

# A Review of Space Syntax Contextual Relevance for Cognitive Experience of Heritage Sites

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DOI: <https://doi.org/10.51244/IJRSI.2026.13010141>

Received: 06 January 2026; Accepted: 13 January 2026; Published: 07 February 2026

## ABSTRACT

Historic sites and places are vital settings for fostering sensitive understanding and acknowledging the existing cultural knowledge among people. However, understanding the spatial configuration and the correlations among heritage spaces can promote cognitive-based experiences. Space syntax is a well-known theory and research technique that examines how spatial analysis affects social characteristics. Even with its substantial contributions, some domains remain under investigated. This review paper will evaluate the inductive analysis of the effectiveness of space syntax in enhancing behavioural and cognitive experiences in and around heritage sites. The purpose of this study is to identify existing knowledge in space syntax, with a primary focus on the cognitive experiences of heritage sites. The study used the VOSviewer tool and the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) framework to systematically review a selection of papers from a Scopus database literature search, after screening 694 pertinent articles. Twenty-three publications were chosen for a thorough examination of existing knowledge after the inclusion criteria were used. This assessment of the literature took a fresh tack by combining and evaluating the varied existing applications and predictions of space syntax in planning and conservation. The discussions suggest a wide range of research contributions and directions for a comprehensive overview of cognitive analysis. In conclusion, exploring the interplay and integration of space syntax is robust enough to capture the cognitive experience of heritage sites. The study underscores the significance of space syntax, which sets the foundations for conceptual and methodological research frameworks to create sensitive environments in and around heritage sites.

**Keywords:** Heritage site, Space syntax, Spatial configuration, Cognitive experience, Spatiotemporal characteristics

## INTRODUCTION

Space syntax is a collection of theories and methods that examine how individuals navigate and use spaces in constructed environments. Space syntax predicts human performance in how people interact with one another in configurative spatial relationships in built environments [1][2]. It also envisages space as an integral part of human activity, and how spaces are configured influences how people perceive, use, and move through them [3]. In the 1970s, Space syntax was developed scientifically to explain how architectural and urban space is used [4]. Hillier and his colleagues suggested that, to better understand the people and societies that shape spaces, they represent a mathematical relationship between spaces within a system on patterns of space usage [5],[6]. There are four main components to space syntax. First of all, it serves as a representation of urban space[6]. The second technique is for analyzing cities as spatial networks of space created by the placement, arrangement, and orientation of buildings [7]. Thirdly, it provides a collection of methods for examining the connections between these spatial networks and functional patterns, land use, mobility, and social well-being [8]. Fourth, the overall relationship between urban space networks and the social, economic, and cognitive elements-based theories that are possible by space syntax [9], [10], [11]. Space syntax objectively quantifies spatial relationships[12]. The configuration of the urban street network itself plays a significant role in determining movement flows, regardless of their starting or ending points or the motivations behind their decisions to move [7]. Space syntax

quantitatively describes the spatial layout and its correlation with social activities such as movement, navigation, behaviour, and even social meanings [13]. The trend of Space syntax in research as a method solicited in various categories of urban and architectural spaces includes traffic flow [14], [15], pedestrian and vehicular mobility [16], land use efficiency for crime distribution [17], [14], urban renewal, regeneration, and revitalization, cognitive map studies[18], mental imagery[19], social interactions[20], accessibility, navigation [21], social equality [8], [22] wayfinding and behavioural studies[23], [24].

According to earlier records, significant syntactic measures have been tested for understanding and analyzing various spatial properties using axial line analysis (ALA). ALA examines a network of lines of access in a plan, and connections between spaces, which also abstractly considers the human behavioural characteristics, such as movement paths and navigational choices[25]. The convex space analysis (CSA) develops the spatial layout to be described visually by connecting straight lines connecting any two points in a space where people interact, and visually navigate[26], [13]. Isovist analysis (ISA) is based on the visibility that geometrically represents the spatial-visual properties of space [27]. The other techniques are used with justified plan graph (JPG) analysis, visibility graph analysis (VGA), axial segment analysis (ASA), and agent-based simulation (ABS) by using the DepthmapX software tool [11][28]. The space syntax is applied with quantitative measures for various syntactic measures in urban design, conservation, planning, and architecture [29], [30], [31]. In addition, space syntax inspects the studies on heritage protection and preservation [32], [32], [33], adaptive reuse, rehabilitation [34], World Heritage sites, urban heritage sites, historic core, and town[35], historic precincts[36], urban revitalization[37], sustainable heritage[38], tourism heritage sites[39], [40], [41], historic neighborhood, policymaking [42], semi-detached historical areas[43], historic gardens[44], conservation strategy[45], heritage management and development plan, industrial heritage[46], historical street[47], density and land use of the historical region[17], [40], archaeological research[48], heritage housing [34], and modern heritage[49]. The scope of the study largely recorded a broad spectrum of analyzing wayfinding[44], [50], navigation[47], movement[23], walkability[51], accessibility[52], visitor impact[53], spatial-functional[39], morphological[54], historical[55], Spatial-temporal activity[56], and spatial cognition[57].

