A systematic review of factors influencing signage salience in indoor environments

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Review

A Systematic Review of Factors Influencing Signage Salience in Indoor Environments

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Abstract: Wayfinding signage is an intermediary public facility that coordinates the relationship between space and people, and it is crucial to help people find their way in complex indoor environments. In people's cognitive behaviour towards wayfinding signs, the visual salience of the signs is the prerequisite and key to ensuring their effective operation. This paper aims to review published research articles on the effect of indoor environments on the saliency of wayfinding signs. The literature review was conducted by PICO methodology to formulate the research question and develop search strategies. Relevant research articles were identified by systematically searching electronic databases, including Web of Science, ScienceDirect, ProQuest, and EBSCO. This paper summarises two categories of factors influencing signage salience: (1) floor plan factors and (2) environmental factors. This study examined and condensed the attributes of wayfinding signage and their impact on how pedestrians perceive visuals while navigating. Exploring the elements that influence the visual prominence of indoor signs enhances our comprehension of how pedestrians engage with visually guided information indoors. Furthermore, this offers a theoretical foundation for the realm of indoor wayfinding.

Keywords: signage; indoor environment; wayfinding; visual salience; decision points

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1. Introduction

When searching for a specific location, building, or environment, people often need to use cognitive strategies to understand environmental cues, a search process known as "wayfinding" [1]. Although the definition of wayfinding varies from study to study, it usually refers to finding the appropriate way to a specific destination or location [2,3]. The places for wayfinding include indoor and outdoor environments. Pedestrians getting lost indoors may lead to serious consequences, such as missing flights or being unable to locate emergency exits during building fires [2,4]. Outdoor pedestrians can utilise various methods to navigate easily [5]. However, indoor settings are often more constrained than outdoor environments, with narrow passageways, numerous details, and limited visibility [6–8]. Due to a lack of precise data and technology, indoor navigation research lags behind outdoor navigation. Therefore, landmarks and signage are necessary in complex indoor environments to guide routes and assist people in reaching their destinations. Compared to outdoor navigation, human visual behaviour is more intricate during indoor navigation [9]. Studies indicate that the impact of saliency on visual guidance is less pronounced in outdoor navigation [10,11]. On the other hand, it is widely believed that objects or signs with high visual saliency can attract attention during indoor navigation [12]. Signage is defined as objects that stand out from the surrounding environment in terms of visual, semantic, and structural attributes. They are typically used as supplementary tools or guides for navigation [13]. During indoor navigation, the visual saliency of signage predominantly influences visual attention [14]. Therefore, the visual saliency

of signage holds significant importance in spatial cognition research and the design of navigation systems.

Humans can determine the priority of information received from the visual environment in real time and process that information [15]. They can swiftly select information through visual attention. The development of complex building types (e.g., hospitals and underground spaces) has made indoor layouts more complex, leading to greater challenges in navigation and visual comprehension [16]. Therefore, inaccurate visual access can impede effective navigation and decision-making [17]. Faced with increasingly ambiguous and unfamiliar spaces, people often lose their sense of direction inadvertently [18]. To provide individuals with information about their location and route to their destination, signage systems have become an indispensable part of indoor environments. As a result, research focusing on destination routes and signage providing visual cues plays a crucial role in the visual information of indoor navigation.

Furthermore, an increasing number of researchers have delved into the study of the graphics, symbols, and text of signage to aid individuals in temporarily memorising their positions during indoor navigation [9,19]. Their commonality lies in the graphics and text associated with signage, which brings about distinct visual experiences. Simplified graphic signage possesses clear advantages; it can facilitate memory and communication among individuals by drawing attention [20,21]. Signage is pivotal in indoor navigation, serving as the foundation for planning destination routes and determining one's location [22]. Previous research has primarily focused on enhancing the informational capacity of signage graphics and symbols to improve environmental legibility [23].

Despite these encouraging findings, research exploring the visual saliency of signage in indoor environments has been scarce so far. Closing this research gap is crucial, as the visual saliency of signage is contingent upon the distinctive features of the surrounding environment [13]. Reflecting on the factors influencing the visual saliency of signage in indoor settings aids in comprehending how pedestrians attend to visual guidance information indoors, thereby facilitating improved indoor navigation.

This paper systematically integrates previous research and understanding, aiming to explore the factors influencing the salience of wayfinding signage in complex indoor environments, addressing the following questions:

- What are the theories related to human wayfinding in indoor environments?
- Which factors in indoor environments influence the saliency of signage?
- What are the research methods employed to study the visual saliency of signage?

