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An Analysis of Pedestrian Preferences for Wayfinding Signage in Urban Settings: Evidence from Nanning, China

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Abstract: As global urbanization accelerates, the integration, readability, and connectivity of urban spaces are becoming focal points of international concern, particularly in rapidly developing regions like Asia. The inadequacies of urban wayfinding systems directly affect pedestrians' wayfinding experiences within city spaces. Pedestrian wayfinding signage, as a critical element supporting pedestrian navigation and urban readability, is often neglected in vehicle-centric urban planning. This study explores the visual preferences of pedestrians regarding wayfinding signage and how these perceptions can be incorporated into the design process. A photo-based survey consisting of 385 pedestrians in Nanning, China, reveals that while many wayfinding signs provide cognitive information, they score lower in visual preference due to poor sensory perception and difficulty in conveying meaning. This study also highlights that the material, color, graphics, and text on signage are key physical attributes influencing the visual preferences of pedestrians. Demographic factors such as age, gender, and professional background also impact these preferences. These findings underscore a broader urban design issue: wayfinding signs must not only clearly communicate navigational information but also enhance the aesthetic and cultural expressions of urban spaces. Current signage systems often neglect these aesthetic and cultural needs, potentially leading to visual fatigue or cultural disconnection, thereby affecting navigation efficiency and urban experience. The results provide empirical foundations for optimizing wayfinding signage designs in urban areas, aiding urban planners and designers in integrating pedestrian preferences to create clearer, more attractive navigation systems, thus improving walking experiences and significantly enhancing the daily lives of city residents.

Keywords: visual preference; wayfinding signage; pedestrian experience; signage design; urban walking; China Nanning

Citation: Zhou, J.; Ujang, N. An Analysis of Pedestrian Preferences for Wayfinding Signage in Urban Settings: Evidence from Nanning, China. *Buildings* **2024**, *14*, 2986. https://doi.org/10.3390/buildings14092986

Academic Editor: Pramen P. Shrestha

Received: 7 August 2024
Revised: 25 August 2024
Accepted: 7 September 2024
Published: 20 September 2024

1. Introduction

With the acceleration of global urbanization, optimizing urban spaces becomes crucial for improving the quality of life of residents and enhancing urban competitiveness. Research by the United Nations Environment Program [1] United Nations Human Settlements Program [2], and the Transport, Health, and Environment Pan-European Program [3] indicates that effective urban planning and pedestrian-friendly designs are vital for driving economic growth and play an increasingly important role in the urbanization process.

Against this backdrop, Nanning, one of China's rapidly developing cities, faces challenges in urban planning and pedestrian orientation systems amid urban expansion and modernization processes, representing a typical situation for similar cities in Asia. The city's population surge (from 6.9169 million in 2008 to 8.8917 million in 2023) is particularly notable [4]. This growth urgently requires urban planners to rethink the pedestrian environment, especially the layout and design of wayfinding systems. In recent years, the Nanning municipal government has placed significant emphasis on urban planning and on developing pedestrian-friendly spaces. This focus ensures that the findings of this study can have a direct and practical impact on the city's future development plans, offering

viable design and strategic recommendations. All these factors make Nanning, China, an ideal choice for this study.

Despite the critical objectives of enhancing the pedestrian environment and improving urban quality of life, research specifically addressing pedestrian wayfinding signage remains scarce. Existing literature studies often conflate pedestrian wayfinding systems with vehicular traffic guidance systems, overlooking the fundamental differences between pedestrians and drivers regarding spatial cognition, information needs, and modes of movement [5]. The "Nanning Slow Traffic Wayfinding Signage System Construction Plan", proposed by the Nanning Municipal Government in 2014, officially recognizes the deficiencies in the existing system [6]. The policy aims to install approximately 1000 sets of uniformly designed slow traffic signs, providing clear road names and geographical directions to accommodate the city's rapid development and its increasingly complex spatial structure. Figure 1 displays the final design of Nanning's slow traffic wayfinding signage.

Figure 1. Slow traffic wayfinding signs in the city of Nanning (from Nanning News) [6].

Although Nanning completed installing its slow-traffic wayfinding signage in January 2015, the pedestrian orientation experience in the city has not achieved the desired effects. Issues include outdated signage information due to rapid urban expansion, aging signage from different construction periods, and some information that is difficult to comprehend. These factors collectively hinder residents' and tourists' reliance on the orientation system for effective navigation [7]. Studies also indicate that there has been no significant increase in Nanning residents' willingness to walk despite the installation of these systems [8]. This underscores the need for a deeper exploration of the factors that influence pedestrian satisfaction and effectiveness in wayfinding systems, particularly in fast-growing urban areas like Nanning.

The importance of wayfinding signage has been explored from multiple perspectives, with literature demonstrating its direct impact on urban orientation efficiency and walking experiences. Improperly designed pedestrian signage can lead to cognitive overload, negatively affect walking experiences, and even introduce safety risks [9–12]. An effective pedestrian orientation system is expected to improve pedestrian orientation efficiency significantly while enhancing the overall urban image [13–15]. However, most studies primarily focus on the functional aspects of wayfinding signage, such as clarity and consistency, and pay less attention to the aesthetic and cultural dimensions of signage, especially within specific urban contexts like China. In cities with rich and diverse cultures, such as Nanning, there is a pressing need to explore how wayfinding signage can also serve as a tool for visual communication and cultural expression.

There remains a critical gap in the literature regarding how pedestrian wayfinding signage design can balance both functional and aesthetic needs while aligning with the cultural and visual preferences of local residents. This study aims to address this gap by exploring the visual preferences of pedestrians in Nanning for wayfinding signage design, focusing on the following research questions: (1) What types of wayfinding signage do pedestrians in Nanning prefer? (2) What physical factors influence the visual preferences of pedestrians for wayfinding signage? (3) Are there differences in visual preferences for wayfinding signage among people with different demographic characteristics?

To address these questions, this study employs a modified version of the classic visual preference research method to ensure its applicability to pedestrian wayfinding signage. The results are expected to validate existing theories of visual preferences while offering new insights into the design of pedestrian-oriented urban spaces.

This research provides a framework for understanding how wayfinding signage can simultaneously enhance urban navigation and serve as a medium for cultural expression. The findings will offer empirical data and actionable strategies for urban planners and designers to optimize the pedestrian environment by incorporating the visual preferences of residents into future urban planning efforts. By transforming wayfinding signage into a more effective tool that enhances the city's image and showcases its cultural characteristics, this research will contribute to improving pedestrian orientation efficiency and strengthening Nanning's brand as a culturally rich and pedestrian-friendly city.

2. Literature Review

2.1. Visual Preference Studies

Visual preference surveys (VPSs), as a method of assessing public visual preferences for landscapes, architecture, or design elements, have been widely validated as effective and reliable [16,17]. In urban design and cultural studies, the application of VPSs is extensive. For example, Wang et al. [18] found that landscapes with high vegetation coverage were more favored through VPSs; Deng et al. [19] explored the combination of natural landscapes and soundscapes through visual preference research to investigate their effects on restorative environments and health benefits; Tabatabaie et al. [20] examined the influence of urban walkways, trees, and shading on pedestrian preferences. Li et al. [21] discovered varying preferences of university students in different emotional states toward natural landscapes and visual openness. Chen et al. [22] explored the spatial distribution of the landscape preferences of tourists via the landscape preference method. Pan et al. [23] studied the public's visual preferences for the exteriors of Chinese court buildings and the influence of demographic characteristics on these preferences. Šafárová et al. [24] compared the differences in architectural aesthetic evaluation between young and non-architects through visual preference methods. Qiu et al. [24] focused on the visual preferences for deadwood in different landscapes and their influencing factors. Deghati Najd et al. [25] also used visual preference methods to explore the visual preferences of international visitors for the Kuala Lumpur Historical Center.

The VPS method is a mature approach that is widely applied across multiple domains. However, there is a relative scarcity of research on visual preferences for wayfinding signage in pedestrian walking environments, especially within the broader context of urban spaces. For instance, Iftikhar et al. [26] limited their research to campus environments, comparing pedestrian wayfinding signage visual preferences only under the diverse cultural backgrounds of Hong Kong and Pakistan, thus restricting the universality and applicability of their results.

2.2. Wayfinding Signage Studies

Most studies on wayfinding signage have primarily focused on specific application scenarios, such as emergency evacuation, transportation hubs, and hospitals. For example, a Swiss study highlighted the importance of designing emergency evacuation signage, especially in situations where it is necessary to discourage the use of certain exits. Re-

searchers examined the visibility and effectiveness of dissuasive emergency signage and proposed design improvements [27]. Similarly, researchers in Japan used virtual reality (VR) experiments to explore how the placement and type of emergency evacuation signage affect evacuees' response behavior and compliance with directional cues [28]. These studies emphasize the crucial role of signage functionality and readability in critical situations.

In transportation hubs, such as airports and subway stations, the central issue in signage design is how to help large numbers of passengers quickly find transfer routes and exits. For instance, Dutch researchers discussed the use of animated signage to address the limitations of static airport signage in quickly updating wayfinding information, thereby providing more timely guidance [29]. In Chinese cities such as Beijing and Xi'an, signage design focuses on optimizing signage layout to improve wayfinding efficiency for subway passengers. These studies underscore the importance of accuracy and timeliness in addressing the challenges posed by rapidly changing information in transportation hubs [28,30].

In hospital environments, signage design primarily focuses on reducing psychological stress for patients and visitors In a U.S. study, researchers conducted usability tests to evaluate the effectiveness of wayfinding signage design in emergency departments and proposed an optimized design process to better meet patients' wayfinding needs [31]. In China, researchers simulated patients' visual focus in emergency departments to analyze issues with the current signage design and provided targeted optimization suggestions [32]. Researchers from Taipei, Taiwan, used virtual wayfinding experiments to assess the deficiencies of the signage system in the West Campus of National Taiwan University Hospital and proposed design standards for optimizing signage placement in complex environments to reduce patients' wayfinding anxiety [33]. These signage systems often need to be designed by considering the complexity of medical facilities, the specific needs of patients, and the readability of the signage itself.

Although these studies provide valuable insights into signage design in specific contexts, they typically remain confined to emergency evacuation, transportation hubs, and hospital environments, with less attention given to wayfinding signage design in broader urban settings. Wayfinding signage design in urban environments is more complex, requiring the accommodation of diverse pedestrian groups and intricate spatial structures, while also considering cultural diversity. Therefore, it is necessary to further study the real experiences of users in urban environments to better understand their actual needs for signage systems within multicultural and complex spatial contexts.