While several literature reviews have been conducted for space syntax, their scope and focus were restricted to the following areas: socio-spatial experience[25], healthcare[58], Enhancing (Mohamed & Van Der Laag Yamu, 2024) the sociability of urban space [24] and the geographic distributions and contributions of published space syntax research[24]. The spatial experience review is yet to be more fully explored, with cognitive-based experience specifically reviewed in planning and conservation. Therefore, a thorough literature review of the cognitive experiences of heritage sites is conducted, using space syntax as a methodological framework. The heritage sites are characterized as dynamic[59]. Heritage sites are culturally defined as significant with various values and associations. However, the review of cognitive experiences is intended to better understand heritage sites and precincts. To address existing knowledge and directions, a comprehensive literature review is conducted on the applicability of space syntax to the cognitive experience of heritage site spaces. Therefore, with a primary aim of cognitive experience, the current study highlights the existing knowledge boundaries of space-syntactic inquiry and offers predictions relevant to heritage site spaces for future research.

The research question primarily investigated is: How do spatial characteristics of space syntax enhance understanding of heritage site spaces for better cognitive experiences? This research anticipates assisting urban planners, conservators, and architects in uncovering this unexplored area within the space syntax literature and in identifying strategies for creating a culturally sustainable environment. The conservators can comprehensively integrate the approach in conservation and planning by exploring other research tools that can strengthen the research design methodology for heritage sites. These presumptions will guide the organization of this work. Following this succinct introduction, Section 2 will offer a thorough explanation of the material and methods used in this adopted literature investigation. The established research will be thoroughly examined, and 28 papers will be screened in Sections 3 and 4. The observations in Section 3 will be consolidated. Lastly, the conclusion and potential directions will be presented in Section 4.

## MATERIALS AND METHODS

In the past, researchers have frequently used literature reviews to examine what is already known about a subject, assess its limitations, and predict possible future developments [24], [60]. By emphasizing present scientific gaps and heavily utilizing previous research findings, this method is crucial for developing policies and expanding the scope of current research [13]. The current research has revealed drawbacks of traditional methods for

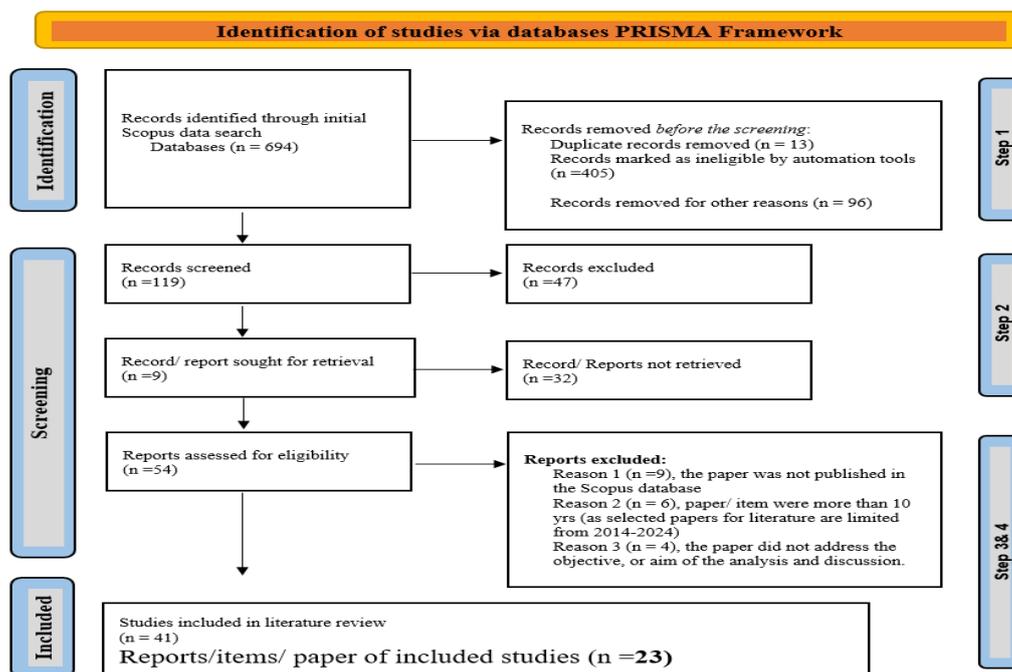
literature reviews, including a lack of scientific rigor, intrinsic biases, and significant omissions [61]. In the field of social science research, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards have gained widespread recognition as a leading paradigm for systematic literature reviews. Nonetheless, current research has revealed the drawbacks of traditional methods for literature reviews [61]. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses standards have become a prominent paradigm for systematic literature reviews in the social science research sector, garnering significant respect and recognition. The PRISMA framework was selected because of its rigorous and systematic approach, which ensures a thorough and objective synthesis of the present research, given the topic's vast and complex nature—applying space syntax to increase sociability in urban public spaces [25]. PRISMA's transparent and systematic approach ensures that the research gaps identified are supported by a comprehensive, reliable framework, enabling the discovery of all relevant studies. The research technique used in this systematic review adhered to the PRISMA guidelines.