To enhance indoor environment wayfinding, especially in transportation hubs, it is possible to formulate strategies that boost wayfinding efficiency by conducting a thorough review to understand the factors affecting the visibility and prominence of signage. These encompass factors influencing signage saliency and visual saliency techniques and methods in the following sections.

2. Materials and Methods

2.1. PICO Methods

The review paper typically requires manual searching to collect and organise relevant literature. The PICO method is a commonly used retrieval approach in the medical field, helping researchers quickly locate relevant literature resources by defining four key elements of the research question. These four elements include the Problem, Intervention, Comparison, and Outcome [24]. It should be noted that the PICO model is not limited to medical research; it is equally applicable to exploring research questions in other disciplines and fields [25]. By applying the PICO model, researchers can conduct literature surveys more systematically, ensuring that selected literature resources align with their research objectives and questions, thereby enhancing the quality and credibility of the literature review [26]. We employed the PICO method for our literature review to formulate research questions and develop search strategies (see Table 1). Relevant research articles were identified through systematic searches of electronic databases, including Web of Science,

ScienceDirect, ProQuest, and EBSCO. Among these sources, Web of Science includes a significant number of articles related to signage saliency.

Table 1. Illustration of the utilisation of the PICO method to structure the approach for conducting the search.

P	Problem	Indoor environment; Visual saliency of wayfinding signage
I	Intervention(s)	Floor plan; Environmental characteristics; Techniques and methods
C	Comparison of Intervention(s)	NA
O	The Outcome to Measure or Achieve	Wayfinding; Saliency of signage

This strategy employed several search terms within the defined research question, including wayfinding, indoor, signage, and visual saliency. For instance, in the case of Web of Science, the following search string was employed: (TS = (wayfinding) or TS = (wayfinding)) and (TS = (indoor)) and (TS = (signage) or TS = (signs)) and (TS = (visual saliency) or TS = (visibility) or TS = (legibility) or TS = (noticeability) or TS = (continuity)). Note: TS = Topic Search, encompassing titles, abstracts, keywords, and keywords plus®.

The initial list of records consisted of 793 articles obtained through database searches and 9 through manual searches. After removing duplicate reports, 738 articles were formed through a three-stage review process. A graphical representation of the search strategy is shown in Figure 1. In addition to the exclusion of conference papers, grey literature, books, book chapters, and notes, the inclusion and exclusion criteria were as follows:

(1) Studies related to wayfinding, indoor environments, signage, and visual salience.

(2) Studies focusing or partially focusing on factors influencing the visual salience of indoor wayfinding signage.

(3) Research conducted with real users through qualitative and quantitative methods; the methods used and results obtained must be thoroughly detailed.

(4) Analyses utilise exclusively peer-reviewed publications, while non-peer-reviewed articles only provide additional context and background.

(5) Articles are restricted to full text in English until June 2023 only.