2.3. Physical Features and Aesthetic-Perceptual Characteristics of Wayfinding Signage

Evaluating visual preferences primarily comprises two methods: objective evaluation based on physical paradigms and subjective evaluation based on psychological paradigms [34,35]. The objective method regards the aesthetic quality of landscapes as an intrinsic attribute of the object, evaluating objects or landscapes through quantified design parameters [36]. This approach emphasizes measurable physical features, such as color, shape, and material. In contrast, the subjective evaluation method assumes that aesthetic quality is determined by the observer's subjective experience, focusing on individual perceptions and emotional responses, such as decorativeness, readability, and safety [37–39]. However, many researchers in the field of aesthetic preference assessment contend that the evaluation is not merely a simple correspondence between object features and individual responses, it is a complex interactive process where the physical characteristics of the landscape and the psychological reactions of the observer interact, jointly influencing visual preferences [40,41]. Therefore, it is essential to systematically review the physical features and aesthetic-perceptual characteristics of wayfinding signage, observing their interactions to fully understand the mechanisms forming visual preferences in wayfinding signage.

To undertake a comprehensive and systematic analysis of the physical features of wayfinding signage, this study draws upon the "Signage Pyramid" method proposed by Chris Calori and David Vanden-Eynden in their work "Signage and Wayfinding Design:

A Complete Guide to Creating Environmental Graphic Design Systems" [42]. According to this method, the physical features of wayfinding signage are divided into three core dimensions: information system, graphic system, and hardware system.

The information system primarily describes the content of information presented on the signage and its relationships and hierarchical structure. This system includes text, text size, text layout, font, and language. Text refers to the information content displayed on the signage, such as names of destinations, distances, and descriptions of destinations [42,43]. Text size pertains to the font size or height used on the signage [42]. Text layout concerns the arrangement of all text on the signage [42,43], while font refers to the typeface, weight, and design of the text [42,43]. Language encompasses the type of language used on the signage, which may include a single language, bilingual, or multilingual, incorporating local languages [42,44].

The graphic system focuses on the visual elements used on the signage and their harmonious unity [42]. This system includes graphics, arrows, graphic layout, destination icons, advertisements, and maps. Graphics refer to decorative patterns (geometric shapes or symbols with specific meanings) or actual photographs on the signage [45], and arrows are symbols used to indicate directions such as up, down, left, and right. Graphic layout involves the arrangement of graphics on the signage, and destination icons are used to identify destinations, such as apartments, parks, museums, restrooms, etc. [42]. Advertisements refer to commercial or public service advertising information on the signage, including text, images, or video advertisements [42]. Maps are thumbnail images of areas or routes displayed on the signage [42,46].

The hardware system involves all the physical components of the signage and their connections and stability [42]. This system includes color, color coding, size, shape, and material. Color refers to the overall color choice of the signage [42], and color coding is the method of differentiating information through various colors [42]. Size pertains to the overall dimensions or height of the signage [42,47], and shape is the design of the signage's form, such as square, directional shapes, or irregular shapes with special meanings [42,47]. Material refers to the substances used to make the signage, such as metal, wood, or biodegradable plastic [42].

This study reviews relevant literature according to the definitions of physical feature classification based on these three systems and provides a comprehensive analysis. Table 1 summarizes the main physical features of wayfinding signage.

Table 1. Wayfinding signage physical features.

Dimension	Features	References
Information system	Text, text size, text layout, font, languages	[42,44,48–51]
Graphics system	Graphics, arrows, graphic layout, Destination icons, advertisements, maps	[42,45,52–58]
Hardware system	Color, color coding, size, shape, material	[42,47]

Adapted from [42].

To conduct a comprehensive and systematic analysis of the aesthetic perception characteristics of wayfinding signage, this study employs Berlyne's (1974) landscape perception model and reviews related literature based on its definition across three dimensions. Firstly, the sensory-perceptual dimension describes pedestrians' intuitive psychological reactions to signage [59]. Under this definition, the aesthetic-perceptual characteristics of wayfinding signage include uniformity, uniqueness, and decoration. Uniformity refers to the psychological response when pedestrians perceive consistency and coordination in signage design, offering a harmonious overall experience; uniqueness is the reaction to the distinctiveness and recognition of signage design, allowing the signage to stand out among numerous

pieces of information; decoration is the aesthetic pleasure derived from the decorative elements on the signage.

The cognitive dimension describes how pedestrians understand and interpret the information on the signage [59], with aesthetic-perceptual characteristics including readability, accessibility, accuracy, and security. Readability assesses whether the information on the signage is easy to read and understand; accessibility concerns whether pedestrians can easily access the information; accuracy refers to the correctness and precision of the information; security pertains to the perception of safety that pedestrians have while using the signage.

The meaning dimension explores the deep cultural values conveyed by the signage [59], specifically encompassing local history, local culture, and landmarks. Local history involves the historical background and cultural stories displayed on the signage; local culture reflects the local cultural characteristics embodied by the signage; landmark indicates distinctive local symbols marked on the signage, all of which enhance pedestrians' cultural identification and sense of belonging with the signage.

Based on this model, this study reviews and analyses historical literature to organize and comprehensively discuss the aesthetic-perceptual of wayfinding signage. Table 2 summarizes the variables of aesthetic-perceptual for pedestrian wayfinding signage.

Table 2. Aesthetic-perceptual characteristics of the pedestrian wayfinding signage variable.

Dimension	Characteristics	References
Sensory perception	Uniformity, uniqueness, decoration	[40,42,48,60–62]
Cognition	Readability, accessibility, accuracy, security	[42,44,61–73]
Meaning	Local culture, local history, landmark	[9,49,62,64,67–69,71,72,74]

We first confirmed the effectiveness of visual preference as a method for evaluating the design of urban spaces, particularly in urban planning and environmental design. Through a review of relevant literature, we further understood that visual preference is driven by a complex mechanism involving the interplay of physical and psychological characteristics. The physical characteristics relate to the tangible design elements of wayfinding signage, such as text, graphics, and materials, which directly influence how pedestrians process information. The psychological characteristics emphasize the subjective perceptions and emotional responses pedestrians experience when interacting with signage, such as perceived uniformity, uniqueness, and the cultural or historical significance conveyed.

After reviewing the main variables of the physical and psychological characteristics of wayfinding signage, this research developed a visual preference model that integrates both aspects (Figure 2). This model clearly divides visual preference into two main dimensions: the physical features dimension and the aesthetic-perceptual dimension. This model highlights the interaction between physical features and aesthetic-perceptual, offering a structured approach to understanding pedestrian wayfinding signage visual preferences. By synthesizing insights from previous studies, this model serves as the theoretical foundation for further investigation into how wayfinding signage can be optimized to better align with pedestrian needs in complex urban environments.

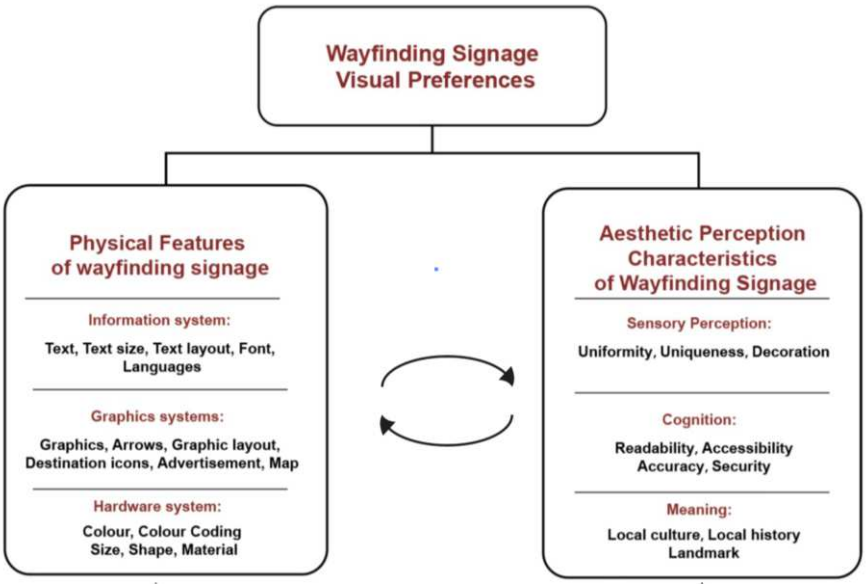


Figure 2. Model of pedestrian wayfinding signage visual preferences.

3. Materials and Methods

3.1. Photo Collection

To ensure the research sample comprehensively covered the variety of pedestrian environments and wayfinding signage in Nanning, this study collected photos of wayfinding signs across seven different urban districts of Nanning. The photographs encompassed a range of walking environments, including complex intersections, busy and quiet streets, commercial walking areas, financial districts, and residential areas (Figure 3). A total of 362 photographs were taken, ensuring the sample broadly represents the diverse application of pedestrian wayfinding signage throughout the city. This extensive collection of samples enables this study to accurately reflect the visual preferences of Nanning's pedestrians under various environmental conditions.

Figure 3. Pedestrian environment involved in the survey in Nanning.

All photographs were taken using a Canon 60D digital camera with a 5× optical zoom lens to ensure consistency in image quality and perspective. The camera height was fixed at 162 cm, aligning with the average height of women in Nanning, aiming to capture the

signage from the typical pedestrian's perspective. The shooting distance was maintained between 3 to 5 m, ensuring visual consistency and accurate proportionality of the scenes. All photographs were taken between 11 March and 7 April 2022, from 11 a.m. to 1 p.m., utilizing the stable natural light of midday to ensure uniform lighting conditions. This timing was chosen to minimize the impact of light variations, enhancing the comparability of the images. All photographs were taken with the same technical settings, including ISO, shutter speed, and aperture, ensuring technical consistency and thus enhancing the generalizability and reliability of the research findings.

3.2. Photo Selection Procedure

To ensure the representativeness of these photos, strict selection criteria were applied. Images that were blurry, overly crowded with people or vehicles, or poorly angled were eliminated, ultimately retaining 152 high-quality photographs. Additionally, to minimize errors potentially caused by background variations, photos were specifically chosen that were shot under similar lighting conditions and with non-intrusive backgrounds.

This study involved a panel of five experts (average age 44.60 $\pm$ 8.14, including 2 males and 3 females), comprising one urban planner, two wayfinding design experts, and two traffic engineers. Their tasks were to screen and categorize the photographs based on the visual characteristics of wayfinding signage. The expert panel conducted three rounds of discussions and evaluations. Each round was meticulously documented, with detailed records of the discussions and all decision-making processes recorded and transcribed to ensure transparency.

The meetings were conducted in a semi-structured manner. The research team first introduced the study's objectives and the wayfinding signage samples that needed to be categorized. Subsequently, each expert provided their preliminary assessments of the samples. Open discussions followed, where experts deliberated on the classification criteria and the appropriate categories for each sign. The evaluation results and consensus-building processes for each signage were recorded. In cases of disagreement, a majority vote determined the final classification. The classification criteria were based on the following three main characteristics: the shape, color, and map of the signage. Each category was quantitatively scored using a rating scale jointly developed by the expert panel, including specific evaluation metrics and corresponding score ranges. To verify the consistency and reliability of the classification, internal consistency testing was conducted, yielding a Cronbach's alpha coefficient of 0.85, indicating high reliability.

