EYE TRACKING USABILITY EVALUATION MODEL FOR SMART GUIDE TOURISM APPLICATION IN CHINA

YANG YANJUN

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ABSTRACT

The rapid expansion of the smart tourism sector in China has intensified the demand for high quality smart guide applications. However, many existing products still suffer from usability flaws, including cluttered layouts, poor visual guidance, and high cognitive demands, which undermine visitor experience and limit industry competitiveness. Addressing this urgent gap, this study proposes and validates an eye-tracking based usability evaluation model for smart guide tourism applications in China, aimed at optimising digital cultural tourism product design. Integrating Human Computer Interaction theory, Cognitive Load Theory, and the Technology Acceptance Model, the framework examines how interface usability influences user experience through emotional attractiveness, design complexity, perceived usefulness, perceived ease of use, and cognitive load. A mixed methods approach combined eye-tracking metrics, task performance indicators, and Likert scale ratings with structured interviews and eye-tracking video analysis. Forty six Chinese participants aged between eighteen and twenty seven years interacted with a main functional interface and a map navigation interface. A single mediation model was applied to the main functional interface, while a dual mediation model was used for the map navigation interface. Results show that simplified layouts, culturally resonant visuals, and balanced colour schemes reduce cognitive load, improve operational efficiency, and enhance satisfaction. The findings bridge theoretical and empirical gaps in usability evaluation for smart guide tourism applications and provide actionable guidelines for advancing the cultural tourism industry of China and informing global digital tourism design.

MODEL PENILAIAN KEBOLEHGUNAAN BERASASKAN PENJEJAKAN MATA UNTUK APLIKASI PANDUAN PELANCONGAN PINTAR DI CHINA

ABSTRAK

Pengembangan pesat sektor pelancongan pintar di China telah memperhebat permintaan terhadap aplikasi panduan pintar yang berkualiti tinggi. Namun begitu, banyak produk sedia ada masih menghadapi kelemahan kebolehgunaan, termasuk susun atur yang berselerak, panduan visual yang lemah, dan tuntutan kognitif yang tinggi, yang menjejaskan pengalaman pelawat serta mengehadkan daya saing industri. Bagi menangani jurang mendesak ini, kajian ini mencadangkan dan mengesahkan satu model penilaian kebolehgunaan berasaskan penjejakan pergerakan mata bagi aplikasi panduan pelancongan pintar di China, dengan tujuan mengoptimumkan reka bentuk produk pelancongan budaya digital. Mengintegrasikan teori Interaksi Manusia-Komputer, Teori Beban Kognitif, dan Model Penerimaan Teknologi, kerangka ini mengkaji bagaimana kebolehgunaan antara muka mempengaruhi pengalaman pengguna melalui daya tarikan emosi, kerumitan reka bentuk, persepsi kegunaan, persepsi kemudahan penggunaan, dan beban kognitif. Pendekatan kaedah campuran digunakan dengan menggabungkan metrik penjejakan mata, penunjuk prestasi tugasan, dan penilaian skala Likert bersama temu bual berstruktur serta analisis video penjejakan mata. Seramai empat puluh enam peserta dari China berusia antara lapan belas hingga dua puluh tujuh tahun berinteraksi dengan antara muka fungsi utama dan antara muka navigasi peta. Model pengantaraan tunggal digunakan untuk antara muka fungsi utama, manakala model pengantaraan berganda digunakan untuk antara muka navigasi peta. Hasil kajian menunjukkan bahawa susun atur yang ringkas, visual yang selaras dengan budaya, dan skema warna yang seimbang dapat mengurangkan beban kognitif, meningkatkan kecekapan operasi, serta meningkatkan kepuasan. Penemuan ini merapatkan jurang teori dan empirikal dalam penilaian kebolehgunaan aplikasi panduan pelancongan pintar serta memberikan garis panduan yang boleh dilaksanakan untuk memajukan industri pelancongan budaya di China dan memberi panduan kepada reka bentuk pelancongan digital global.

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LIST OF ABBREVIATIONS

2.5D	Two Point Five Dimensional
2D	Two Dimensional
3D	Three Dimensional
A	Experimental Sample-Smart Tour of Longmen Grottoes
AD	Attentional Demand
AI	Artificial Intelligence
ANOVA	Analysis of Variance
AOIs	Area of Interest
AR	Augmented Reality
AS	Attentional Supply
B	Experimental Sample-The Palace Museum
C	Experimental Sample-Smart Tour of Yellow Crane Tower
CLT	Cognitive Load Theory
Cohen's d	effect size interpretation
CTT	Concur Task Trees
D	Experimental Sample-Tracing the Mausoleum of the Qin Emperor
e.g.	Exempli Gratia
EDA	Electrodermal Activity