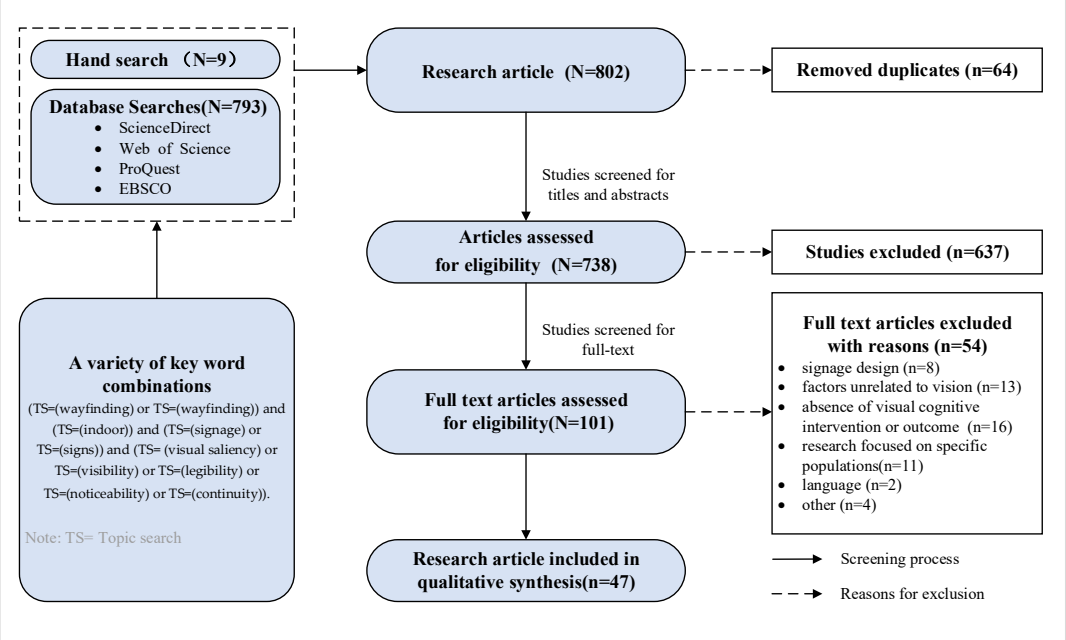


Figure 1. The flowchart of the search strategy.

After the screening, only 47 articles provided research related to the salience of wayfinding signage in indoor environments. We summarise and report the results of these studies and collate and compile the various factors and related theories that influence the visual salience of wayfinding signage in indoor settings.

2.2. Framework of Analysis

A review of past review articles and research articles reveals that the field of wayfinding initially focused on a few main themes, such as outdoor wayfinding, individual and group differences in wayfinding, and wayfinding behaviour in emergency situations [27,28]. However, recent research in the field of wayfinding has become more diverse, indicating the significance of this field, particularly in complex indoor environments. While spatial knowledge acquisition and cognitive mapping remain central areas, in recent years, some research areas have rapidly developed, including indoor wayfinding, signage, landmarks, and the use of eye-tracking and virtual reality [26,29].

In indoor environments, the central themes of review articles revolve around the evolution and trends in wayfinding research, with fewer reviews on the impact of signage on pedestrian wayfinding [30,31]. Research in this field is primarily concentrated in healthcare environments and emergency evacuation scenarios [32]. Despite various categorisations of directional signs, they only focus on specific aspects of signage design itself [33]. Therefore, a new framework is needed to further organise which specific factors within indoor environments might influence the saliency of signage in the indoor wayfinding process. By implementing this framework, factors will be combined with research methods to report findings across interdisciplinary domains.

The visual saliency of signage in the wayfinding process is a significant issue in spatial cognition research and wayfinding system design. Two major factors were identified in the reviewed studies: (a) factors related to signage design and (b) factors unrelated to signage design. Our study focused on the indoor wayfinding process, the role of signage saliency in visual guidance, and the associated research or evaluation methods. This paper provides a review from two aspects: (1) factors influencing signage saliency and (2) visual saliency techniques and methods. Indoor environments have two main factors that influence the saliency of directional signs: plan factors and environmental factors. Each of these domains has subdomains, and the number of articles at the intersection of each research domain is shown in Figure 2.