Under the supervision of the expert panel, the 152 photos were categorized into six groups (Appendix A). From these, 18 photos (3 per category) were selected for the questionnaire to ensure it was not too lengthy, which could cause participant fatigue, while still covering all categories comprehensively.

3.3. Questionnaire

To ensure the research results' intuitiveness and respondents' engagement, we utilized a photo questionnaire tool commonly used in visual preference surveys (VPSs). These photographs vividly displayed various types of wayfinding signage within authentic urban settings, enhancing the realism of the questionnaire. Such visual aids allowed respondents to accurately evaluate the design impact of each signage while also improving the accuracy of their responses and the response rate of the questionnaire. The questionnaire contained 24 photos showing different types of wayfinding signage in the study area. Photos are an effective method that can represent the actual environment [56]. Following the initial development of the questionnaire, a pilot test with 80 respondents confirmed its clarity and effectiveness, leading to minor refinements in question wording and layout. Reliability was assessed using Cronbach's alpha, yielding a value of 0.85, indicating strong internal consistency. Validity was verified through both expert evaluations for content validity and exploratory factor analysis (EFA) for construct validity. EFA confirmed that all factors had eigenvalues greater than 1 and explained 68% of the variance, supporting the validity of

the constructs measured. The questionnaire content was divided into four parts; the details are as follows (Appendix B):

Part One: Signage preference rating. Respondents were asked to rate their preference for 18 different signs using a 5-point Likert scale (1 = least preferred, 5 = most preferred). To enhance the objectivity of the assessment, three additional photos were inserted at the beginning and end of the questionnaire that were not included in the scoring, intended to warm up the respondents and prevent expectation effects.

Part Two: Evaluation of the aesthetic-perceptual characteristics of signage. Respondents were asked to evaluate the aesthetic-perceptual characteristics of six samples. These assessment questions were based on ten aesthetic-perceptual variables reviewed in this study. Each of the six samples was randomly selected from six different types of signage categories.

Part Three: Importance rating of the physical features of the signage. Respondents were asked to rate the importance of 16 physical features of signage using a 5-point Likert scale (1 = unimportant, 5 = very important).

Part Four: Demographics of the respondents. Respondents were required to provide their age, gender, marital status, level of education, professional background, and familiarity with Nanning.

Figure 4 illustrates the stages and components of this study.

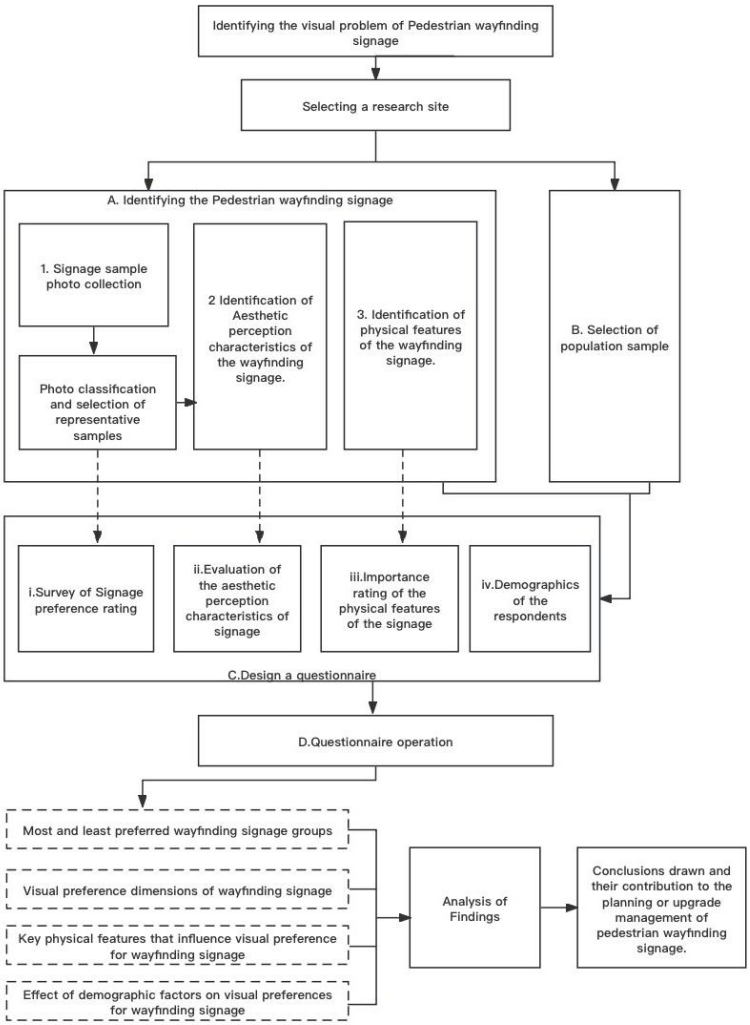


Figure 4. Research design.

This study has obtained ethical approval from the Ethics Committee for Research involving Human Subjects of University Putra Malaysia (JKEUPM), reference no: JKEUPM-

2023-139. All participants were informed about the purpose and anonymity of the survey and provided written informed consent before participating. The recruitment period for this study was from 3 May 2023 to 27 May 2023. Participants completed a paper-based questionnaire. The informed consent process was approved by the relevant ethics committee. We confirm that all methods were carried out in accordance with the guidelines and regulations of the Ethics Committee for Research involving Human Subjects of the University Putra Malaysia (JKEUPM).

3.4. Data Collection Procedure

To ensure a comprehensive reflection of pedestrians' perspectives across Nanning's diverse urban contexts, three survey sites were meticulously selected based on the following criteria to ensure scientific rigor and broad data coverage: (1) The survey sites span three different administrative districts of Nanning, each with roughly equal population sizes, to ensure diversity in geographic distribution (see Figure 5); (2) Each site has a high pedestrian traffic flow, ensuring a rich sample base and data validity; (3) The locations are situated in areas with diverse urban functionalities, including schools, residential zones, shopping centers, and public transit stations, aiding in capturing the visual preferences of pedestrians from varied socio-economic backgrounds. The three red markers in Figure 5 represent the specific survey locations.

Figure 5. Map of Nanning, China, showing the distribution of survey locations.

The sampling method employed was time-stratified sampling. Data collection was conducted at each site during four time slots—11 a.m., 1 p.m., 3 p.m., and 5 p.m.—to ensure the sample encompassed pedestrian traffic and behavior characteristics across different times of the day.

3.5. Population and Sampling Sizes

This study focused on pedestrians in Nanning, China, which has a population of 8,741,584 as of 2022. Utilizing Cochran's formula, the sample size was calculated considering a 95% confidence level and 5% error margin, resulting in a minimum of 384 participants for reliable representation. Eventually, 385 valid samples were collected, slightly above the threshold. The survey obtained informed consent from all participants, ensuring their awareness of the study's purpose and data confidentiality.

4. Results and Analysis

4.1. Analysis of the Most and Least Preferred Wayfinding Signage Groups

This study initially employed descriptive statistics to determine the average visual preference scores for 18 wayfinding signage samples. The descriptive analysis revealed that participants exhibited moderate preferences for Nanning's wayfinding signage, with an overall average preference score of 3.960 (SD: 1.022), indicating a slight preference for these signs. Subsequently, the signage was ranked based on average preference scores, distinguishing the five most and least favored signage photos. This step aimed to identify

the signs that performed best and worst in public preference. Figure 6 displays the most preferred group of signs, which scored an average preference of 4.114 (SD: 0.924), falling within the favorable range on a 5-point Likert scale.

Figure 6. The most preferred wayfinding signage group.

Figure 7 shows the least preferred group of signs, with an average preference score of 3.803 (SD: 1.131). Although this score is lower than that of the most preferred group, it remains within an acceptable range. The subsequent sections will provide a detailed analysis of the common features and differences between these two groups of signage.

Figure 7. The least preferred wayfinding signage group.

4.2. Analysis of the Visual Preference Dimensions of Wayfinding Signage

This study utilized SPSS 24 to conduct exploratory factor analysis (EFA) on 18 wayfinding signs to identify and interpret preference dimensions. Factor analysis was chosen because it allows for the reduction of multiple related variables into underlying factors, which

is particularly useful for identifying latent dimensions in preference data [75]. Initially, we verified the suitability of the data for factor analysis using the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's test of sphericity. The results showed a KMO value of 0.85, indicating good sampling adequacy, and Bartlett's test was significant ($p < 0.001$), confirming sufficient correlation between variables for EFA. Following Nunnally's recommendations, we ensured that each extracted factor's internal consistency (Cronbach's alpha) exceeded 0.7 (Nunnally, 1978), with each factor comprising at least three variables. Ultimately, four main dimensions were extracted, explaining 62% of the total variance, with Cronbach's alpha values all exceeding 0.7, indicating high reliability and internal consistency of these factors.

The factor analysis only identified four main dimensions, which did not completely align with the six categories previously classified by experts through different methods. To address this discrepancy, an expert panel employed the Delphi method to scientifically and uniformly name these four dimensions. In this process, each expert independently proposed names and their justifications, which were then compiled and reviewed by the research team. Adjustments were made after considering this feedback, and a final consensus was reached through multiple rounds of anonymous surveys. All feedback and decision-making processes were meticulously recorded and archived to enhance the transparency and scientific integrity of the analysis.

Table 3 displays the naming and preference ranking of the four dimensions. The highest-ranked dimension scored an average of 4.048, while the lowest-ranked dimension scored 3.774. Although the difference in scores between them is minimal, such subtle differences are significant in evaluating user preferences. This reflects the nuanced reactions of pedestrians to different Physical features and provides precise guidance for optimizing signage design and enhancing the pedestrian experience. Therefore, despite the small numerical gap, these ranking differences have significant practical implications and should be noted.

Table 3. Wayfinding signage: visual preference dimension rankings.

Rank	Visual Preference Dimensions	Mean	S. D	Alpha
Dimension 1	Aesthetically balanced pedestrian wayfinding signage	4.048	0.948	0.912
Dimension 2	Pedestrian wayfinding signage (lacking local meaning)	3.992	0.991	0.885
Dimension 3	Pedestrian wayfinding signage (lacking cognizance)	3.913	1.076	0.874
Dimension 4	Pedestrian wayfinding signage (lacking sensory perception and local meaning)	3.774	1.166	0.872

To gain a deeper understanding of pedestrian preferences or aversions to different dimensions of wayfinding signage, this study conducted a descriptive analysis of aesthetic-perceptual characteristics for representative samples from six categories previously determined by an expert panel. While initially, the expert panel had established six categories, with one sample selected from each for assessment, the exploratory factor analysis ultimately extracted only four main dimensions. This means that the original six samples were redistributed among these four dimensions, with each dimension containing at least one sample selected from the expert classifications. A detailed description of the results for each preference dimension is provided below.