EEG	Electroencephalogram
EFA	Exploratory Factor Analysis
ER	Error Rate
F	F-value
FC	Fixation Count
FD	Fixation Duration
H	Hypothesis
HCI	Human-Computer Interaction
HRR	Help Request Rate
HRV	Heart Rate Variability
Hz	Hertz
I-CVI	Item-Content Validity Index
IoT	Internet of Things
ISO	International Organization for Standardization
KMO	Kaiser-Meyer-Olkin Measure
M	Mean
ms	Milliseconds
NLP	Natural Language Processing
P	P-value
PC1	The First Principal Component
PC2	The Second Principal Component
PCA	Principal Component Analysis

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Post-hoc	After the Event
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RC	Revisits Count
RO	Research Objective
RQ	Research Question
SA	Situation Awareness
SART	Situation Awareness Rating Technique
S-CVI	Scale Content Validity Index
SD	Standard Deviation
SPAM	Situation Present Assessment Method
SU	Understanding of the Situation
Sum	Summary
TAM	Technology Acceptance Model
TCT	Task Completion Time
TLX	Task Load Index
UCD	User-Centered Design
UE	User Experience
UI	User Interface
UT	Usability Theory
VR	Virtual Reality
X	Usability Evaluation Experiment of Main Function Interface
Y	Usability Evaluation Experiment of Map Navigation Interface

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter discusses the research background, problem statement, research objectives, research questions, research hypotheses, conceptual frameworks, operational definitions, scope, limitations, and significance of the study. These elements systematically present the overall framework and logical structure of the research, clarifying the research motivation, objectives, and relationships among various variables, providing the theoretical foundation and guidance for the research design, data analysis, and conclusions in the subsequent chapters.

1.2 Research Background

With the advancement of technology and the booming development of the cultural tourism industry, smart tourism has gradually become an important component of the tourism sector. As one of the core applications of smart tourism, cultural tourism smart guide products have gained widespread use in recent years (Castro et al., 2024). Smart guide systems, through the deep integration of digital technology and cultural content, provide tourists with precise travel information and personalized cultural experiences. These systems not only include traditional map navigation functions but also integrate various features such as scenic spot explanations, virtual reality experiences, and interactive games, significantly enhancing tourists' cultural engagement and sense of immersion (Yang et al., 2024). Therefore, cultural tourism smart guide products are considered essential tools for improving the effectiveness of cultural dissemination and promoting the development of the cultural tourism industry (Blundell et al., 2023; Lu et al., 2023).

In China, the development of smart tourism has become a key initiative to enhance the quality of cultural tourism and promote cultural dissemination (Zhang et al., 2020). In recent years, various regions across China have continuously advanced the construction of smart tourism infrastructure and developed multiple smart guide products, such as the smart guide system at the Palace Museum and the intelligent guide platform for the Great Wall scenic area. These guide systems integrate advanced technologies such as the Internet of Things, big data, and artificial intelligence, providing tourists with convenient cultural information services through multi-terminal devices (e.g., smartphones, tablets, and VR equipment) (Yang, 2022). Additionally, the Chinese Ministry of Culture and Tourism has introduced several policies encouraging governments at all levels and cultural tourism enterprises to accelerate the development and promotion of smart tourism products, aiming to improve the overall service quality of the cultural tourism industry (Wang et al., 2023). Smart guide systems have been widely applied in many key scenic spots in China, becoming crucial means for enhancing scenic spot management efficiency and visitor satisfaction.

In the development of cultural tourism smart guides, eye tracking technology has gradually become an essential tool for evaluating user-system interaction behaviours. Eye tracking technology records and analyzes users' fixation points, fixation durations, and gaze paths, revealing users' visual attention distribution and cognitive states while using the interface (Kim et al., 2022). Originally applied in psychology and cognitive science research, this technology has, in recent years, extended to the field of human-computer interaction. Through eye tracking data, researchers can gain deep insights into user behaviour patterns in interface design and information processing, providing data support for optimizing user interface design (Ismail et al., 2022; Kim et al., 2021). Especially in the complex interfaces of cultural tourism smart guides, eye tracking technology can precisely capture users' visual behaviour during the browsing process, revealing obstacles and difficulties encountered during interactions, thus providing critical references for improving the scientific and rational design of interfaces (Zhang et al., 2023).

Overall, the development of cultural tourism smart guides and the application of eye tracking technology mutually reinforce each other, offering new research perspectives and technical methods for enhancing user experience and interface design. In China, the rapid development of smart tourism is steering smart guide products towards greater intelligence, personalization, and interactivity. The application of eye tracking technology in cultural tourism smart guides is also deepening, bringing more opportunities for the digital transformation and innovative development of the cultural tourism industry (Huang, 2020; Zhang & Cui, 2022).