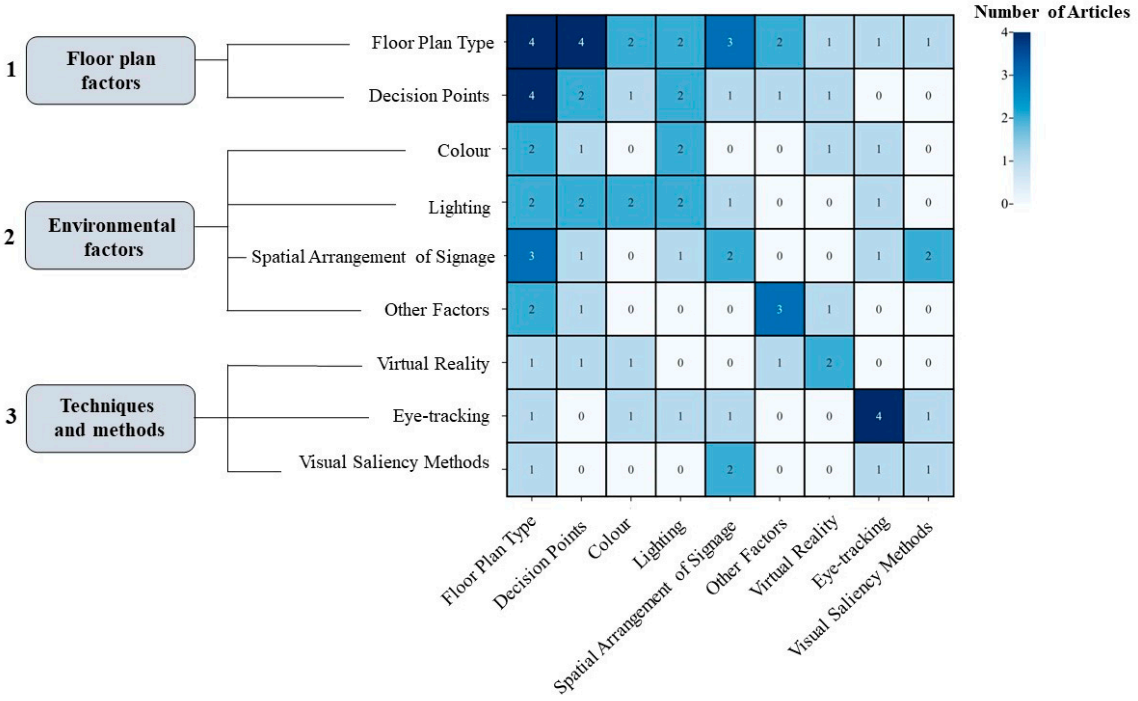


Figure 2. Co-occurrence matrix.

3. Results

Two categories of factors influencing signage saliency were identified: (1) plan-related factors, encompassing plan types and decision points, and (2) environmental factors, including colour, lighting, signage placement, auditory environment, smoke, and pedestrian flow. Additionally, research methods employed to explore its influencing factors and mechanisms were summarised, including virtual reality, eye-tracking techniques, and visual saliency modelling.

3.1. Factors Influencing Signage Saliency

3.1.1. Floor Plan Factors

Several studies have indicated that the complexity of floor plan layouts is a primary factor influencing wayfinding performance. Researchers can evaluate the difficulty of wayfinding by assessing the complexity level of floor plans [34,35]. When investigating the impact of different floor plan types on wayfinding efficiency, linear, circular, and grid floor plan types have shown significant effects (shown in Figure 3). Among these three types, linear floor plans positively impact wayfinding efficiency due to their strong sense of direction, enabling movement along the main corridor from one point to another [1]. On the other hand, circular and grid floor plans negatively impact wayfinding efficiency due to the frequent changes in direction and resulting ambiguity and confusion during wayfinding [36,37]. Circular layouts, with their movement around a central space in a circular path, present moderate wayfinding difficulty [38].

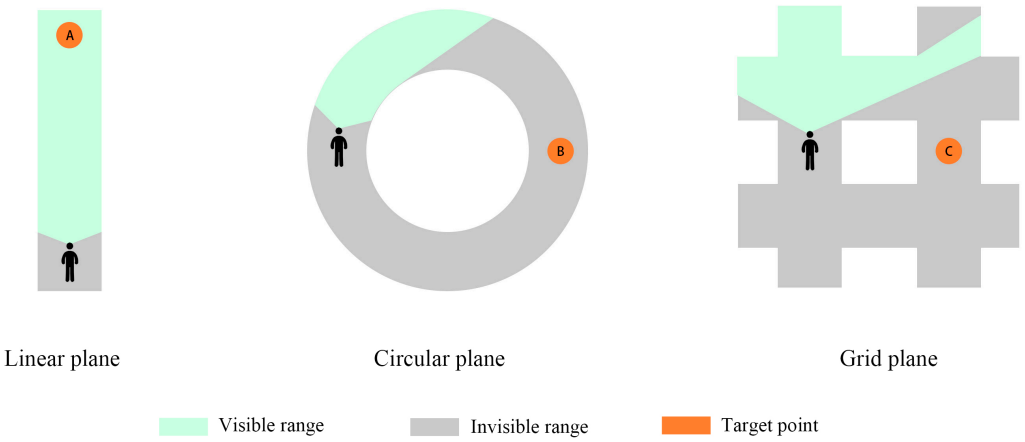


Figure 3. Comparison of Floor Plan Factors.

In contrast, grid layouts pose the most significant challenge to pedestrian wayfinding due to dispersed grid points, unattractive layouts, and higher complexity. Most researchers agree that signage must be placed in main entrances, corridors, intersections, and areas with multiple pathways within the floor plan to aid pedestrian navigation [39]. However, some studies suggest that placing temporary signs in these areas could lead to confusion among pedestrians [40,41]. In the areas where signage is placed, the visual range of decision points affects the usage of signage. A more comprehensive visual range at decision points enhances pedestrians' ability to acquire information from signage and positively influences indoor wayfinding performance [42].

It has been established that complex floor plan types significantly negatively impact wayfinding efficiency, but further exploration is needed to understand the effects of different combinations of floor plan types on wayfinding efficiency.