### Search Strategy

A comprehensive literature review was conducted to identify gaps in the application of space syntax to enhance the cognitive experience of heritage site spaces, in line with the study's goal. To document the analytical process and the inclusion criteria, a pre-established protocol was developed. As a result, from August 2, 2024, through January 19, 2025, a thorough search of the Scopus database was conducted for all pertinent papers. Among other credible academic databases, Scopus was selected for its broader coverage. To ensure the accuracy of the resources, the search encompassed a wide range of publications from sources listed in Figure 3, including MDPI, Elsevier, Springer, Taylor & Francis, Sage, etc. To control for all potential articles relevant to studying spatial cognition and the experiential characteristics of heritage sites, the authors chose to keep the search items as inclusive as possible, given the broad nature of the topic and the applicability and extent of space syntax for heritage sites. Hence, the search protocol for this study included the following terms: (space syntax AND heritage) OR (spatial cognition AND heritage sites) AND (spatial characteristics AND Heritage sites).

### Inclusion and Exclusion Criteria

To increase the dependability of the search procedures, some restrictions were included. acquired books. For example, the search was limited to articles and review journal papers because of the stringent peer-review process for journal publications. Likewise, the other languages were not included in the search results; only English was used. The identified records' titles, abstracts, keywords, and other necessary bibliographic information were exported to a 2016 Microsoft Excel Spreadsheet.



**Fig. 1.** The Flowchart of the PRISMA Framework, Screening Process

## Data Analysis

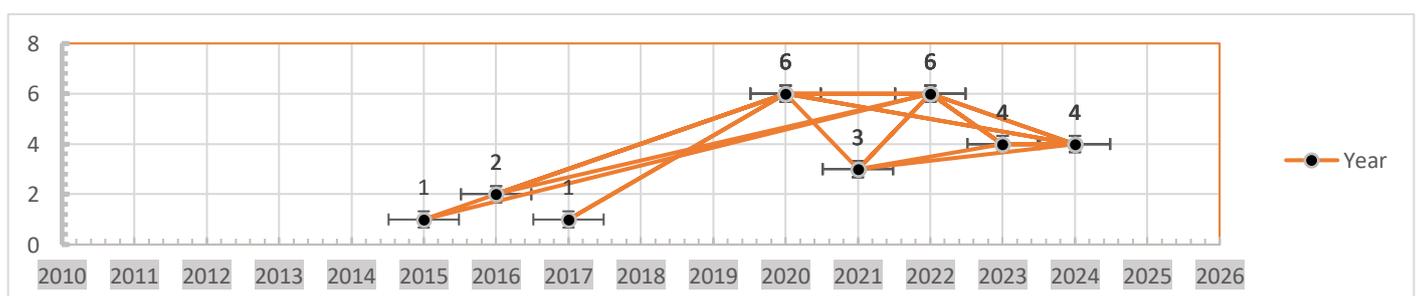
To gather essential information for the study, a thorough review of the selected publications was conducted. Miles investigated a wide range of research gaps, including the knowledge, evidence, methodological, practical, empirical, theoretical, and population gaps, to evaluate the current level of knowledge [62][63]. This review further transformed the gathered data into the categorized items based on the subthemes using inductive analysis for the content analysis. In other words, to begin gathering essential information for the study, a thorough review of the chosen publications was conducted. Several study gaps, such as the knowledge, methodological, empirical, and population gaps, were investigated to evaluate the current level of knowledge[57], [64], [65], [66]. Preliminary assessments were conducted by collecting data in line with the formulated research question. The biases towards the literature review have been independently evaluated to resolve and achieve consensus. Research on the concepts and themes of urban conservation and space syntax has shown a cumulative trend in academic databases; in particular, over the last five years, the number of pertinent articles has increased significantly. As illustrated in Figure 4, in addition to the systematic review, the VOS viewer software, which provides substantial discipline-wide structure, was used to analyse term co-occurrence in the data. To ensure the validity and reliability of the systematic review's outcomes, sensitivity analyses were conducted to assess the robustness of the synthesized results.