1.3 Problem Statement

With the rapid advancement of digital technologies and the rise of smart tourism, cultural tourism smart guide applications have emerged as essential tools for enhancing visitor experiences. However, many existing smart guide interfaces still suffer from significant usability issues, particularly in terms of interface design, information delivery, and interactive functionality（Zhou & Li, 2021）. These problems often lead to operational difficulties, increased cognitive burden, and low user satisfaction during actual use, thereby reducing the overall effectiveness of such systems in cultural tourism promotion (Zhang et al., 2023).

While some prior studies have examined interface design and user experience in smart tourism systems, there remains a notable lack of comprehensive usability evaluation, especially one that addresses users' visual attention, cognitive load, and task performance in an integrated manner (Sutcliffe & Namoun, 2019). Most existing evaluations rely either on subjective satisfaction ratings or on general performance metrics, failing to capture the complexity of real-time human–computer interaction in dynamic tourism contexts (Norman, 2019; Kim et al., 2021; Sweller et al., 2021). Therefore, there is an urgent need for a mixed-methods approach that combines both quantitative and qualitative data to conduct a multi-dimensional usability assessment. This approach should go beyond surface-level satisfaction to explore how interface elements influence visual behaviour, information processing, and emotional response (Sweller et al., 2021).

To address this gap, the present study adopts an integrated theoretical framework based on Human–Computer Interaction (HCI) theory, Cognitive Load Theory, the Technology Acceptance Model (TAM), and usability theory (ISO 9241-11). By employing eye-tracking experiments, Likert scale surveys, structured interviews, and behavioural observations, this research aims to systematically investigate how interface design features affect users' visual attention distribution, operational performance, cognitive processing, and satisfaction(Nielsen, 1993). The ultimate goal is to provide empirical evidence and actionable insights for improving the design effectiveness and user experience of cultural tourism smart guide interfaces (Nielsen, 2000; Castro et al., 2024; Szekely et al., 2023).

1.4 Research Objectives

RO1: To research users' behavioural characteristics and interface design requirements in the cultural tourism smart guide interface.

RO2: To construct comprehensive evaluation models to measure the usability of the cultural tourism smart guide interface.

RO3: To evaluate how users' visual behaviour, operational efficiency, and cognitive load affect the overall user experience in the eye tracking experiment of the cultural tourism smart guide interface.

1.5 Research Questions

RQ1: What are the behavioural characteristics and usability requirements of users when using the cultural tourism smart guide interface?

RQ2: How to build eye tracking evaluation models that can comprehensively evaluate the usability of the cultural tourism smart guide interface?

RQ3: How do users' visual behaviour, operational efficiency, and cognitive load in the cultural tourism smart guide interface affect the overall user experience?

1.6 Research Hypotheses

To comprehensively evaluate the usability of cultural tourism smart guide interfaces, this study formulates a series of hypotheses based on two theoretical evaluation models—one for the main function interface and one for the map navigation interface. The hypotheses are grounded in a multidimensional integration of Human–Computer Interaction (HCI) theory, Cognitive Load Theory (CLT), the Technology Acceptance Model (TAM), and ISO 9241-11 usability attributes, with a particular focus on the relationships among interface design quality characteristics (e.g., emotional attractiveness, design complexity, and cognitive load), visual behaviour, operational performance, and user satisfaction (Huang, 2020; Zhang & Cui, 2022).

These hypotheses aim to explore how specific interface design variables influence users' visual attention, task efficiency, and cognitive processing, as well as how cognitive load mediates users' perceived satisfaction. The rationale for proposing these hypotheses is twofold: to bridge the theoretical gap in understanding how perceptual and cognitive mechanisms affect user interaction in digital cultural tourism contexts, and to build an empirical usability evaluation model that captures both objective metrics (e.g., fixation data, task performance) and subjective experiences (e.g., satisfaction ratings). The proposed hypotheses provide the analytical foundation for the usability evaluation models detailed in Section 4.6.

1.6.1 Hypotheses Based on Main Function Interface Evaluation Model

This research, based on the mapping relationships between independent variables (efficiency, effectiveness, learnability), the mediator (cognitive load), and the dependent variable (satisfaction) in the main function interface evaluation model, proposes the following hypotheses:

H1: The emotional attractiveness of the cultural tourism smart guide interface significantly affects users' visual behaviour and cognitive load.

H1a: The design of basic interface elements and color style significantly impacts users' first fixation duration and cognitive load.

Designs incorporating complex color combinations or dynamic visual elements capture more user attention, extending the first fixation duration but may also increase cognitive load during information processing.

H1b: Interfaces with high emotional attractiveness enhance users' visual focus, increasing the proportion of high-attention areas in the heatmap while significantly reducing subjective cognitive load ratings.

High emotional attractiveness guides users' attention to key areas, reducing fixation and revisit counts in non-essential regions, thereby lowering cognitive load.

H2: The complexity of the cultural tourism smart guide interface significantly impacts users' operational behaviour, visual behaviour, and cognitive load.