3.1.2. Environmental Factors

1. Colour

Colour serves as an environmental cue, and studies have indicated that the arrangement of colours within a building can directly impact the saliency of signage and pedes-

trians' acquisition of spatial cognitive information in unfamiliar environments [19,43]. Research shows that both the type and contrast of colours in the environment can influence signage saliency. Early studies focused on the impact of the number of colours in the environment on signage saliency. In the research conducted by Min and Ha in 2021, it was discovered that the presence of multiple colours in the surrounding environment impeded pedestrians' ability to rapidly and precisely acquire spatial knowledge (shown in Figure 4) [44]. Recent studies have explored the relationship between environmental background and colour contrast [45,46]. The results suggest that high-contrast colour combinations and solid-colour backgrounds contribute to wayfinding [46].

(a) The impact of less colour in indoor environments on spatial cognition

(b) The impact of excessive colour in indoor environments on spatial cognition

Figure 4. The impact of the presence of colours in the surrounding environment on pedestrians' ability to acquire spatial cognition.

However, existing research has predominantly focused on the influence of the number of colour types and the contrast of environmental backgrounds, lacking a comprehensive investigation into their combined effects. Additionally, certain specific colours' impacts on signage saliency have not yet been considered.

2. Lighting

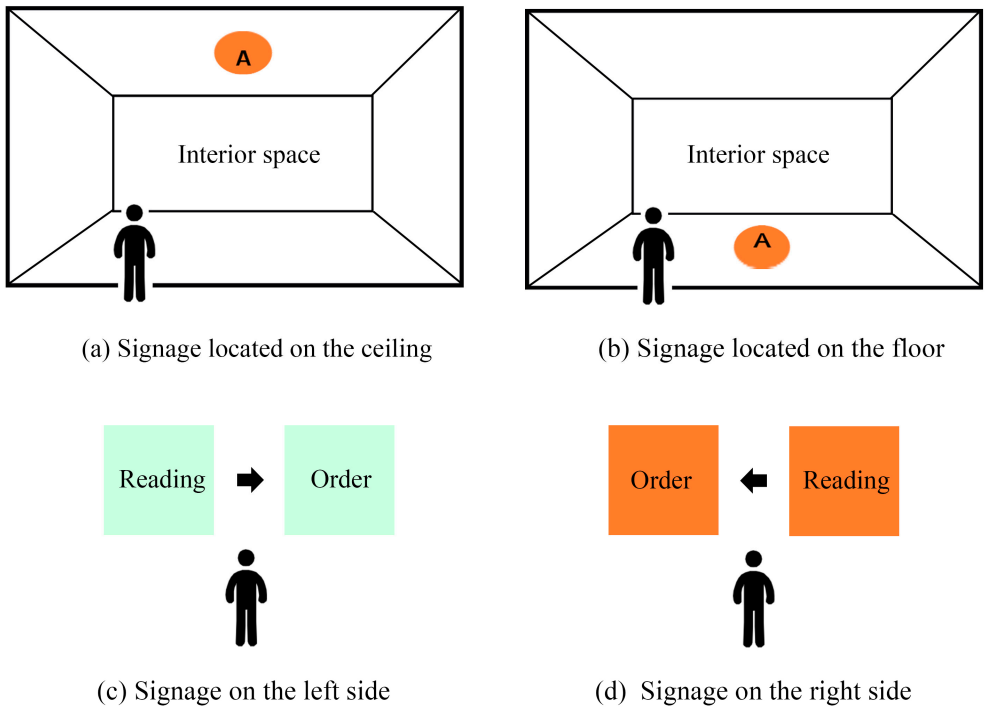
Lighting is a crucial factor influencing the saliency of indoor wayfinding signage, including both natural and artificial lighting. Concerning the impact of natural light on signage saliency, research has found that higher levels of natural light brightness in indoor environments lead to stronger signage saliency [47]. Fletcher et al. compared vivid dark and bright environments, suggesting improvements in signage brightness design recommendations [48]. Regarding the influence of artificial lighting facilities on signage, studies have shown that setting appropriate and bright lighting can enhance pedestrians' wayfinding efficiency [33]. Vilar et al. utilised virtual reality technology to simulate the visual environment of indoor corridors [49]. Their findings indicated that users' responses to warm and cool colours were more negative in low-light indoor environments. Lasauskaite and Reisinger conducted on-site investigations at Swiss train stations, revealing that signage saliency was higher under high ambient lighting conditions compared to low conditions [45]. However, an increase in signage saliency tended to saturate when lighting brightness reached a certain level.