## Discussions on the screened articles

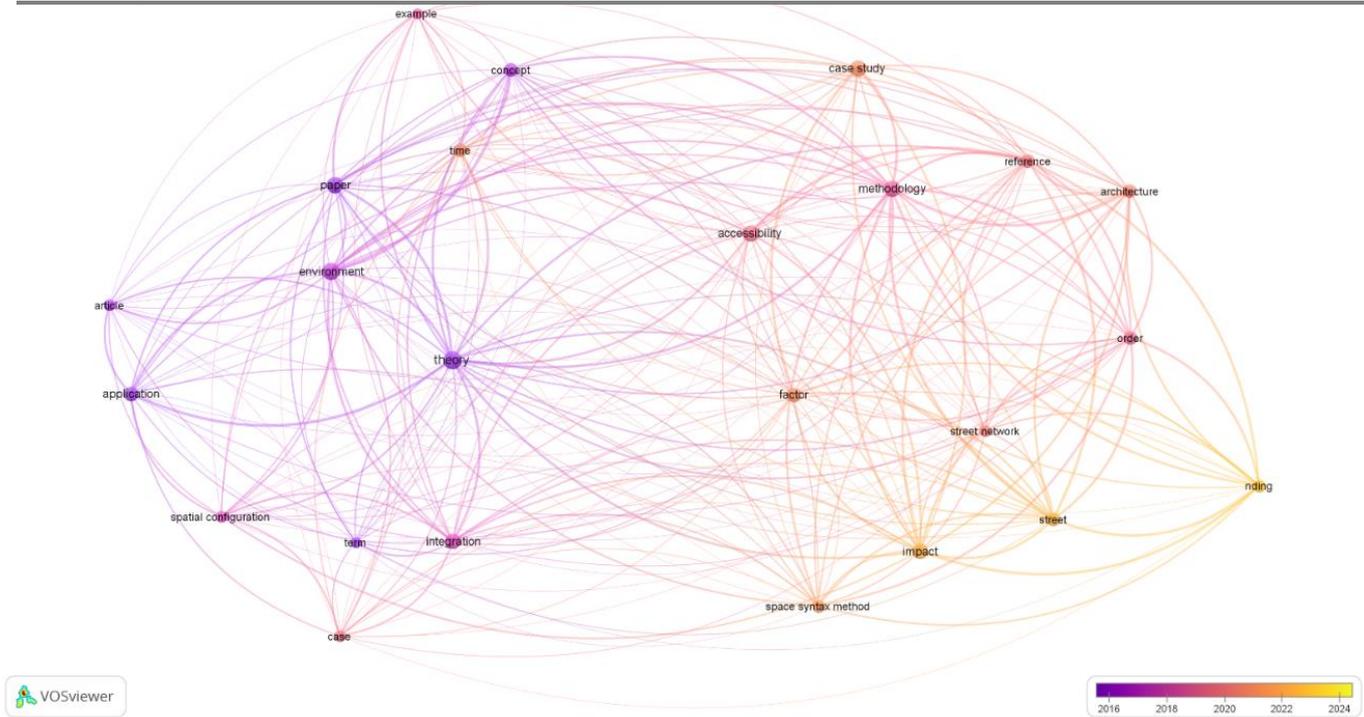
### General Overview

The publication of research on space syntax and heritage sites in journal articles has revealed a cumulative tendency in academic databases; in particular, during the last five years, the number of pertinent publications has increased significantly. The biggest contributions in this discipline are made by scholars in China, the United Kingdom, and the United States, according to statistics. Delft University of Technology, University College London, and Istanbul Technical University have so far contributed the most. Sustainability, Buildings, and Urban Tourism are the top three publications, with the most papers on space syntax. Additionally, Professors Bill Hillier, Michael Ostwald, and Laura are noted as the most prolific authors of academic articles exploring space syntax interdisciplinarity. Young researchers may find these statistics useful in identifying the most prominent syntactical researchers and the journals that publish syntactical research the most frequently. In the next step, the obtained keywords were collected from articles on heritage sites using space syntax as a research method, collated from the Scopus database. Spatial configuration, urban morphology, street network, accessibility, movement patterns, pedestrians, social activities, architecture, heritage neighbourhoods, sustainable development, heritage streets, industrial spaces, wayfinding, historic gardens, town and city revitalization, urban conservation and preservation, and public spaces were among the terms frequently used in urban studies that were found to be significantly correlated with space syntax (Figure 2). The way various areas of space are navigated, moved, accessible, and visible can affect how people are likely to move through them and interact with the surroundings.

In this regard, space syntax can be examined in terms of its applicability and limitations. In addition, the terms "cognition", "spatial", and "configuration" have attracted growing interest in the social and psychological effects of using spatial analysis of spaces with space syntax as a method, with the ability to be applied to a certain extent in a heritage context. Overall, the word cloud from the literature study explores a complex and important subject: the integration of other tools to make objective and subjective investigations more effective for evaluating culturally rich, valuable heritage sites.