H2a: The design of the interface layout and information organization significantly affects users' fixation count and saccade path, influencing task completion efficiency through cognitive load.

Complex layouts and information organization increase fixation count and saccade paths, raising cognitive load, which leads to longer task completion time and reduced operational efficiency.

H2b: Interfaces with low design complexity can reduce user error rates, improve task completion efficiency, and decrease information processing load.

Simpler designs and rational information organization reduce users' cognitive burden, allowing them to complete tasks more accurately and efficiently.

H3: Cognitive load in the cultural tourism smart guide interface mediates the effect on users' visual behaviour and operational performance.

H3a: Interfaces with high information processing load cause an increase in users' average pupil diameter and revisits count, indirectly reducing their satisfaction ratings on the Likert scale.

Interfaces that impose high cognitive load require users to invest more cognitive resources in information comprehension and operation, leading to changes in visual behaviour and negatively affecting overall satisfaction.

H4: The emotional attractiveness, design complexity, and cognitive load of the cultural tourism smart guide interface significantly influence user satisfaction, with cognitive load acting as a mediating variable moderating these effects.

H4a: Interfaces with high emotional attractiveness, low design complexity, and low cognitive load significantly enhance users' subjective satisfaction scores on the Likert scale.

Users experience lower cognitive load when interacting with emotionally appealing and well-organized interfaces, resulting in higher satisfaction and positive subjective evaluations of the interface.

H4b: Interfaces with high design complexity and high cognitive load significantly reduce user satisfaction.

When interface design is overly complex and cognitive load is high, users are likely to experience fatigue and frustration, leading to lower subjective evaluations of the overall interface experience and satisfaction.

These hypotheses construct the relational pathways among variables in the main function interface, emphasizing the mediating role of cognitive load between emotional attractiveness, design complexity, and user satisfaction. Emotional attractiveness and design complexity influence users' visual behaviour and operational performance through cognitive load, which in turn moderates their overall satisfaction with the interface design.

1.6.2 Hypotheses Based on Map Navigation Interface Evaluation Model

Based on the mapping relationships among usability attributes, evaluation methods, and evaluation indicators in the cultural tourism smart guide map navigation interface evaluation model, the study proposes the following hypotheses:

H5: The operational efficiency of the cultural tourism smart guide interface significantly affects users' visual behaviour metrics (Fixation Duration and Fixation Count).

H5a: Higher operational efficiency results in shorter fixation duration and fewer fixation counts.

H5b: Low operational efficiency leads to longer fixation duration and increased visual search attempts.

H6: The effectiveness of the cultural tourism smart guide interface significantly affects users' task performance indicators (Task Completion Time and Error Rate).

H6a: High interface effectiveness significantly reduces task completion time.

H6b: High interface effectiveness significantly decreases the error rate during operation.

H7: The learnability of the cultural tourism smart guide interface significantly impacts users' regression count and help request rate during operation.

H7a: High learnability in interface design reduces regression counts during user operation.

H7b: High learnability lowers the frequency of users seeking assistance during tasks.

H8: Users' satisfaction with the cultural tourism smart guide interface is significantly correlated with their subjective satisfaction scores on the Likert scale.

H8a: Cultural tourism smart guides with interface designs that closely align with user requirements significantly increase satisfaction scores.

H8b: Interfaces with high design complexity or unreasonable layouts result in decreased satisfaction scores.

1.7 Conceptual Frameworks

The conceptual framework of this study aims to reveal the interaction pathways between the usability of the cultural tourism smart guide interface and user experience, analyzing the mediating effects of cognitive load and the technology acceptance model (perceived usefulness and perceived ease of use) between these two factors. Additionally, control variables are employed to eliminate the interference of demographic variables and interface usage experience, ensuring the accuracy and scientific validity of the research findings (Emelia et al., 2019).

"Usability" is defined as the independent variable, encompassing four dimensions: efficiency, effectiveness, learnability, and satisfaction. It directly influences users' visual behaviour and operational performance when using the cultural tourism smart guide interface, which, in turn, affects their overall experience (Li et al., 2015).

"Cognitive load" serves as the mediating variable, linking the relationship between usability and user experience. Theoretically, improving usability directly reduces users' cognitive load when interacting with the interface, such as by decreasing information processing load and cognitive resource consumption. Therefore, cognitive load plays a mediating role in explaining how usability affects user experience within the model (Hu et al., 2023).