Nevertheless, existing research primarily focuses on the impact of environmental lighting on the saliency of medical and transportation signage, with relatively fewer studies on other indoor spaces of buildings, particularly underground areas. Furthermore, studies utilising virtual reality technology only simulate the visual environment of indoor corridors, lacking simulations of complex indoor spaces.

3. The spatial arrangement of signage

The installation angle and position of signage can impact pedestrians' line of sight and reading habits, thereby affecting signage saliency. Researchers have been focusing on the influence of pedestrians' reading angles on signage saliency [33,50]. Garvey found that signage saliency is affected when the viewing angle is between 20° and 40° outside

the line of sight [51]. Cai and Green's research indicated that indoor signage installed near intersections with signage faces nearly parallel to the line-of-sight direction can be read more easily [50]. Zhu et al. discovered that signage installed on the floor is more easily recognisable by participants compared to horizontally installed ceiling signs [52]. Furthermore, the installation position of signage can affect pedestrians' visual attention [53]. Given the left-to-right reading habit, signage on the left side is more attractive (Figure 5). Similarly, using left-to-right descriptions and directional arrows provides a smoother, more efficient, and higher-quality wayfinding experience, especially in indoor environments [40].



(a) Signage located on the ceiling (b) Signage located on the floor

(c) Signage on the left side (d) Signage on the right side

Figure 5. Comparison of Signage Space Layout.

Compared to researching the impact of signage installation angles and positions on signage saliency, there is relatively limited research on the quantity and cognitively perceivable layout of indoor spatial signage. Additionally, the layout and content of signage should be adjusted appropriately for different age, cultural, and linguistic groups to ensure ease of understanding and acceptance.

4. Other factors

Additional indoor environmental elements such as sound, smoke, and people's movement can substantially influence the visibility of signs, especially during critical situations such as fire evacuations. Dalirnaghadeh and Yilmazer pointed out that the combination of visual signage and auditory environment enhances people's cognition of indoor spaces [54]. Xu et al.'s research indicated that environmental visual noise affects people's visual cognition and wayfinding ability [55]. High-noise environments could mask or make hearing audio cues from wayfinding signs difficult, thereby reducing their effectiveness. Additionally, if the auditory cues from directional signs resemble other sounds in the environment, it can also affect signage saliency.

In emergency scenarios, if smoke is present within a building, signage might become less salient due to the obscuring effect of the smoke, reducing their visibility [56]. Zhu confirmed the detrimental impact of smoke on wayfinding by simulating fire evacuation scenarios in a virtual subway station [53]. Similarly, crowd flow is a factor influencing signage saliency. In densely crowded situations, visual cues from signage might be obstructed or interfered with by the crowd, leading to the potential for signage to be ignored and reduced saliency. Lin et al.'s research demonstrated that in emergency evacuation scenarios,

the likelihood of people choosing exits with signage indicating a higher age or the exits chosen by most people around them is over 18 times higher than other exits [56].

These studies highlight the influence of indoor environmental factors on signage saliency. However, the current research landscape still exhibits limitations, requiring more comprehensive investigations from different perspectives into the impact of indoor environments on signage saliency and summarisation. To better comprehend signage saliency and enhance the legibility of signage in various settings, there is a need for more systematic research into the impact of these indoor environmental factors in the future.

3.2. Visual Saliency Techniques and Methods

Research methods applied to visual environmental cognition include virtual reality technology, eye-tracking technology, and visual saliency models. Studies employ subjective methods to analyse the correlation between individual cognition and wayfinding behaviour, including cognitive mapping, questionnaires, interviews, and behavioural observations [57,58]. With advances in scientific technology, computer simulation technology is gradually being applied to the field of wayfinding [59]. Researchers can better understand and simulate human behaviour and decision-making during wayfinding through these technologies. The application of computer simulation technology relies on standardised exploration of human physiological mechanisms to achieve accurate results and guidance. Currently, the primary focus of this technology is to study and optimise the visual interaction between "environment" and "vision," guiding better environmental design and path planning. Virtual reality technology can provide realistic environmental simulations, eye-tracking technology can record and analyse human gaze trajectories, and visual saliency models can help determine the level of attention humans allocate to the environment during wayfinding. The integrated application of these technologies and methods holds the promise of bringing new breakthroughs and advancements to the field of wayfinding research and practice.