**Fig. 2.** Frequency of journal-type publication recorded for the literature review



**Fig. 3.** Co-occurrence of words recorded from the literature review

After removing extraneous publications, the target papers were scrutinized in depth to identify gaps in the field. The findings indicated that, among the case studies that adopted the space syntax technique for spatial analysis, Iran, Turkey, Algeria, and China were among the most frequently chosen study areas in these empirical analyses. In the context of the study, however, more urban cultural context-based studies have been explored to understand heritage site spaces in China. More than 80% of the target studies used the visual graph model, the axial model, and the Isovist. The analysis of the syntactical models was measured with connectivity, integrity, and intelligibility based on choice and integration variables. 20% of the target studies used mixed methods to assess the spatial and cognitive qualities of heritage spaces. The adopted methodologies indicate the widespread preference for integrating space syntax and mixed methods to capture the cognitive experience in and around heritage places. The listed paper emphasizes the importance of using a variety of techniques when recording heritage places with diverse interests, and it is published in high-impact journals. Space syntax was most commonly used in conjunction with questionnaires, interviews, empirical observations, MCDM- Multi-Criteria Decision Making, GIS- Geographic Information System, AR-Augmented Reality, and eye tracking. Nevertheless, the particular focus on the methodological and empirical gap is further discussed in the following subsection.

### Analysis and Discussions on Listed Articles

An outline of the field's present level of knowledge, uncovering the latest achievements that contribute to understanding heritage sites in a cognitive experience way, with space syntax applicability. Tim Stonor's analysis of pedestrian activity patterns revealed two major problems: tourists do not travel from Trafalgar Square to Parliament Square, and Londoners avoid the Trafalgar Square area [5]. The Space syntax applicability-based questions for heritage-related have a long track record. These existing studies used space syntax to explore the cognitive experiences of the significance of historic sites. Palaiologou & Griffiths [42] stated that space syntax provides a framework for understanding and analyzing spatial configurations in urban environments, which can be valuable for policy development in heritage urbanism. By adopting a diachronic understanding of spatial cultures, policymakers can ensure that heritage is integrated into contemporary urban practices. Specifically, space syntax can inform three key research areas: conservation areas, street scales, and the broader concept of spatial cultures. This approach helps create policies that respect historical contexts while promoting sustainable urban development. According to Karimi [4], [67] A configurational approach to analytical urban design involves using methodologies like 'space syntax' to inform and enhance the urban design process. Whereas Shiran Geng [68], attempted to explore the potential of space syntax while introducing factors such as coherence, mystery,

and legibility to evaluate experiential qualities. The spatial characteristics were investigated using a spatial form distribution of the ancient area of Naxun Canal town streets. John Rollo [38] Further suggested that studying from an experiential perspective can help address physical, social, and spatial cognition, reflecting people's perceptions, and could provide a sensitive understanding of future development pressures. A questionnaire survey can be conducted to test whether there is a correlation between residents' and tourists' perceptions and interpretations. To better understand the relationship between the psychological and physical aspects of the space, Borolosy [43] research combined the method used in this paper, which involves evaluating the visibility features of each path and testing people's perceptual responses in each path, Bazazzadeh [46].

A review of previous studies found that, despite a wide range of approaches to the conservation and development of historical context, relatively few examined how spatial legibility affected the creation of cognitive maps. Askarizad's [18] study closely analyses the relationship between legibility and cognitive maps in a heritage context, focusing on the organization and configuration of spatial layout, interaction between people, and their perception of the environment. This approach starts with baseline analyses to identify potential design problems, enabling data-driven decisions throughout the design process. Space syntax enables designers to quantitatively analyze spatial configurations, leading to more effective urban planning and design outcomes [67]. Zerouati [48] has used space syntax analysis at the UNESCO archaeological site of the Roman city of Setif to understand the urban layout and spatial relationships within this ancient city. Zerouati & Bellal [22] aim to uncover how the urban spatial configuration influences social interactions and urban activities in key spaces such as theatres, markets, and temples by implementing line analysis, Visibility Analysis, and Agent-Based analysis [64]. The results suggest that the two major street networks were more intelligible, with mostly socially integrated spaces for urban activities. Such analysis is essential for comprehending urbanization patterns that are more closely integrated with the system. David L. Chatford Clark's [69] study explores how visibility and accessibility in Byzantine churches in Jordan are analyzed using space syntax. The visibility graph analysis and point Isovist examine the spatial organization.

