, ocular blinks, and environmental noise. By establishing a decision rule requiring convergence across at least two independent data streams (e.g., EEG attention peak + behavioral dwell time or survey validation), this study provides a methodological template for applying non–invasive physiological tools in real–world heritage environments without overclaiming their diagnostic validity (Sun & Dong, 2022).

Suggestions

Based on the research findings, the researchers make the following recommendations:

1. Suggestion for Implementing the Research Findings

The study results can provide alternative applications for heritage site managers, curators, and sustainable tourism planners. Physiological and behavioral tracking confirmed that central water bodies and architectural framed views serve as natural attentional anchors (AOI–1 and AOI–2). Heritage planners can leverage these high–attention nodes as strategic locations for key educational signage or guided interpretation stops, mitigating spatial congestion while maximizing narrative retention.

2. Suggestion for Future Research

Future research should consider expanding sample sizes and conducting cross–site comparisons across multiple classical gardens. Integrating mobile eye–tracking and spatial tracking will enable high–precision mapping of visitor movement and neuro–attentional allocation. Over the longer term, seasonal longitudinal studies and post–navigation stimulated–recall interviews should be deployed to capture the temporal variability and qualitative drivers underpinning visitor engagement.

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