4.2.1. Visual Preference Dimension 1: Aesthetically Balanced Pedestrian Wayfinding Signage

Dimension 1 consists of 7 wayfinding signage groups (Figure 8), with an average preference score of 4.048 (SD 0.948), representing the highest preference level across all signage dimensions. This dimension is dubbed "Aesthetically balanced pedestrian wayfinding signage". Signs 14 and 8, representing this dimension, are included in the participants' descriptions of aesthetic-perceptual, with participants considering this type of signage to

excel in uniqueness, consistency, decorativeness, readability, local cultural display, and information accuracy. Figure 9 provides a detailed performance overview of the signage in this dimension across 10 aesthetic-perceptual characteristics. It is evident that the signage in this dimension performs well in the areas of sensory perception, cognition, and local meaning, although a few characteristics received neutral evaluations. Notably, none of the characteristics received negative evaluations.

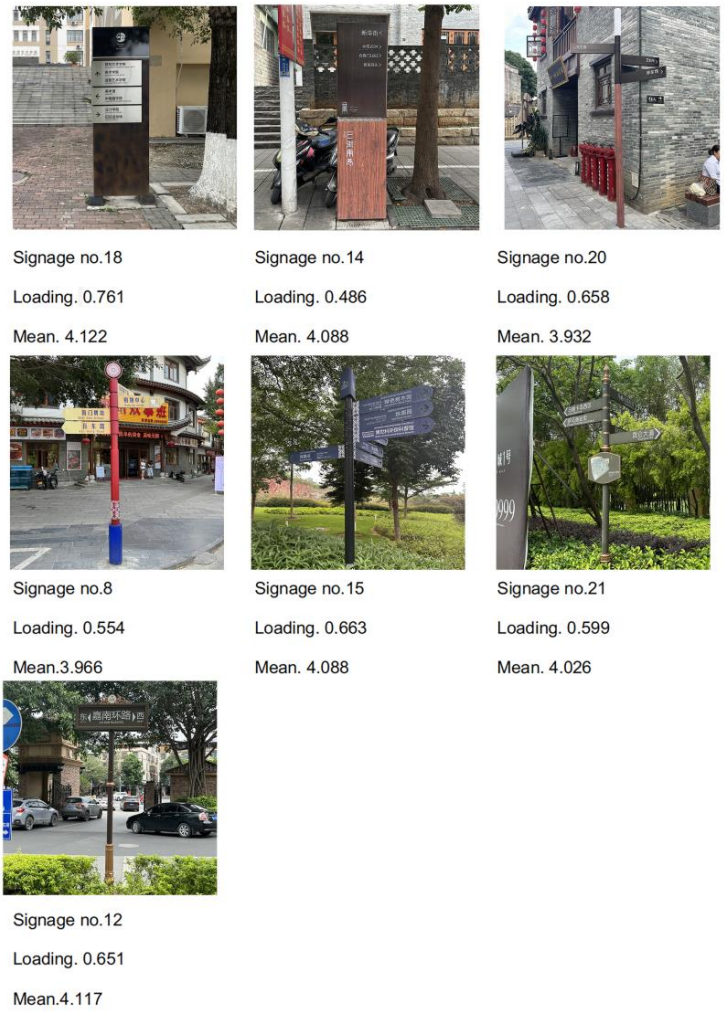


Figure 8. Visual preference dimension 1: aesthetically balanced pedestrian wayfinding signage.

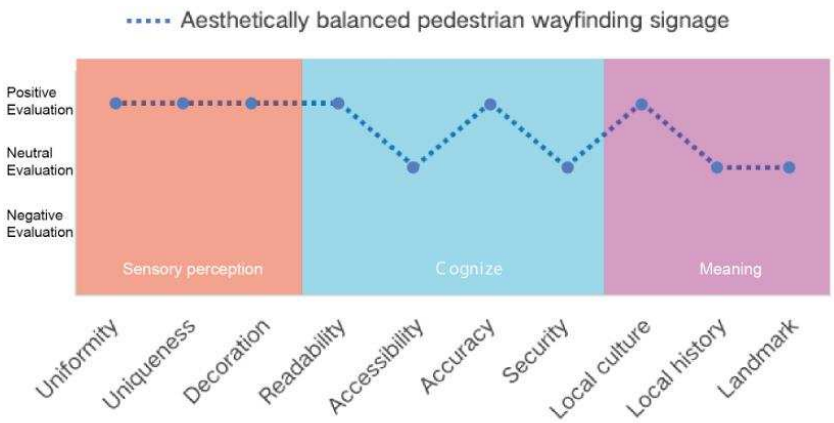


Figure 9. Evaluation of aesthetic-perceptual characteristics of visual preference dimension 1.

4.2.2. Visual Preference Dimension 2: Pedestrian Wayfinding Signage (Lacking Local Meaning)

Dimension 2 comprises four signs (Figure 10), with an average score of 3.992 (SD 0.991). It was named "Pedestrian wayfinding signage (lacking local meaning)". The participants' descriptions include signage 11, representing this dimension. While favored by participants for its excellence in uniqueness, unity, decorativeness, and readability, its lack of local significance reveals a critical shortfall in current designs. Figure 11 provides a detailed performance overview of the signage across 10 aesthetic-perceptual characteristics. The signage was favored by participants for its excellent performance in uniqueness, uniformity, decoration, and readability, but received moderate or negative evaluations in several other aspects. It is evident that the signage performs well in the dimensions of sensory perception and cognition, but the negative evaluations in the meaning dimension reveal significant shortcomings in the current design.

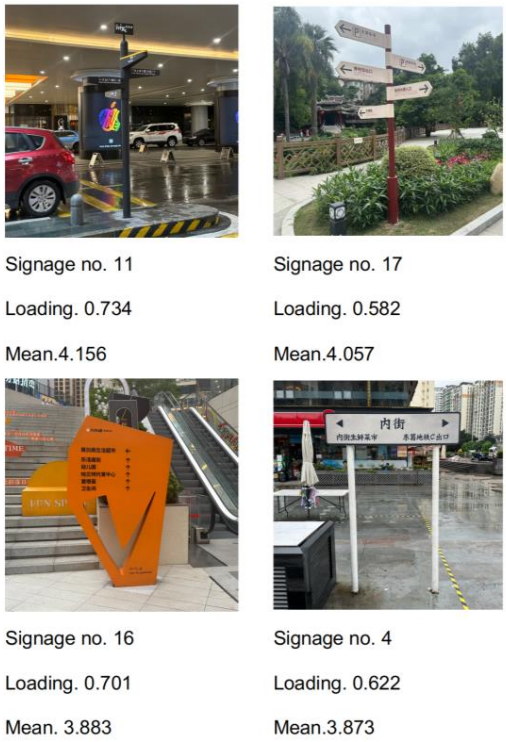


Figure 10. Visual preference dimension 2: Pedestrian wayfinding signage (lacking local meaning).

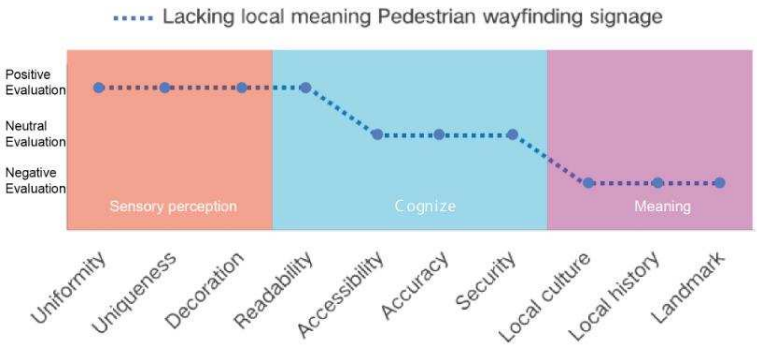


Figure 11. Evaluation of aesthetic-perceptual characteristics of visual preference dimension 2.

4.2.3. Visual Preference Dimension 3: Pedestrian Wayfinding Signage (Lacking Cognizance)

Dimension 3 consists of four signs (as shown in Figure 12) named "Pedestrian wayfinding signage (lacking cognizance)", with an average score of 3.913 (SD 1.076). Signs 10 and

19, representing this dimension, are included in the participants' descriptions. Figure 13 provides a detailed performance overview of the signage across 10 aesthetic-perceptual characteristics. Participants found the signage in this dimension to be difficult to understand, lacking in accessibility, and lacking in security. However, they also acknowledged its uniqueness, decorative aspects, and reflection of local culture. It is evident from the dimensional distribution that the signage performs well in sensory perception and meaning but receives very low evaluations in cognition. According to on-site responses from participants, the large maps on the signage made other information difficult to identify, leading to difficulties in understanding the information.

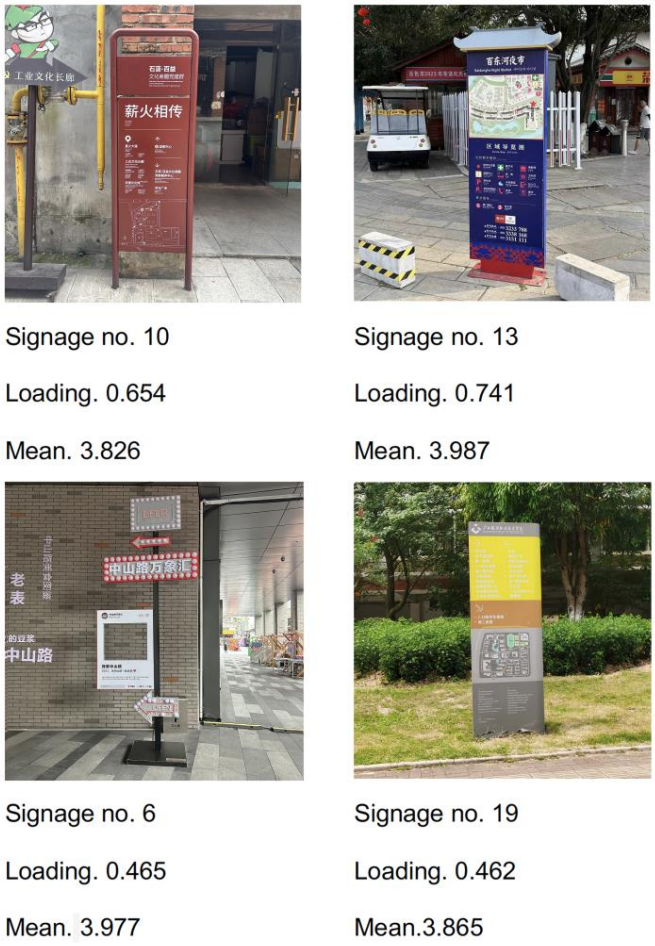


Figure 12. Visual preference dimension 3: Pedestrian wayfinding signage (lacking cognizance).