Turner [70] inspects the six typological churches, shedding light on changes in liturgical practices and installations such as the altar, ambo, and presider's chair. The visual patterns guided the placement of community interactions over time. Fan Mo [71] used the Space Syntax approach to utilize improved pedestrian accessibility and safety in George Town, Penang. This methodology involves modelling and analysing the unique conditions of the area's pedestrian landscape to identify effective strategies to enhance pedestrian movement and ensure pedestrian safety. The mathematics of spatial transparency and mystery in Yuyuan Garden can be analyzed through syntactical data by examining the layout, pathways, and visual connections within the garden, Rongrong Yu [72]. This involves using mathematical models to represent relationships among spaces, garden parts, and their accessibility, enabling a deeper understanding of how these elements contribute to the garden's overall experience and aesthetic. Such analysis can reveal layers of meaning and deepen appreciation of its design. The study of spatial form cognition in historical streets in Hongcun Village employs a space syntax approach, combining spatial analysis with cognitive imagery to explore how historical street layouts influence human movement and interaction. This method quantifies spatial structures and their relationships to human behaviour, helping to understand the cognitive dimensions of these spaces [54]. Li & Kormecli [45], [66] Both addressing the accessibility of urban tourism in historical areas, particularly at UNESCO World Heritage Sites like Safranbolu, can vary significantly. [66] Safranbolu features well-preserved Ottoman architecture, and while it attracts visitors for its cultural and historical value, factors such as uneven cobblestone streets, limited public transportation, and historical features that may not be easily accessible can pose challenges for tourists, especially those with mobility issues. Zerouati [73] Efforts to improve accessibility, including infrastructure improvements and enhanced services, have been made to ensure that everyone can enjoy the site's historical significance. Mansouri & Ujang [21] analyzed data by using heat maps, mathematically and visually, and demonstrated space syntax analysis to provide an understanding of tourist space at historic sites. Despite their widespread application in urban planning and other domains, space syntax and cognitive intention each have drawbacks when applied separately. The two approaches working together can have a complementary effect.

For instance, Xiao Feng [56] examined several sections of Hengyang City's ancient urban area using the cognitive map approach and space syntax, and identified a viable point at which the two theories work in tandem, Hyun Lee [55]. Geng [41] suggests that future research may examine how the spatial restructuring of Safranbolu's historical centres will impact social and economic life. More significant issues in space syntax may

be identified by examining the city's morphology, accounting for the road network and people's mobility patterns. Manioudis & Meramveliotakis [55]. Sharmin & Kamruzzaman [26], [55]. The inclusion of human movement in evaluation parameters to create inclusive living spaces between people and the city. Individual spatial preferences of behaviours are not directly taken into consideration by the methods employed in this work, while they offer a statistical and geometrically mapped generalization of spatial and visual features [74]. Rongrong Yu [72] suggests that, instead of determining the visual accessibility and several responsible attributes that contribute to the analysis of Yuyuan Gardens' characteristics, the feeling of spatial mystery, examined through cognitive and phenomenological approaches, might aid a better understanding of the site's challenges as one moves through it. Liao [35], using a mathematical study of the structural and visual arrangement of the spaces in the design, with poorly understood perceptual-transparency and mystery investigations for the TCPG traditional Chinese private garden. Based on unique public data from a pedestrian volume survey of 10,000 locations in Seoul, Korea, Sugie [17] combined GIS-based spatial zoning with ArcGIS, including Space syntax model visual graph analysis, to assess pedestrian volume across various land-use zones using built-environment measures. Sahar Soltani [39] examined the role of heritage tourism, and the results show that tourist-focused functions tend to be distributed and aggregated in the urban cores of historical cultural towns. Ericson [64] examined the robustness of correlations between space syntactic measures and high spatial and temporal resolution human walking data across a broad range of spatiotemporal resolutions, addressing an important gap in the literature. Yingsheng Zheng [75] surveyed 353 lion groves in China to examine the spatial behaviour quality and comprehend the spatial-temporal behaviour. To calculate the proportion of visitors, average time, and average speed in ArcGIS, as well as the temporal-spatial behaviour of visitors and the spatial characteristics of Lion Grove that draw them in, visitors were recorded using GPS data loggers.

**Table 1 The Characteristics of the Listed Previous study in context with heritage sites for the literature review**

Reference	Journal	Key area focus	Title	Research Area (Land Use)	Tools/Techniques
[53]	MDPI (Building)	Spatio-Temporal Characteristics, spatial function, and layout	Quantitative Estimation of the Internal Spatiotemporal Characteristics of Ancient Temple Heritage Space with SpaceSyntax Models: A Case Study of Daming Temple	Urban (Temple Heritage Site)	Angle Segment Analysis (ASA), Visibility Graph analysis (VGA), Mean Depth (MN), NAIN & NACH
[54]	MDPI (Land)	Spatio-Functional Analysis	A Syntactical Spatio-Functional Analysis of Four Typical Historic Chinese Towns from a Heritage Tourism Perspective	Urban (Heritage Tourism)	(NAIN) Normalized Angle integration, Normalised angle choice (NACH), Point of Interest (POI), Star Model
[71]	MDPI-Urban Science	Enhance Pedestrians' Accessibility and Safety	Using a Space Syntax approach to Enhance Pedestrians. Accessibility and Safety in the Historic City of George Town, Penang	Urban (Historic city)	Space Syntax- Axial and Segment map, Depth map
[48]	ELSEVIER-	Social Interactions and movement Patterns	Using space syntax analysis in an archaeological site: Case of Cuicul (Djemila) in Setif, Algeria	Urban (Archaeological site)	All-line Analysis, Visibility Graph Analysis and Agent-Based Analysis.
[68]	MDPI (Building)	Evaluating Experiential Qualities - Spatial	Evaluating Experiential Qualities of Historical Streets in Nanxun Canal Through a Space Syntax approach	Urban (Historic Street)	Visual Graph Analysis- Depth map (Topological