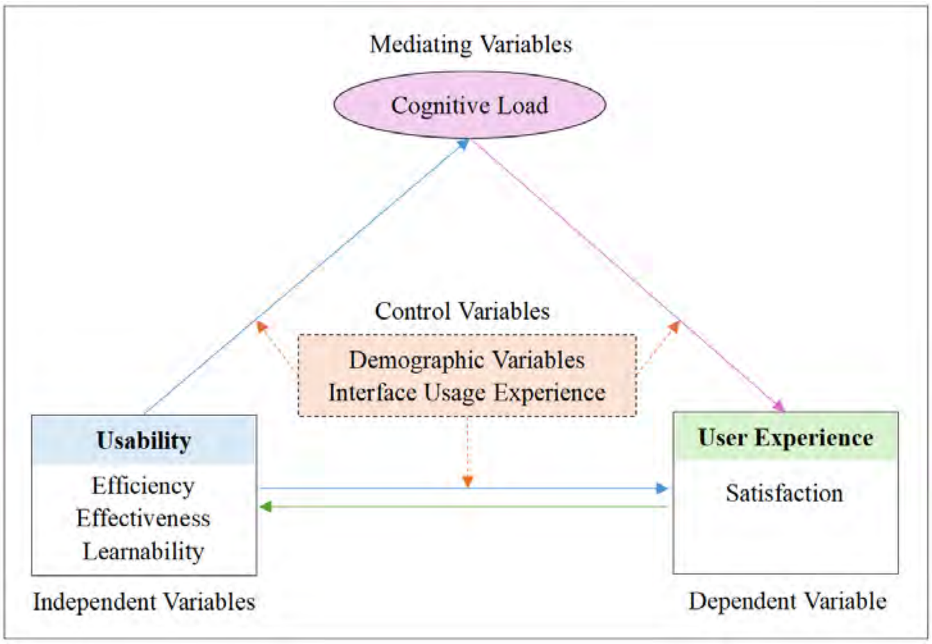
"User experience," as the dependent variable, uses "satisfaction" as a representation of "user experience" evaluation, which is influenced by the independent variable (usability) and the mediating variable (cognitive load). The study suggests that enhancing the usability of the cultural tourism smart guide interface can directly or indirectly improve user experience, thereby increasing satisfaction, interaction experience, and overall usage perception. Furthermore, the study not only examines the positive effects of usability on user experience but also considers how user experience, in turn, influences usability, forming a bidirectional relationship (Hu et al., 2023; Fadda et al., 2015).

The study also introduces "Demographic Variables" and "Interface Usage Experience" as control variables. These control variables may interfere with the relationship between usability and user experience, such as differences in perceptions and behaviours among users of varying ages, genders, and educational backgrounds, as well as how familiarity with the interface may influence operational performance (Wang et al., 2023). By controlling these variables, the research ensures that the model accurately and objectively reflects the relationships among the independent, dependent, and mediating variables.

Figure 1.1 illustrates the relationships among the variables in the evaluation of the main function interface.

Figure 1.1

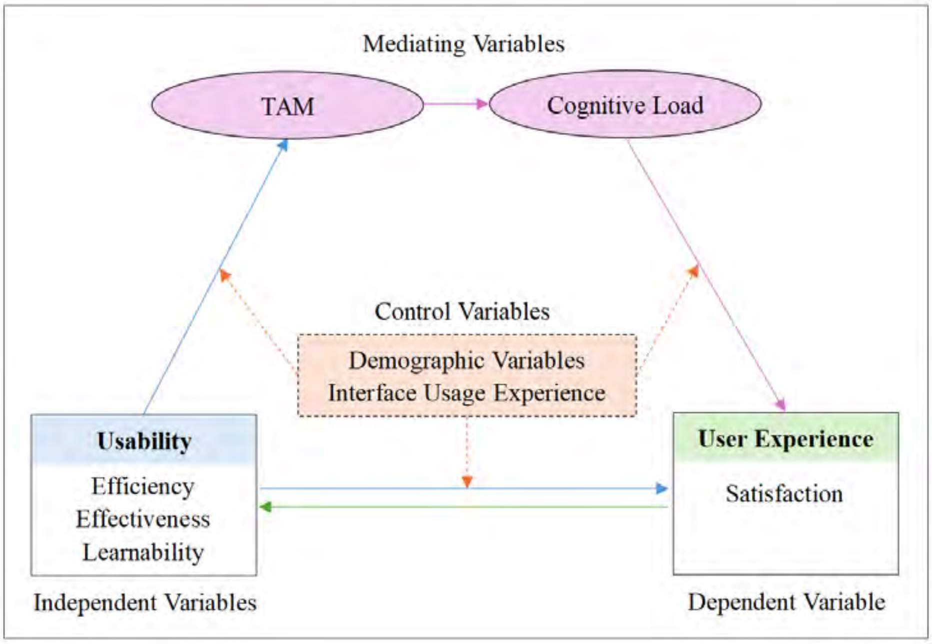
Conceptual Framework for Main Function Interface Evaluation



The conceptual framework in Figure 1.2 illustrates the relationships among the variables in the evaluation of the map navigation interface.