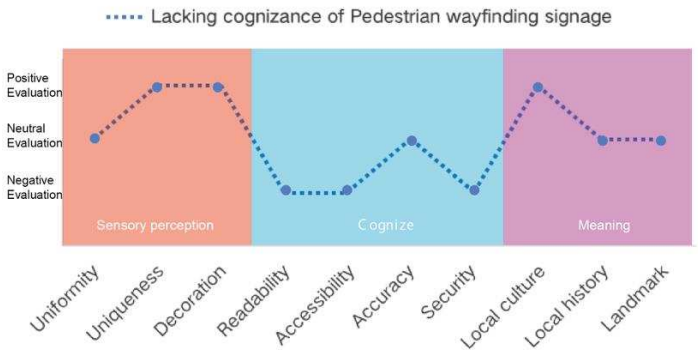


Figure 13. Evaluation of aesthetic-perceptual characteristics of visual preference dimension 3.

4.2.4. Visual Preference Dimension 4: Pedestrian Wayfinding Signage (Lacking Sensory Perception and Local Meaning)

Dimension 4 comprises three signs, as shown in Figure 14, named "Pedestrian wayfinding signage (lacking sensory perception and local meaning)", with an average score of 3.774 (SD 1.166). Notably, all signs in this dimension were rated as the least popular, reflected in their lower average scores, revealing the participants' general dissatisfaction when interpreting such signage. Signage 9, as a typical representative of this dimension, is included in the participants' descriptions. Figure 15 provides a detailed performance overview of the signage across 10 aesthetic-perceptual characteristics. Participants primarily considered it to be lacking in uniqueness, with average performance in both uniqueness and decoration. It failed to present local history, culture, landmarks, etc. However, due to its ease of understanding, accessibility, and accurate information, it received positive evaluations. It is evident from the dimensional distribution that the signage performs very well in cognition but received very low evaluations in sensory perception and meaning.

Figure 14. Visual preference dimension 4: Pedestrian wayfinding signage (lacking sensory perception and local meaning).

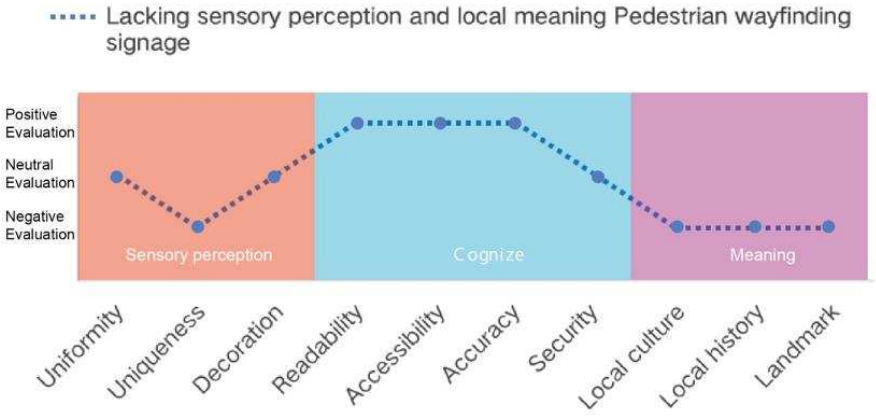


Figure 15. Evaluation of aesthetic-perceptual characteristics of preference dimension 4.

4.3. Analysis of Key Physical Features That Influence the Visual Preference of Wayfinding Signs

To comprehensively understand the key physical features that influence the visual preferences for wayfinding signage, this study employed a two-stage analytical approach. Initially, by comparing the most preferred and least preferred signage, common and significantly different physical features were identified, revealing potential factors affecting preferences. Subsequently, stepwise regression analysis further verified these factors, determining which physical features decisively impact visual preferences for wayfinding signage.

Firstly, the expert panel used the Delphi method to assess the similarities and differences between the two most and least preferred signage groups and four dimensions of

signage. This was to deeply uncover the potential factors influencing the visual preferences for wayfinding signage. Specifically, each expert independently assessed the performance of six signage groups on sixteen physical features. The research team then compiled and provided feedback on these assessments, which experts revised after considering additional opinions. Through several rounds of anonymous surveys and feedback, a consensus was finally reached. Table 4 displays the comparative analysis of the physical features' similarities and differences.

Table 4. Commonalities and differences in the physical features of wayfinding signage groups.

	The Most Preferred Signage	**The Least Preferred Signage**	**DIM1**	**DIM2**	**DIM3**	**DIM4**
Text	Correct	Correct	Correct	Correct	Correct	Correct
Text size	Suitable	Too big or too small	Suitable	Suitable	Too small	Too big or too small
Text layout	Tidiness	Tidiness	Tidiness	Tidiness	Tidiness	Tidiness
Font	Easy to recognize	Easy to recognize	Easy to recognize	Easy to recognize	Easy to recognize	Easy to recognize
Languages	Multilingualism	Single language	Multilingualism	Multilingualism	Almost no use of multiple languages	Single language
Graphics	All have graphics	Almost no decorative graphics	All have graphics	No graphics	Almost no graphics	No graphics
Arrows	Arrows present	Arrows present	Arrows present	Arrows present	Almost all have	Arrows present
Graphic layout	Small range	No graphic layout	Small range	No graphic layout	No graphic layout	No graphic layout
Destination icons	none	none	none	none	Almost none	none
Advertisement	None	Signage 5 contains advertisements	None	None	None	There are
Map	None	Signage 10 and 19 provide maps	None	None	There are	None
Color	Use of darker colors that harmonize with the surrounding environment	Use of bright colors that are noticeably distinct	Harmonious	Harmonious	Bright	Bright
Color coding	Bicolor coding	No color coding or multicolor coding	Bicolor color coding	Bicolor color coding	Monochrome or multicolor coding	Bicolor color coding
Size	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
Shape	Normal	Normal	Normal	special	Normal	Normal
Material	Special	Normal	Special	Normal	Normal	Normal

Note: Green refers to commonalities.

It is evident that the following physical features consistently presented similar characteristics across six groups: text, text layout, font, arrows, destination icons, and size. These elements displayed uniformity across all signage groups, indicating that they are fundamental features ensuring the functional operation of wayfinding signage, yet they have minimal impact on visual preferences. However, significant variations were observed in the following physical features across the groups: text size, languages, graphics, graphic layout, advertisement, map, color, color coding, shape, and material. Variations in these elements are considered potential factors affecting the visual preferences for wayfinding signage.

In the second phase, to further identify and validate the key physical features influencing the visual preferences of pedestrians, this study employed a stepwise regression analysis method, analyzing the critical impact of each physical feature across four dimensions of wayfinding signage preference. Initially, Table 5 presents the ranking of importance that pedestrians place on different physical features of wayfinding signage. Subsequently, we applied a stepwise regression analysis to specifically assess the key impacts of these physical features across the four preference dimensions, thereby validating which physical features play a significant role in influencing the visual preferences of pedestrians.

Table 5. Importance ratings of the physical features of the signage.

Design Elements	N	Mean	SD
Text	385	4.579	0.714
Arrows		4.556	0.709
Destination icon		4.553	0.720
Text Size		4.532	0.714
Text layout		4.499	0.726
Color		4.486	0.767
Graphic layout		4.483	0.750
Size		4.478	0.736
Map		4.434	0.788
Fonts		4.423	0.800
Material		4.382	0.831
Shape		4.369	0.862
Graphic		4.361	0.830
Language		4.286	0.867
Color coding		4.213	0.982
Advertisement		3.992	1.209

Note: 1 means least important, 5 means most important.

The results of the stepwise regression analysis (Table 6) indicated that four physical features had a significant impact on the visual preferences of pedestrians across various dimensions. Specifically, color exhibited a significant positive influence across all four dimensions, highlighting its importance in enhancing the visual preferences of wayfinding signage. Similarly, graphics showed significant effects in three dimensions: aesthetically balanced signage, signage lacking cognitive content, and signage lacking local significance. Additionally, text had a significant impact on dimensions lacking sensory perception and local significance, while material demonstrated significant influence in the dimension of aesthetically balanced signage. These four physical features are consistent with the potential influencing factors identified in the previous phase of the analysis, therefore confirming that these four physical features are key features in influencing the visual preferences for wayfinding signage.

Table 6. Summary of regression analysis results of the physical features of 4 signage dimensions.

Physical Features	DIM4	DIM3	DIM2	DIM1
Material	-	-	-	0.162, $p = 0.016$
Graphics	-	0.196, $p = 0.000$	0.259, $p = 0.000$	0.164, $p = 0.022$
Color	0.230, $p = 0.000$	0.325, $p = 0.000$	0.249, $p = 0.000$	0.254, $p = 0.000$
Text	0.229, $p = 0.000$	-	-	-
Adjusted R^2	0.160	0.208	0.193	0.232

4.4. Analysis of the Influence of Demographic Factors on Visual Preferences of Wayfinding Signs

Exploring the relationship between demographic factors and visual preferences for wayfinding signage can provide valuable insights for decision-makers. This study conducted a survey and difference analysis of respondents' backgrounds. The sample included 385 participants, with detailed background information presented in Table 7. Respondents

varied across age, gender, educational level, marital status, and professional background. Statistical analyses, including *t*-tests and ANOVA, were employed to examine the differences. The results of this study showed that the gender, age, and professional background of the respondents had a significant impact on the visual preference of wayfinding signs. Other demographic factors were not significant.

Table 7. Analysis of the demographic backgrounds of respondents N = 385.

Items	Categories	N	Percent (%)
Gender	Male	118	30.65
	Female	267	69.35
Age groups	Below 19	40	10.39
	19–39	298	77.40
	40–49	5	1.30
	50–59	16	4.16
	Over 60	26	6.75
Marital status	Unmarried	266	69.09
	Married	74	19.22
	Divorced	4	1.04
	Other	41	10.65
Educational level	High school and below	22	5.71
	College	63	16.36
	Undergraduate	257	66.75
	Postgraduate and above	43	11.17
Professional background	Related to Art	269	69.87
	Not Related to Art	116	30.13
Total		385	100.0

Table 8 presents the results of a *t*-test analysis showing the impact of gender on pedestrian preferences for wayfinding signage. In DIM3 (Pedestrian wayfinding signage lacking cognizance), the results indicate that the average score of females (3.97) is significantly higher than that of males (3.78), with statistical significance ($p = 0.049$). This suggests that females may have a higher acceptance of signage with insufficient cognitive functions. In DIM1 (aesthetically balanced pedestrian wayfinding signage) and DIM2 (Pedestrian wayfinding signage lacking local meaning), females (4.09) also scored higher than males (3.92), although the *p*-value is close to 0.05, suggesting a difference in aesthetic preferences based on gender. In DIM4 (Pedestrian wayfinding signage lacking sensory perception and local meaning) and DIM2 again, while the scores for females were higher than those for males, these differences did not reach statistical significance (*p*-values are 0.051 and 0.255, respectively). Overall, although females generally scored higher across all dimensions, significant differences were only observed in DIM3, indicating that females have a significantly higher preference for wayfinding signage with fewer cognitive functions compared to males.