		Characteristics			Geometrical   and Metric)
[67]	MDPI (Sustainability)	Accessibility	Accessibility of Urban Tourism in Historical Areas: Analysis of UNESCO World Heritage Sites in Safranbolu	Urban (World Heritage Site)	Space Syntax- Axial and Segment map, Depth map
[46]	MDPI (Sustainability)	user's perception and visibility starting point	Promoting Sustainable Development of Cultural Assets by Improving Users' Perception through Space Configuration; Case Study: The Industrial Heritage Site	Urban (Industrial Heritage site)	Visibility and Isovist Cognitive Mapping- Questionnaire, documentary coding, interviews
[21]	Routledge (Urbanism)	Movement pattern	Space syntax analysis of tourists' movement patterns in the historical district of Kuala Lumpur, Malaysia	Urban (Historic District)	Space Syntax- Connectivity, Axial Mapping
[76]	MDPI (Sustainability)	spatial cognition-mental mapping	The Legibility Efficacy of Historical Neighbourhoods in Creating a Cognitive Map for Citizens	Urban (Historical Neighbourhood)	Space Syntax, Axial map, connectivity and integration (Correlation)
[45]	ELSEVIER- Tourism Management	Tourists' flow and preference	Understanding tourist space at a historic site through space syntax analysis: The case of Gulangyu, China	Urban (Heritage site)	Axial plan analysis, Angular segment analysis, connectivity, local and global integration, and GIS-Heat map, person correlation
[77]	ELSEVIER- Cell Press -Heliyon	Syntactical context around heritage buildings	Socio-spatial vulnerability assessment of heritage buildings through using space syntax	Urban (Heritage site)	Visibility, Isovist, Axial Graph, and Visual Graph Analysis- Measures (Choice and integration), EFA Method SPSS-Multiple Linear Regression Analysis
[78]	MDPI (Heritage)	Perception behaviour linking with visibility	Visibility Model of Tangible Heritage. Visualization of the Urban Heritage Environment with Spatial Analysis Methods	Urban (Heritage site)	Isovist, Visual graph analysis
[37]	Science Direct (Higher Education Press)	Spatial characteristics and visitors' cognitive abilities	Unveiling the potential of the space syntax approach for revitalizing historic urban areas: A case study of Yushan Historic District, China	Urban (Heritage District)	Visibility graph analysis, Visual Integration and Agent-based model

[79]	MDPI (Buildings)	Accessibility	Spatial Feature Analysis of the Beijing Forbidden City and the Shenyang Imperial Palace Based on Space Syntax	Urban (World Heritage Site)	Space Syntax
[80]	Science Direct	Movement flow- Pedestrian and Vehicular	Using space syntax and TOPSIS to evaluate the conservation of urban Heritage sites for possible UNESCO listing, the case study of the historic center of Rosetta, Egypt	Urban (Heritage Market)	Axial Graph, Visual Graph Analysis-Choice, Intelligibility, TOPSIS- MCDM
[41]	MDPI (Sustainability)	Spatial Characteristics	Understanding the Street Layout of Melbourne's Chinatown as an Urban Heritage Precinct in a Grid System Using Space Syntax Methods and Field Observation	Urban (Heritage Precinct)	Field Observation, Isovist, Visual Graph Analysis, connectivity, integration, and Intelligibility
[81]	MDPI (Sustainability)	Spatial configuration and movement pattern	Tourist movement Patterns and the Effects of Spatial Configuration in a Cultural Heritage and Urban Destination: The Case of Madaba, Jordan	Urban (Heritage Site)	Axial Map, VGA, Questionnaire, Observation, Interview, connectivity, integration
[82]	MDPI (Geoinformation)	Development directions and routes	Using Space Syntax and GIS to Determine Future Growth Routes of Cities: The Case of the Kyrenia White Zone	Urban (city Route)	Space Syntax - Axial Graph Analysis and GIS
[75]	Routledge (Landscape)	walking accessibility, first-time visit, and visual accessibility and permeability	Combining GPS and space syntax analysis to improve understanding of visitor temporal-spatial behaviour: a case study of the Lion Grove in China	Urban (Heritage site)	GPS, ArcGIS, Space Syntax- Axial map, connectivity, integration, Intelligibility, Kernel Density Analysis, Spearman Correlation
[51]	Routledge (Urban Design)	Pedestrian Network	Combining multi-criteria and space syntax analysis to assess a pedestrian network: the case of Oporto	Urban (Heritage Site)	GIS, Multicriteria, Space Syntax- Axial Map
[64]	SAGE	changes in spatial or temporal scale	Space syntax visibility graph analysis is not robust to changes in spatial and temporal resolution	Urban (Virtual and Motion tracking)	Virtual Reality, Motion Tracking, Space Syntax, Correlation
[83]	Springer	structural and visual configuration of the spaces-movement and Vision	The mathematics of spatial transparency and mystery: using syntactical data to visualize and analyse the properties of the Yuyuan Garden	Urban (Landscape)	Convex Space & Isovist
[53]	MDPI (Sustainability)	Spatial Sequence	Exploring visitors' visual perception along the spatial sequence in temple heritage	Urban (Temple)	GIS, Space Syntax