Figure 1.2

Conceptual Framework for Map Navigation Interface Evaluation



i. Independent Variable (Usability) → Mediating Variable (Cognitive Load). The usability characteristics of interface design, such as emotional attractiveness and design complexity, directly influence the cognitive load users experience during interaction. Interfaces with high emotional attractiveness and low design complexity can effectively reduce cognitive load, thereby enhancing the overall user experience (Zhang et al., 2023).

ii. Mediating Variable (Cognitive Load) → Dependent Variable (User Experience). The cognitive load users experience when interacting with the interface significantly affects their visual attention distribution, operational efficiency, and subjective satisfaction. When users need to invest fewer cognitive resources while operating the interface, their experience is smoother and more comfortable, which correspondingly increases their satisfaction (Emelia et al., 2019).

iii. Independent Variable (Usability) ⟷ Dependent Variable (User Experience). A high-usability interface can directly improve operational efficiency, reduce errors, and enhance user satisfaction and overall experience. Moreover, the overall user experience can, in turn, influence the usability design of the interface. Through users' subjective perceptions of task difficulty, information organization, and interface layout, designers can identify issues and optimize the interface. For instance, if users find certain features complex or hard to understand during their experience, their feedback can help designers detect potential usability barriers, allowing for targeted adjustments to layout and simplification of operational processes, thereby reducing cognitive load and improving usability (Zhang et al., 2023). Therefore, user experience provides critical feedback for usability design, forming a positive optimization cycle.

iv. Control Variables. In this study, control variables are factors that may influence the relationship between the independent variable (usability) and the dependent variable (user experience). Introducing control variables helps eliminate potential external interference, allowing the study to more accurately assess the actual impact of the independent variable on the dependent variable and scientifically explain the direct influence of usability on user experience. The following are the two main control variables introduced in this study (Hu et al., 2023):

(i) Demographic Variables: These include factors such as age, gender, educational background, and specialization. These variables can affect users' ability to understand the cultural tourism smart guide interface, their operational habits, and visual behaviour, potentially influencing their cognitive load and overall experience. For example, older users may have slower information processing speeds, while users with higher education levels may have an advantage in understanding complex information. Controlling these variables allows the study to isolate their effects, ensuring a purer causal relationship between the independent and dependent variables (Aslina et al., 2019).

(ii) Experience with Interface: Users' familiarity with and experience using the cultural tourism smart guide interface is another important control variable. Users with extensive experience may experience significantly reduced cognitive load when facing complex interfaces, thereby improving operational efficiency and satisfaction. Conversely, users with little experience may feel confused during their initial interaction, leading to increased cognitive load (Emelia et al., 2019). Controlling for user experience enables a more precise assessment of how interface design itself affects user experience, eliminating confounding factors related to varying levels of user familiarity.

Overall, this study integrates the independent, dependent, mediating, and control variables into a unified model, clarifying the pathways and mechanisms through which cultural tourism smart guide interface design influences user experience. This provides a theoretical foundation and empirical basis for subsequent research. The construction of this framework offers theoretical guidance for the eye tracking experiment evaluation model, laying a solid foundation for future studies.

1.8 Operational Definitions

1.8.1 Cultural Tourism Smart Guide Interface

The cultural tourism smart guide interface refers to a digital information service platform specifically designed for the cultural and tourism sectors, primarily based on mobile devices such as smartphones and tablets. It integrates various functions, including scenic spot explanations, map navigation, cultural knowledge dissemination, and virtual tours, providing tourists with interactive and immersive cultural tourism experiences. The interface not only supports scenic information display and route navigation but also enhances users' cultural cognition and tourism experience through multimedia content (e.g., videos, audio, images), improving the effectiveness of cultural content dissemination (Fadda et al., 2015).

The cultural tourism smart guide interface typically consists of two main forms: the main function interface and the map navigation interface:

i. Main Function Interface: This focuses on information display and functional operations. Users can access overviews of scenic spots, introductions, activity recommendations, and cultural knowledge through this interface. The design of the main function interface aims to provide convenient access points, helping users quickly browse and understand information about the scenic area (Menzel et al., 2022).

ii. Map Navigation Interface: This emphasizes spatial positioning and interactive functions for scenic spots and route navigation. Users can perform operations such as location search, route planning, and viewing services around scenic spots through the map interface. The map navigation interface highlights the visualization and interactivity of spatial information, aiming to assist users in better locating and planning their travel routes (Goncalves et al., 2022).

In this study, the cultural tourism smart guide interface serves as the primary research subject. By combining eye tracking technology and user experience analysis, the research explores how interface design elements (e.g., layout, color, functional configuration) and interactive features (e.g., navigation, information retrieval) impact users' visual behaviour, operational efficiency, and subjective satisfaction (Yang and Su, 2021). The study focuses on the distribution of visual attention influenced by interface layout, the impact of functional configuration on operational efficiency, and the enhancement of user satisfaction through interactive experiences, providing data support and theoretical foundations for the design and optimization of cultural tourism smart guide interfaces.