Table 9 presents ANOVA results demonstrating the significant impact of age on preferences for wayfinding signage across various dimensions. The younger group (aged 19 and under) exhibited a higher preference in all dimensions, particularly in DIM1 (aesthetically balanced pedestrian wayfinding signage) andDIM3 (Pedestrian wayfinding signage lacking cognizance), with the highest scores of 4.38 and 4.39, respectively. The middle-aged group (aged 50 to 59) also showed similar high preferences, especially in DIM2 (Pedestrian wayfinding signage lacking local meaning), where the average score was 4.59, the highest among all age groups. In contrast, adults aged 19 to 39 scored generally lower across the four dimensions, with a score of 3.61 in DIM4 (Pedestrian wayfinding signage lacking sensory perception and local meaning), possibly indicating higher expectations for the functionality and design quality of directional signage. Overall, the younger and older age groups tend to show higher satisfaction with the signage, whereas the middle-aged segment has higher demands for quality and functionality in signage.

Table 8. Gender impact on 4 dimensions of wayfinding signage preferences: *t*-test results.

Variable Description	Group	Sample Size (N)	Mean (M)	Standard Deviation (SD)	Mean Difference (ΔM)	95% Confidence Interval (CI)	t-Value	Degrees of Freedom (df)	*p*-Value
DIM4	Male	118	3.62	1.10	−0.22	−0.449~0.001	−1.955	383.000	0.051
	Female	267	3.84	1.01					
	Total	385	3.77	1.04					
DIM3	Male	118	3.78	0.99	−0.20	−0.398~−0.001	−1.973	383.000	0.049 *
	Female	267	3.97	0.88					
	Total	385	3.91	0.92					
DIM2	Male	118	3.89	0.93	−0.11	−0.304~0.081	−1.139	383.000	0.255
	Female	267	4.01	0.86					
	Total	385	3.97	0.89					
DIM1	Male	118	3.92	0.83	−0.17	−0.344~0.000	−1.966	383.000	0.050
	Female	267	4.09	0.77					
	Total	385	4.04	0.79					

* $p < 0.05$.

Table 9. ANOVA results for the impact of age on wayfinding signage dimensions.

Signage Dimension	Age	N	Mean ± SD	F	*p*
DIM4	Below 19	40	4.33 ± 0.90	9.373	0.000 **
	19–39	298	3.61 ± 1.04		
	40–49	5	3.60 ± 1.36		
	50–59	16	4.50 ± 0.73		
	Over 60	26	4.35 ± 0.66		
	Total	385	3.77 ± 1.04		
DIM3	Below 19	40	4.39 ± 0.86	7.333	0.000 **
	19–39	298	3.78 ± 0.91		
	40–49	5	4.00 ± 0.94		
	50–59	16	4.50 ± 0.69		
	Over 60	26	4.29 ± 0.73		
	Total	385	3.91 ± 0.92		
DIM2	Below 19	40	4.36 ± 0.88	7.809	0.000 **
	19–39	298	3.85 ± 0.88		
	40–49	5	3.75 ± 1.16		
	50–59	16	4.59 ± 0.60		
	Over 60	26	4.45 ± 0.59		
	Total	385	3.97 ± 0.89		
DIM1	Below 19	40	4.38 ± 0.84	6.333	0.000 **
	19–39	298	3.93 ± 0.78		
	40–49	5	4.03 ± 0.97		
	50–59	16	4.55 ± 0.63		
	Over 60	26	4.38 ± 0.64		
	Total	385	4.04 ± 0.79		

** $p < 0.01$.

Table 10 presents the results of a *t*-test analysis demonstrating the significant influence of professional background on the visual preferences of pedestrians for wayfinding signage. The data indicate that individuals with an artistic background generally scored lower across all dimensions compared to those without an artistic background. Specifically, inDIM4 (Pedestrian wayfinding signage lacking sensory perception and local meaning), those with an artistic background scored 3.66, lower than the 4.03 scored by those without an artistic background. In DIM3 (Pedestrian wayfinding signage lacking cognizance), the artistic group scored 3.83, lower than the 4.11 of the non-artistic group. In DIM2 (Pedestrian wayfinding signage lacking local meaning), the score for the artistic background was 3.88, also lower than the 4.19 for the non-artistic background. In DIM1 (aesthetically balanced pedestrian wayfinding signage), which is also related to the lack of local meaning, the artistic group scored 3.96, lower than the 4.23 of the non-artistic group. These findings suggest

that individuals with an artistic background have higher visual preference requirements and hold stricter standards for the aesthetic and functional performance of signage.

Table 10. Professional background impact on 4 dimensions of wayfinding signage preferences: *t*-test results.

Variable Description	Group	Sample Size (N)	Mean (M)	Standard Deviation (SD)	Mean Difference (ΔM)	95% Confidence Interval (CI)	t-Value	Degrees of Freedom (df)	*p*-Value
DIM4	Related to art	269	3.66	1.04	−0.37	−0.597~−0.148	−3.265	383.000	0.001 **
	Not related to art	116	4.03	0.99					
	Total	385	3.77	1.04					
DIM3	Related to art	269	3.83	0.91	−0.28	−0.480~−0.082	−2.781	383.000	0.006 **
	Not related to art	116	4.11	0.91					
	Total	385	3.91	0.92					
DIM2	Related to art	269	3.88	0.89	−0.31	−0.504~−0.121	−3.212	383.000	0.001 **
	Not related to art	116	4.19	0.85					
	Total	385	3.97	0.89					
DIM1	Related to art	269	3.96	0.80	−0.27	−0.441~−0.098	−3.092	383.000	0.002 **
	Not related to art	116	4.23	0.76					
	Total	385	4.04	0.79					

** $p < 0.01$.

5. Discussion

5.1. Visual Preferences of Pedestrians for Wayfinding Signs

This study reveals that visual preferences of pedestrians for wayfinding signage depend not solely on a single dimension but require a balance between ensuring the accuracy and readability of information transmission (cognitive dimension), while also considering visual appeal (sensory perception dimension) and the expression of local culture (meaning dimension). This balanced perspective is seldom mentioned in previous research on wayfinding signage, which tends to focus on the impact of single physical features or dimensions. For example, studies by Yu et al. and Xie et al. mainly concentrate on the functionality and usage efficiency of signage [30,76], paying less attention to the combined role of local meaning and sensory perception. Conversely, although the studies by Ma et al. and Nafisur Rahman et al. highlight the importance of local cultural features, they do not fully consider the multidimensional impact of signage [77,78]. Building on this, our study's comprehensive perspective offers new insights: an effective wayfinding signage system should balance ensuring the accuracy and readability of information (cognitive dimension) with visual appeal (sensory perception dimension) and the expression of local culture (meaning dimension). This balance reflects the complex needs of pedestrians in modern urban environments and points out the shortcomings in previous research.

The analysis of dimension 4 holds practical implications for the city of Nanning. Field surveys indicate that wayfinding signage encompassed by dimension 4 is most widely used and distributed across Nanning. Specifically, signage no. 5 is extensively utilized in Nanning's pedestrian wayfinding project. While these signs excel in providing directional information (cognitive function), they lack sensory perception and expression of meaning. Their design reflects a common trend in current urban directional system design: prioritizing direct information transmission while neglecting users' sensory experiences and cultural connections. This design approach may lead to lower overall acceptance of these signs by pedestrians, thus affecting the directional effectiveness of urban spaces and pedestrian satisfaction. If Nanning could consider integrating sensory perception and meaningful aspects more in future signage designs, it would not only enhance the

pedestrian navigation experience but also showcase the city's cultural characteristics and aesthetic aspirations through the design of this public infrastructure.

For this purpose, it is recommended that the city of Nanning adopt a more comprehensive approach in future directional system design, balancing the functionality and aesthetic appeal of signage while emphasizing the integration of local culture. For instance, interactive wayfinding signage systems, which respond to touch screens or voice commands, would allow pedestrians to access specific information, such as local history and festival events. These signs could be designed to be visually appealing while providing detailed navigation information and guidance, also offering an engaging educational and cultural experience. Such signage could deliver rich content without sacrificing aesthetics, simultaneously enhancing the cognitive and meaningful functions of signage. Inviting local community participation in the design of wayfinding signage is also an excellent method, not only strengthening the functionality and aesthetic value of the signage but also fostering a sense of community involvement. This could be accomplished through inviting the public by directly inviting well-known or emerging local artists to participate in the creation of the signage. Artists could incorporate local cultural elements and stories into the design, making the signs not only navigational tools but also artworks that showcase local culture. The unique perspective of artists can add a distinct sensory appeal to the signage design, making it an integral part of the urban landscape. To make the signage design more inclusive and representative, the final design proposals could be opened to public voting. This could be conducted via online platforms or community events, allowing community members to participate directly in the selection process of the final design. This mode of involvement not only increases public acceptance of new signage but also enhances their connection to the local environment. Through these in-depth community engagement methods, wayfinding signage can effectively integrate sensory perception, cognition, and local significance dimensions, becoming a tool to foster community cohesion and cultural pride.

5.2. Key Physical Features That Influence the Visual Preferences of Wayfinding Signs

This study finds that the materials, colors, graphics, and text of wayfinding signage are significant physical features influencing the visual preferences of pedestrians. This discovery aligns with previous studies but extends a more comprehensive understanding of related factors. For instance, research by Rousek et al. demonstrated that signage with high-contrast colors and consistent decorative graphics improves recognizability [79]. Guo's research emphasized the symbolic design of artistic graphics and graphic symbols in directional signage systems, highlighting the role of emotional conveyance in enhancing cognitive efficiency and aesthetic value [80]. Additionally, Cook's study explored how different materials convey messages of durability and identity, emphasizing the impact of material choices on social perception and signage functionality [81]. Schnell et al. investigated the impact of the type, quantity, and complexity of textual information on short-term memory capacity, underscoring the critical role of text [82]. While these studies provide valuable insights within their respective fields, they typically focus on how single factors independently affect wayfinding signage. They often overlook how physical features interact in complex real-world applications and how these interactions affect ultimate visual preferences.