3.2.1. Virtual Reality Technology

Virtual reality (VR) technology creates immersive environments through a combination of real-world data and computer simulations. Initially used for pilot training simulations, VR has gained popularity in architectural spatial environments due to its interactive advantages [60]. In recent years, VR technology has been applied to the analysis of cognitive behaviours in architectural space wayfinding [56], allowing researchers to explore the interactive mechanisms between spatial wayfinding behaviour and environmental cognition using virtual spatial environments.

In the field of wayfinding, studies involving VR technology include developing new algorithms for wayfinding problems within virtual environments [61,62], path planning and optimal path design during wayfinding processes [63], development of wayfinding visualisation and human–computer interaction tool systems [64], as well as investigations into visual perception and attention [23,65]. Through VR technology, the wayfinding process can be visualised for users, allowing them to intuitively understand and intervene in the wayfinding process. This technology has enabled researchers to delve into various aspects of wayfinding and explore the relationships between spatial perception, attention, and the built environment.

3.2.2. Eye-Tracking Technology

Eye-tracking technology, introduced from studies in psychology and neuroscience [66], has been applied to research and design focused on spatial wayfinding. Eye-tracking devices enable highly accurate measurements of various eye-related data to establish correlations between human vision and spatial environments. This technology can provide numerous metrics about eye movements, including gaze point positions, gaze duration, and the number of fixations. By conducting spatial wayfinding experiments with the aid

of eye-tracking devices, researchers can explore the relationship between human visual attention, direction, focus, and spatial environment design [67–69].

To identify elements that attract visual attention during wayfinding in indoor environments, researchers utilise eye-tracking technology to monitor subjects' eye movements and fixations in complex indoor and outdoor settings. Eye-tracking technology can also study human visual search behaviour, target detection abilities, and infer individuals' levels of attention and search strategies [70]. Furthermore, it can be used to understand decision-making and cognitive load levels during different wayfinding tasks and assess attention concentration [71]. Comparing differences in wayfinding behaviours under different environmental conditions, such as road layouts, traffic flow, and their impact on attention and wayfinding strategies, helps study how humans adapt to environmental changes [72].

3.2.3. Visual Saliency Methods

The use of visual saliency methods has become increasingly prominent in the field of computer science [73]. Specifically, visual saliency methods simulate the selective attention mechanism of the human eye through intelligent computer algorithms. The hotspots presented in saliency maps represent specific environmental information that attracts human eye fixation [57]. In navigation studies, visual saliency models can analyse the visual attention of pedestrians in a scene [59]. Currently, visual saliency is in its early implementation stage in navigation research, primarily focusing on urban visual interfaces, building facades, and other studies. Concerning the saliency of signage in indoor environments, Motamedi et al. (2017) used saliency models to simulate the visibility of intersection signs and proposed directional signage optimisation strategies [23]. Xu et al. (2020) utilised saliency models to simulate human attention to directional signage in indoor environments that affect traffic architecture, exploring the applicability of saliency models to simulate human visual attention in indoor settings [57].

These three research methods have distinct advantages, disadvantages, and focuses (see Table 2). Simultaneously, these three research methods can be combined to address various complex issues in the wayfinding field. For instance, VR technology can be utilised to research and develop algorithms and models that predict salient targets in virtual scenes. Analysing visual saliency information can help understand human attention to and interest in targets within the visual environment. Through eye-tracking technology, researchers can observe and understand users' navigation behaviour in virtual or augmented reality environments. By analysing eye-tracking data, insights into users' gaze points and attention distribution in virtual environments can guide the design and optimisation of virtual navigation systems. Comparing eye-tracking technology with computer-vision-based visual saliency can refine and validate the applicability of visual saliency models. In conclusion, the cross-disciplinary integration of different technologies can provide a more comprehensive and in-depth study of visual attention. For spatial navigation research, quantitative methods can present participants' behavioural patterns through visualisation, offering intuitiveness, efficiency, and persuasiveness. However, the technical complexity of visual saliency algorithms still poses a challenge for noncomputing professionals conducting architectural design and environmental psychology experiments, hindering the practical application of saliency models in the field of navigation.

Table 2. Advantages and disadvantages of visual saliency techniques.

Research Methods.	Advantages	Disadvantages	Wayfinding Behaviour	Visual Behaviour	References
Virtual reality technology	It can interact with the environment; the simulated environment can change rapidly.	The research object space is challenging to construct, and the research effect is better in a natural environment.	×	×	[62,74]
Eye-tracking technology	It can accurately measure the eye movement data.	Obtaining sufficient subject samples for the experiment is challenging, as conducting it within the research subject domain is hindered by safety concerns and other factors.		×	[75,76]
Visual saliency methods	It can be verified without requiring a sample of experimental subjects.	There are many types of saliency models, and the applicability of different saliency models to simulate scenes needs to be verified.		×	[63,77]

Note: Wayfinding behaviour refers to a person's ability to find targets or move from one place to another in complex environments; visual behaviour refers to a person's responses to visual stimuli, such as tracking and fixating on visual targets.