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1.8.2 Eye Tracking

Eye tracking is a technology that uses specialized devices (e.g., eye trackers) to record and analyze the movement and fixation behaviour of users' eyes while they interact with an interface. It precisely captures users' visual attention distribution, information processing methods, and attention shifts during operations (Lewis, 2014).

In this study, eye tracking technology is employed to evaluate users' visual behaviour and attention distribution on the cultural tourism smart guide interface. By recording data such as Fixation Count, Average Pupil Diameter, and Saccade Path, the study reveals users' visual search strategies, information processing patterns, and operational habits. Eye tracking results help researchers assess the rationality of interface design and identify areas where users encounter difficulties during interaction, providing a basis for interface optimization.

1.8.3 Eye Tracking Experiment

An eye tracking experiment is a method that records users' eye movement data in real-time using eye tracking devices while they complete specific tasks. This method analyzes their visual behaviour and operational performance when interacting with the interface. The experiment typically includes device calibration, task execution, data recording, and data analysis stages, aiming to uncover indicators such as users' attention distribution, information acquisition efficiency, and cognitive load during operation (Quiñones & Rusu, 2017).

This study's eye tracking experiment involves both the main function interface and the map navigation interface. During the experiment, participants are required to complete specific tasks in different interfaces, while the Tobii Pro Glasses 2 eye tracking device records their eye movement data. Combined with task completion time, error rate, and help request rate as performance indicators, the experiment analyzes the impact of different interface designs on users' visual behaviour and operational performance (Kim et al., 2021).

1.8.4 Usability

According to Weichbroth (2018), usability is a measure of an interface's overall performance in meeting user needs, enhancing operational efficiency, and improving user experience. It is one of the most critical attributes in interface design evaluation. Usability typically encompasses several dimensions, including efficiency, effectiveness, learnability, and satisfaction. Each dimension assesses aspects such as ease of operation, task completion accuracy, ease of learning and understanding, and users' subjective perceptions of the overall experience, aiming to reveal the interface's performance in practical applications and its impact on user experience.

In this study, usability is defined as the overall operational performance and user experience when using the cultural tourism smart guide interface. By integrating efficiency, effectiveness, learnability, and satisfaction into the usability evaluation model, the study comprehensively analyzes the performance of the cultural tourism smart guide interface under different design and functional layouts, providing a systematic and thorough evaluation of its usability.

1.8.5 Evaluation Models

An evaluation model integrates usability attributes and their corresponding evaluation indicators in a systematic and structured manner to comprehensively assess the overall design performance of the cultural tourism smart guide interface and its impact on user experience. Evaluation models typically encompass multiple dimensions and indicators, employing various methods to evaluate users' operational efficiency, visual behaviour, cognitive load, and subjective perceptions while using the interface (Naeini & Mahdipour, 2023). Specifically, evaluation models help researchers identify issues in interface design and their potential impacts on user experience, providing scientific evidence and data support for interface optimization.

This study constructs two evaluation models based on the main function interface and the map navigation interface, respectively. The main function interface evaluation model focuses on assessing interface layout, color design, and functional configuration, while the map navigation interface evaluation model emphasizes interactive functions and the effectiveness of spatial information presentation (Szekely et al., 2023). Both models center on the core evaluation criteria of efficiency, effectiveness, learnability, and satisfaction. They utilize eye tracking data, task performance data, and subjective evaluation data (e.g., Likert scale) for multidimensional assessment. By integrating data from different dimensions into the evaluation models, the research systematically reveals the strengths and weaknesses of the cultural tourism smart guide interface design and its impact on user experience, providing comprehensive and scientific guidance for interface usability evaluation.

1.9 Scope and Limitations of Research

1.9.1 Research Scope

1.9.1.1 Research Field

This study focuses on the fields of cultural tourism and human-computer interaction, specifically examining the usability and user experience evaluation of cultural tourism smart guide interfaces. The research covers topics such as digital services in cultural tourism, smart guide interface design, user visual behaviour analysis, and the application of human-computer interaction theories in cultural tourism contexts.

1.9.1.2 Research Content

The study systematically evaluates the design performance and user experience of two types of interfaces in cultural tourism smart guides: the main function interface and the map navigation interface. The research emphasizes analyzing how interface layout, color design, information organization, and interactive features influence users' visual behaviour, operational efficiency, and subjective satisfaction, revealing the relationships between usability attributes and evaluation indicators.

1.9.1.3 Research Region

This research is conducted at Huazhong Agricultural University, located in Wuhan, Hubei Province, China. The usability investigation is carried out in the natural environment of the campus to simulate real-life scenarios in which users would interact with cultural tourism smart guide products. The eye tracking experiment is conducted in a controlled laboratory environment to ensure the accuracy and precision of the data.