In response to these findings, this study proposes the following practical recommendations. Firstly, when selecting materials for wayfinding signage, prioritize not only weather resistance and visual appeal but also cultural relevance. For example, using local materials such as bamboo, stone, or traditional ceramic materials can reflect the area's heritage while ensuring durability. High-durability composite materials and UV-resistant coatings can also ensure that the colors and patterns of the signage remain vivid and durable in all weather conditions. Secondly, the design of signage colors and patterns should balance visual appeal with cultural symbolism. Utilizing principles of color psychology can optimize user emotional responses and cognitive efficiency, while also integrating traditional

colors and motifs that reflect the local identity. For instance, using red and gold in Chinese cities or maritime themes in coastal regions can enhance both the signage's effectiveness and cultural resonance. Moreover, ensuring the accuracy and timely updating of textual information is crucial for maintaining the practicality and functionality of signage. Regular checks and updates to wayfinding signage, especially in areas of rapid urban development or frequent traffic changes, can prevent navigation errors due to outdated information. Additionally, considering the inclusion of local languages or dialects in the text can both enhance accessibility and preserve the cultural heritage of the area. These recommendations aim to enhance the overall efficacy of the signage system, improve public navigation experiences, and increase urban space accessibility and safety.

5.3. The Influence of Demographic Factors on the Visual Preferences of Wayfinding Signs

This study analyzed the potential impact of various demographic factors, such as gender, age, marital status, and professional background, on visual preferences for wayfinding signage. The results revealed that age, gender, and professional background significantly influence visual preferences, while other factors like marital status and education level did not show the same statistical significance. These findings highlight the importance of considering these key demographic factors when designing directional signage to ensure broad applicability and effectiveness.

In light of the effects of gender, age, and professional background on visual preferences for wayfinding signage, it is recommended that a series of application suggestions tailored to meet the navigation needs of different demographics be developed. For example, in areas frequently visited by men, such as industrial zones and sports complexes, signage design should emphasize functionality and directness, such as incorporating detailed textual information (distance to destinations, detailed descriptions), using industrial-style materials, and colors and decorative patterns that align with male aesthetics to ensure the signage's functionality and practicality. Conversely, at locations predominantly frequented by women, such as maternity hospitals or parenting education centers, signage could emphasize soft color tones and elegant, curved decorative patterns to create a comfortable and friendly navigation experience. For pedestrians aged 19 to 49, who may frequently visit areas around universities, business parks, modern residential areas, and transportation hubs, signage should be regularly updated to ensure all information is current, especially regarding public transportation, subway stations, bus stops, hospitals, schools, and shopping centers, to assist these highly demanding groups in quickly locating and planning their routes. Enhancing signage with night-time illumination technology can also ensure its usability after dark. In areas frequented by artists and designers, such as craft markets or creative parks, wayfinding signage design should focus on innovation and aesthetics, employing unconventional materials and modern art styles, such as colored glass or fabric textures, incorporating local artistic elements to turn the signage itself into a miniature piece of art. By comprehensively considering these demographic factors, not only can the visual preferences of pedestrians for wayfinding signage be optimized, but adjustments can be made to ensure that the signage design more precisely meets the specific needs of each demographic group.

5.4. Contributions and Limitations with Suggestions for Future Research

This study advances theoretical understanding by bridging the gap between functional and aesthetic dimensions in urban wayfinding systems. Traditionally, wayfinding research has prioritized cognitive clarity, but this study introduces a critical perspective that highlights the role of visual preferences, suggesting that sensory perceptions and cultural resonance are essential for enhancing the pedestrian experience. The identification of material, color, graphics, and text as key elements offers a new framework for understanding how urban signage can simultaneously fulfill navigational and aesthetic needs. Practically, this research provides urban planners and designers with actionable insights to create signage that not only aids orientation but also enriches urban identity, advocating for a

design approach that harmonizes functionality with cultural expression, thereby enhancing both urban readability and the emotional connection between pedestrians and the city.

However, this study has limitations. Its geographic and cultural specificities, with data collected exclusively in Nanning, China, limit the generalizability of the findings to cities with different cultural contexts. Additionally, the use of photo-based surveys, while capturing initial impressions, may not fully reflect the dynamic interactions pedestrians have with signage in real-world environments. Future research should employ more immersive methods to simulate these interactions more effectively.

Future studies should expand the geographic and cultural scope through cross-cultural analyses in varied urban settings to examine how local aesthetics and urban forms influence the visual preferences for signage. Incorporating immersive methodologies such as virtual reality simulations or in-situ observations would offer deeper insights into how pedestrians engage with signage under different conditions, such as lighting, weather, and pedestrian flow. Additionally, exploring the integration of digital technologies like augmented reality or smart signage could reveal how these innovations complement traditional signs, offering personalized, culturally resonant wayfinding experiences. Long-term studies could further investigate how aesthetically enhanced signage influences pedestrian behavior, satisfaction, and urban experience over time.

6. Conclusions

This study provides a comprehensive analysis of the visual preferences of pedestrians for urban wayfinding signage, with the primary objective of understanding how these preferences shape signage design. Using a photo-based survey conducted with 385 pedestrians in Nanning, China, the research reveals that while many wayfinding signs perform well in delivering cognitive information, they often fall short in terms of visual preference due to poor sensory perception and inadequate conveyance of meaning. This study emphasizes that key physical attributes—such as material, color, graphics, and text—significantly influence the visual preferences of pedestrians. Additionally, demographic factors, including age, gender, and professional background, also impact these preferences, further highlighting the complexity of designing signage systems that cater to diverse user groups.

The findings indicate that current wayfinding designs may place too much emphasis on navigational function while neglecting sensory stimulation and the communication of urban culture, potentially diminishing the overall pedestrian experience. By addressing both functional and sensory needs, this study offers a more comprehensive approach to designing wayfinding systems that not only enhance urban readability but also foster a deeper emotional connection with the city.

Through this research, urban planners and designers are offered a framework for creating more engaging and culturally resonant signage systems that do more than simply guide—they enrich the urban environment. Moving forward, the lessons learned from this study will continue to inform efforts to create cities that are not only more navigable but also more visually and emotionally connected to the people who use them.

Author Contributions: J.Z. was involved in the conceptualization, methodology, software development, data curation, and writing of the original draft. N.U. contributed to the conceptualization, supervision, writing—review, and editing of the manuscript. All authors have read and agreed to the published version of the manuscript.

Funding: We thank the Guangxi Vocational Education Teaching Reform Research Project for supporting this study through the 2023 project titled "Exploration and Practice of Integrating Intangible Cultural Heritage Inheritance and Cultural Education in Higher Vocational Art Design Majors" (project No.: GXGZJG2023B140).

Data Availability Statement: The data underlying the results presented in this study are available from the Figshare repository at the following DOI: https://doi.org/10.6084/m9.figshare.26169175.v1 (accessed on 7 August 2024).

Acknowledgments: Authors would like to acknowledge Mohd Shahrudin Abd Manan and Faziawati Abdul Aziz for contributing to the conceptualization.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. Sign Categories and Representative Samples.

	Category Name	Representative Samples		
1	Square sign			
2	Monochromatic multi-directional sign			
3	Colorful multi-directional sign			
4	Monochromatic: pillar sign			
5	Colorful square sign with map			

Table A1. *Cont.*

Category Name		Representative Samples		
6	Colorful irregular-shaped sign			

Appendix B

Appendix B.1. Questionnaire Part A

Most and least preferred sign rating survey

Please select the number according to your preference for the wayfinding signage in the image below. 5 means most preferred and 1 means least preferred.

signage 1: 1 2 3 4 5 signage 2: 1 2 3 4 5

signage 3: 1 2 3 4 5

signage 4: 1 2 3 4 5

signage 5: 1 2 3 4 5

signage 6: 1 2 3 4 5

signage 7: 1 2 3 4 5

signage 8: 1 2 3 4 5

signage 9: 1 2 3 4 5

signage 10: 1 2 3 4 5

signage 11: 1 2 3 4 5

signage 12: 1 2 3 4 5

signage 13: 1 2 3 4 5

signage 14: 1 2 3 4 5

signage 15: 1 2 3 4 5

signage 16: 1 2 3 4 5

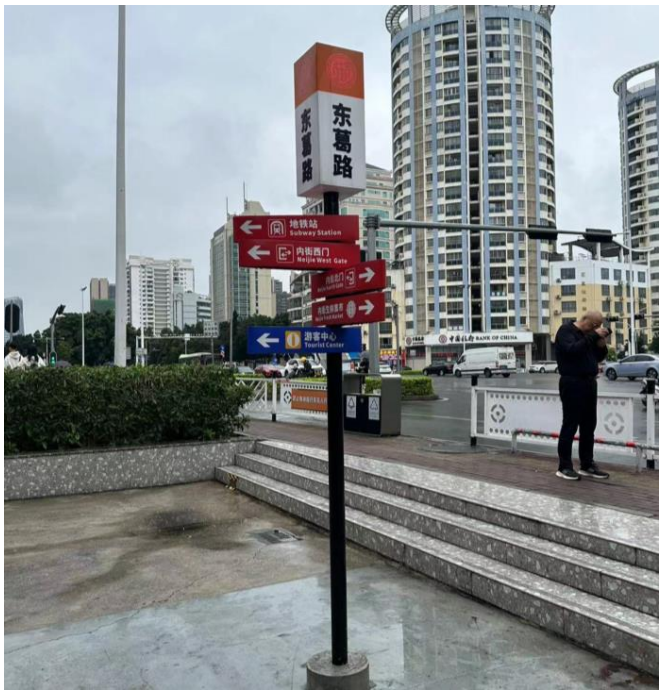
signage 17: 1 2 3 4 5

signage 18: 1 2 3 4 5

signage 19: 1 2 3 4 5

signage 20: 1 2 3 4 5

signage 21: 1 2 3 4 5



signage 22: 1 2 3 4 5

signage 23: 1 2 3 4 5

signage 24: 1 2 3 4 5

Appendix B.2. Questionnaire Part B

Evaluate of sign Aesthetic Perception

Please select a score based on the level of agreement with the phrase describing the picture, given the picture provided. A score of 1 indicates full agreement with the negative description on the left and a score of 4 indicates full agreement with the positive description on the right.

signage 1	Negative description	Couldn't agree more left side	agree left side	agree right side	Couldn't agree more right side	Positive description
	This type of sign is usually very cluttered.	1	2	3	4	This type of sign usually has a very unified visual appearance.
	It is quite ordinary.	1	2	3	4	It is quite unique.
	It is ugly.	1	2	3	4	It is very aesthetically pleasing.
	The information is often incorrect/outdated.	1	2	3	4	The information is usually accurate.