4. Discussion

This paper aims to explore the impact of signage saliency on indoor wayfinding behaviour and the associated research or evaluation methods. The systematic literature review summarised articles from the literature search highlighting the factors influencing directional signage saliency and the methods used to investigate them. The review aims to address the questions introduced earlier. The results of the analysis reveal that research on signage saliency in the field of wayfinding is relatively new. In recent years, with the increasing number of publications, the urgency of updating the overall research outcomes in this area has become evident. Two factors influencing signage saliency were identified: (1) plan-related factors and (2) environmental factors. Moreover, the review also outlined research techniques and methods employed to explore the influencing factors and mechanisms.

The complexity of architectural floor plans has an impact on pedestrian navigation. Different types of floor plans (linear, circular, and grid) influence pedestrian navigation to varying degrees. When designing signage, the influence of environmental colour on signage should be taken into account. Choosing brighter colours can enhance signage saliency if the environmental colour is similar. When there is a strong contrast, harmonising colours that stand out while maintaining harmony with the environment is recommended. Lighting environment factors, such as light intensity, source, direction, background colour, and reflectivity, also influence signage saliency. Additionally, signage height, angle, size, and shape adjustments should be made based on different cognitive and environmental requirements to enhance visibility and recognizability. Environmental noise and the complexity of architectural visual information also affect signage saliency. Virtual reality technology can provide more control variables but faces challenges when adapting to real-world settings. Combining virtual reality and eye-tracking technology can help assess indoor signage saliency by detecting pedestrians' attention points during navigation. However, current virtual reality technology and visual saliency models still fall short of fully simulating the human visual system, with accuracy requiring improvement.

Currently, literature primarily focuses on floor plan layouts, decision points, signage placement, environmental colours, and lighting, while factors such as sound, pedestrian flow, landmarks, and edge nodes receive less attention. Moreover, individual differences

such as gender, age, and culture also impact navigation but tend to be overlooked. Understanding the interaction between different individuals and their surroundings is of significant importance. Future research should emphasise a holistic approach to signage saliency, considering various factors rather than relying on a single indicator. Comprehensive studies that delve into the interplay of multiple factors are needed, as most existing research tends to focus on individual factors in isolation. Employing multiple technical approaches can yield more comprehensive qualitative and quantitative analyses and more accurately evaluate signage saliency in indoor environments. Thus, future research should aim to develop comprehensive methods that consider the combined effects of multiple factors and employ various technical approaches for experimental studies. We anticipate future research that will investigate the factors influencing signage attention within a given scene. This will be accomplished by evaluating the effectiveness of various visual saliency models and choosing an appropriate model for simulating indoor signage scenarios.

This study conducted literature searches across four databases; however, other relevant articles might exist in databases not included in this study. While the investigation was comprehensive, only 34 studies met the inclusion criteria, likely due to various limitations. Furthermore, the choice of keywords and search terms might have led to omitting or losing some available literature. Despite numerous studies exploring factors affecting both indoor and outdoor navigation, there is limited research analysing the impact of these factors on the saliency of navigation signage. Due to limited data, assessing the impact of various factors on signage saliency remains challenging. Additionally, factors such as the complexity of indoor environments, scarcity and incompleteness of real-world behavioural data, high costs, and difficulty establishing controlled experimental conditions significantly hinder researchers' ability to study this topic.

5. Conclusions

This study provides a comprehensive analysis based on environmental psychology, environmental behaviour, and visual cognition theories, focusing on the crucial factors influencing the visibility of indoor environmental signage. Through a systematic review of the factors influencing indoor signage, this paper aims to provide an in-depth understanding and beneficial guidance and recommendations for designers in planning wayfinding paths and evacuation routes. Conclusions are listed as follows:

(1) Two main categories affecting signage saliency were identified: plan-related and environmental factors.

(2) Research methods have been identified and utilised for investigating this field, encompassing virtual reality, eye-tracking technology, and models for assessing visual saliency.

(3) The utilisation of artificial intelligence and computer vision methods to explore and assess signage saliency represents a prospective avenue for future research.

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