The research focuses on Chinese cultural tourism smart guide products and user groups, reflecting the interface design performance and user experience characteristics within the Chinese cultural tourism context, thus ensuring that the findings are applicable and relevant to digital products in China's cultural tourism sector (Zhang et al., 2020).

1.9.1.4 Target Group

The target group of this study consists of young Chinese users, specifically university students aged 18 to 27, who have experience using cultural tourism smart guides. This demographic represents one of the primary user groups of these products, possessing high digital literacy and active participation in cultural tourism activities. The sample selection reflects the characteristics of target users for cultural tourism smart guide interfaces, providing a scientific basis for understanding the impact of interface design on actual user behaviour and experience. Additionally, given the high level of activity and acceptance of digital products among university students, this sample choice ensures the representativeness of the data collected and the validity of the research findings (Fatehi et al., 2022).

1.9.2 Research Limitations

1.9.2.1 Sample Limitations

The study focuses primarily on young users aged 18 to 27, who possess considerable experience in cultural tourism and smart guide products. However, this sample may not fully represent the characteristics of users from other age groups (e.g., elderly individuals, children) or cultural backgrounds. Due to time and resource constraints, this study could not conduct large-scale, multi-regional, or multicultural experiments, meaning that the findings may only apply to specific cultural tourism scenarios and user groups.

1.9.2.2 Interface Type Limitations

This research only analyzes and evaluates two types of interfaces in cultural tourism smart guides: the main function interface and the map navigation interface. Other interface forms are not covered. Therefore, the generalizability of the findings to all smart guide interface designs is limited. Future studies could extend the research to more interface types to enhance the breadth and applicability of the conclusions.

1.9.2.3 Technological Limitations

The eye tracking equipment used in this study, Tobii Pro Glasses 2, provides high accuracy in recording data such as pupil diameter and fixation points, but there may still be instances of errors or data loss. Additionally, the equipment may cause discomfort for users during the recording process, potentially affecting their natural operational behaviour and leading to data bias.

1.10 Importance of Research

This study holds significant theoretical and practical value in the field of cultural tourism smart guide interface design and user experience evaluation. From a theoretical perspective, it integrates human-computer interaction theory, user experience theory, and cognitive load theory into the usability research of cultural tourism smart guides. This approach addresses the gap in the comprehensive evaluation of visual behaviour, cognitive load, and user experience in digital interface design for cultural tourism, offering new perspectives and methodological support for the theoretical development of interface design and user experience evaluation.

From a practical perspective, this research combines eye tracking technology with user experience analysis to quantify users' visual behaviour, operational efficiency, and subjective satisfaction while interacting with cultural tourism smart guide interfaces. The study reveals the impact patterns of interface design on user experience. The findings provide scientific evidence and data support for optimizing the design of cultural tourism smart guide interfaces, enhancing usability and user satisfaction. Additionally, they offer guidance for the design and development of digital service platforms and smart guide products in the cultural tourism sector, contributing to the digital transformation and innovative development of the industry.

Moreover, by focusing on Chinese cultural tourism smart guide products and user groups, this study provides targeted improvement plans for digital service platforms in China's cultural tourism sector. It promotes the deep integration of cultural tourism resources with digital technology, increasing the usage rate and user satisfaction of cultural tourism smart guide products, thus improving the overall service quality and market competitiveness of the cultural tourism industry. The research findings are not only applicable to the Chinese cultural tourism sector but can also extend to the cultural tourism fields of other countries and regions, providing a reference for the design and development of digital cultural tourism products globally and fostering innovation and collaborative development in the global cultural tourism industry. By optimizing the design of cultural tourism smart guide interfaces, this study enhances the attractiveness of cultural tourism products, improves tourists' cultural identification and travel experiences, promotes the coordinated development of cultural dissemination and tourism, and provides a theoretical foundation and practical reference for the sustainable development of the cultural tourism industry.

1.11 Summary

This chapter first outlines the development status and usability issues of cultural tourism smart guide interfaces, clarifying the research motivation and questions, and proposes three main research objectives and corresponding research questions to evaluate the usability and user experience of these interfaces. Subsequently, based on the evaluation models of the main function interface and the map navigation interface, the chapter introduces research hypotheses, highlighting the influence of quality characteristics such as emotional attractiveness, design complexity, and cognitive load on users' visual behaviour and operational performance. By constructing the conceptual framework, the chapter defines the relationships between variables and introduces control variables to eliminate the influence of irrelevant factors on the research outcomes, ensuring the scientific rigor of the model. Additionally, the chapter delineates the scope and limitations of the research, providing a solid theoretical foundation and guidance for the subsequent chapters on research design, data collection, and analysis. The following chapters will delve into the literature review to explore related studies, solidify the theoretical foundation of this research, and provide further empirical evidence for the construction of the research model.