	It is difficult to understand.	1	2	3	4	It is easy to understand.
	Users with visual impairments or reading difficulties cannot understand this type of sign.	1	2	3	4	Users with visual impairments or reading difficulties can also easily understand this sign.
	Makes me feel unsafe/ difficult to find nearby hazardous areas or safe passages.	1	2	3	4	Makes me feel safe/easy to find nearby hazardous areas or safe passages.
	It did not make me notice the history of this place.	1	2	3	4	This sign makes me notice the history of this place/interests me in it.
	It did not reflect the unique culture of this place/made me lose interest in it.	1	2	3	4	It makes me notice the unique culture of this place/interests me in it.
	This sign did not showcase the landmarks of this place/ disappointed me.	1	2	3	4	This sign informs me about the landmarks of this place/interests me in it.
(Not required) Please write down your other thoughts on this sign:						

signage 2	Negative description	Couldn't agree more left side	agree left side	agree right side	Couldn't agree more right side	Positive description
	This type of sign is usually very cluttered.	1	2	3	4	This type of sign usually has a very unified visual appearance.
	It is quite ordinary.	1	2	3	4	It is quite unique.
	It is ugly.	1	2	3	4	It is very aesthetically pleasing.
	The information is often incor-rect/outdated.	1	2	3	4	The information is usually accurate.

	It is difficult to understand.	1	2	3	4	It is easy to understand.
	Users with visual impairments or reading difficulties cannot understand this type of sign.	1	2	3	4	Users with visual impairments or reading difficulties can also easily understand this sign.
	Makes me feel unsafe/ difficult to find nearby hazardous areas or safe passages.	1	2	3	4	Makes me feel safe/easy to find nearby hazardous areas or safe passages.
	It did not make me notice the history of this place.	1	2	3	4	This sign makes me notice the history of this place/interests me in it.
	It did not reflect the unique culture of this place/made me lose interest in it.	1	2	3	4	It makes me notice the unique culture of this place/ interests me in it.
	This sign did not showcase the landmarks of this place/ disappointed me.	1	2	3	4	This sign informs me about the landmarks of this place/ interests me in it.
(Not required) Please write down your other thoughts on this sign:						

signage 3	Negative description	Couldn't agree more left side	agree left side	agree right side	Couldn't agree more right side	Positive description
	This type of sign is usually very cluttered.	1	2	3	4	This type of sign usually has a very unified visual appearance.
	It is quite ordinary.	1	2	3	4	It is quite unique.
	It is ugly.	1	2	3	4	It is very aesthetically pleasing.

The information is often incorrect/outdated.	1	2	3	4	The information is usually accurate.
It is difficult to understand.	1	2	3	4	It is easy to understand.
Users with visual impairments or reading difficulties cannot understand this type of sign.	1	2	3	4	Users with visual impairments or reading difficulties can also easily understand this sign.
Makes me feel unsafe/difficult to find nearby hazardous areas or safe passages.	1	2	3	4	Makes me feel safe/easy to find nearby hazardous areas or safe passages.
It did not make me notice the history of this place.	1	2	3	4	This sign makes me notice the history of this place/interests me in it.
It did not reflect the unique culture of this place/made me lose interest in it.	1	2	3	4	It makes me notice the unique culture of this place/interests me in it.
This sign did not showcase the landmarks of this place/disappointed me.	1	2	3	4	This sign informs me about the landmarks of this place/interests me in it.

(Not required) Please write down your other thoughts on this sign:

signage 4	Negative description	Couldn't agree more left side	agree left side	agree right side	Couldn't agree more right side	Positive description
	This type of sign is usually very cluttered.	1	2	3	4	This type of sign usually has a very unified visual appearance.
	It is quite ordinary.	1	2	3	4	It is quite unique.
	It is ugly.	1	2	3	4	It is very aesthetically pleasing.
	The information is often incorrect/outdated.	1	2	3	4	The information is usually accurate.
	It is difficult to understand.	1	2	3	4	It is easy to understand.
	Users with visual impairments or reading difficulties cannot understand this type of sign.	1	2	3	4	Users with visual impairments or reading difficulties can also easily understand this sign.
	Makes me feel unsafe/difficult to find nearby hazardous areas or safe passages.	1	2	3	4	Makes me feel safe/easy to find nearby hazardous areas or safe passages.
	It did not make me notice the history of this place.	1	2	3	4	This sign makes me notice the history of this place/interests me in it.
	It did not reflect the unique culture of this place/made me lose interest in it.	1	2	3	4	It makes me notice the unique culture of this place/interests me in it.
	This sign did not showcase the landmarks of this place/disappointed me.	1	2	3	4	This sign informs me about the landmarks of this place/interests me in it.
(Not required) Please write down your other thoughts on this sign:						

signage 5	Negative description	Couldn't agree more left side	agree left side	agree right side	Couldn't agree more right side	Positive description
	This type of sign is usually very cluttered.	1	2	3	4	This type of sign usually has a very unified visual appearance.
	It is quite ordinary.	1	2	3	4	It is quite unique.
	It is ugly.	1	2	3	4	It is very aesthetically pleasing.
	The information is often incorrect/outdated.	1	2	3	4	The information is usually accurate.
	It is difficult to understand.	1	2	3	4	It is easy to understand.
	Users with visual impairments or reading difficulties cannot understand this type of sign.	1	2	3	4	Users with visual impairments or reading difficulties can also easily understand this sign.
	Makes me feel unsafe/ difficult to find nearby hazardous areas or safe passages.	1	2	3	4	Makes me feel safe/easy to find nearby hazardous areas or safe passages.
	It did not make me notice the history of this place.	1	2	3	4	This sign makes me notice the history of this place/interests me in it.
	It did not reflect the unique culture of this place/made me lose interest in it.	1	2	3	4	It makes me notice the unique culture of this place/interests me in it.
	This sign did not showcase the landmarks of this place/ disappointed me.	1	2	3	4	This sign informs me about the landmarks of this place/interests me in it.
(Not required) Please write down your other thoughts on this sign:						

signage 6	Negative description	Couldn't agree more left side	agree left side	agree right side	Couldn't agree more right side	Positive description
	This type of sign is usually very cluttered.	1	2	3	4	This type of sign usually has a very unified visual appearance.
	It is quite ordinary.	1	2	3	4	It is quite unique.
	It is ugly.	1	2	3	4	It is very aesthetically pleasing.
	The information is often incorrect/outdated.	1	2	3	4	The information is usually accurate.
	It is difficult to understand.	1	2	3	4	It is easy to understand.
	Users with visual impairments or reading difficulties cannot understand this type of sign.	1	2	3	4	Users with visual impairments or reading difficulties can also easily understand this sign.
	Makes me feel unsafe/difficult to find nearby hazardous areas or safe passages.	1	2	3	4	Makes me feel safe/easy to find nearby hazardous areas or safe passages.
	It did not make me notice the history of this place.	1	2	3	4	This sign makes me notice the history of this place/interests me in it.
	It did not reflect the unique culture of this place/made me lose interest in it.	1	2	3	4	It makes me notice the unique culture of this place/interests me in it.
	This sign did not showcase the landmarks of this place/disappointed me.	1	2	3	4	This sign informs me about the landmarks of this place/interests me in it.
(Not required) Please write down your other thoughts on this sign:						

Appendix B.3. Questionnaire Part C

	Importance rating of physical features Please choose your answer according to how much you agree with the following phrases. A score of 1 indicates strong disagreement, and a score of 5 indicates strong agreement.					
	Description Phrase	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Information system	Whether textual information is used in the sign is very important.	1	2	3	4	5
	Whether the font used in the sign is aesthetically pleasing is very important.	1	2	3	4	5
	Providing corresponding foreign languages (English/Japanese/Chinese/others) in the sign's location is very important.	1	2	3	4	5
	Whether the text layout in the sign is aesthetically pleasing and neat is very important.	1	2	3	4	5
	The size of the text in the sign is very important.	1	2	3	4	5
Graphic system	Whether decorative patterns are used in the sign (geometric shapes, color blocks, local ethnic patterns, location-specific patterns, landmark building patterns, etc.) is very important.	1	2	3	4	5
	Whether the sign provides direction-indicating arrows is very important.	1	2	3	4	5
	The size ratio of decorative patterns in the sign is very important.	1	2	3	4	5
	Icons for destination information in the sign (toilets, parks, restaurants, landmark buildings, etc.) are very important.	1	2	3	4	5
	Providing commercial/public service advertisements on the sign is very important.	1	2	3	4	5
	Providing maps (of the entire area/the location's position) on the sign is very important.	1	2	3	4	5

Hardware system	Using appropriate colors in the sign (eye-catching colors, colors harmonious with the surrounding environment, colors related to the city/location's characteristics) is very important.	1	2	3	4	5
	The color coordination of the sign is very important.	1	2	3	4	5
	The external shape of the sign (square, directional, irregular, shapes with special meanings, etc.) is very important.	1	2	3	4	5
	Appropriate size is very important for the sign.	1	2	3	4	5
	The material used for the sign is very important (cost-effective materials, easy-to-process materials, local specialty materials, materials with special effects or meanings).	1	2	3	4	5

Appendix B.4. Questionnaire Part D

	Importance Rating of Aesthetic Perception Characteristics Please choose your answer according to how much you agree with the following phrases. A score of 1 indicates strong disagreement, and a score of 5 indicates strong agreement.					
	Description Phrase	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Sensory perception	I hope the urban sign in our city have their own style/characteristics, distinguishing them from other cities.	1	2	3	4	5
	I wish for our wayfinding sign to be neat and uniform.	1	2	3	4	5
	I hope the wayfinding sign is attractive and serves as decoration for the streets.	1	2	3	4	5

cognize	It's important that the information provided by the wayfinding sign is accurate and updated in a timely manner.	1	2	3	4	5
	Wayfinding sign should be easily recognizable by individuals with color blindness/color vision deficiency.	1	2	3	4	5
	sign should be easy to understand.	1	2	3	4	5
	Wayfinding sign should make me feel safe/know the locations of escape routes/hazardous areas.	1	2	3	4	5
Meaning	I hope that the city's sign can convey the city's culture/characteristics.	1	2	3	4	5
	I wish for tourists to notice our city's history or become interested in it through the sign.	1	2	3	4	5
	I hope that the city's sign can inform about what the city's landmarks are/where they are located.	1	2	3	4	5

Appendix B.5. Questionnaire Part E

Respondents' background

Your Gender:	○Male ○Female
Your age group:	○Under 19 years old ○19~39 ○40~49 ○50~59 ○Over 60
Your education:	○High school or below ○Vocational/technical college ○Bachelor's degree ○Master's degree and above
How long have you lived in Nanning?	○Less than 1 year ○1–3 years ○4–6 years ○7–10 years ○Over 11 years
What is your occupation type:	○ Related to design/art ○ Nothing to do with design/art

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