			spaces by quantitative GIS methods: a case study of the Daming Temple, Yangzhou City, China.”	Heritage Site)	
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**Heterogeneity among outcomes of the reviewed results**

According to [56] The examined studies demonstrated a wide range of viewpoints and insights into the relationship between spatial configuration and experience dynamics in urban heritage environments. Numerous observations and interpretations emerged from the distinct perspectives each study offered for examining this complex relationship. Researchers have discovered complex connections between spatial cognitive traits and experiences in various urban contexts, including historical districts, heritage neighbourhoods, historic gardens and parks, historic residential settlements, archaeological sites, and tourist destination [68]. For example, research has shown that intermediary spaces are important for promoting community involvement in urban settings, focusing on how street connectivity and in-between spaces enhance the capacity to view and engage with heritage sites. [51] Neighborhood-level research on pedestrian access and cognitive mapping of how people view locations using a variety of techniques, such as point of interest, choice location, photography, survey, etc. Using ArcGIS and observation, the study also examines the complex level, from spatial organization to spatial sequences of cultural heritage sites. Numerous methodologies have been used in the investigations, such as observational techniques, the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method, GPS tracking, surveys, questionnaire surveys, spatial syntax analysis, ArcGIS, the Delphi technique, (EFA) exploratory factor analysis, correlational analysis, and multilinear regression analysis.

These diverse methodologies contributed to the richness of the findings but also introduced variability in interpreting the results. Additionally, each study had a different focus; some looked at how social interaction is affected by spatial visibility and connectivity. Others examined how historic urban landscapes, conservation policies[84], and historic preservation affect urban revitalization efforts, as well as industrial adaptive reuse and sustainable development [46]. This diversity of focus highlights the complexity of spatial cognition and experiences at different scales. The results of the evaluated research provided a variety of insights and recommendations as a result of these diverse techniques and focus [60]. The findings' overall heterogeneity highlights the need for comprehensive, context-specific approaches to conservation and planning that reflect the diversity of urban landscapes and the complex nature of spatial cognition and experience.

**Assessing Existing Contributions**

Upon a comprehensive review of the literature, seven research gaps have been identified and addressed by various authors, each with a distinct model construct. The research gaps commonly addressed are empirical, knowledge, population, and methodological. Few studies have rigorously examined the spatial-functional characteristics of historic cultural towns, and previous research on this topic often relied on qualitative descriptions. Space syntax enables us to analyse spatial configuration and land use within a 2-dimensional street network to achieve a 3-dimensional understanding. The other methods are clubbed for adequate quantitative assessment. The axial segment and (POI) point-of-interest model was explored to provide a theoretical abstraction of the real-world spatial-functional relationship in an urban historic space, as examined by [71]. According to [85]. There are no desired research findings for a qualitative study using the space syntax method. People's socioeconomic lives in constructed environments depend heavily on spatial relationships. ArcGIS and behavioural mapping help to comprehend how space has changed over time and evolved significantly. Broadly understanding the article's research majorly does not conclude the findings as desired in the aim and scope of the study, as it has been noticed that there are knowledge, methodological, empirical, and population gaps that can be further addressed while integrating space syntax with multi-criteria decision-based analysis, behavioural studies, spatial ArcGIS, the cognitive tools, (CFA) Confirmatory Factor Analysis, and Grasshopper that can potentially address the scope for cognitive-based studies for heritage sites experiences in planning and conservation domain.

## CONCLUSIONS

### Findings and Directions

To provide insights for future research, this study focused on the idea of cognitive experience. It aimed to identify understudied directions in the field of space syntactic research within the context of heritage places. As the paper explores the applicability of space syntax, it conceptualizes how the spatial arrangement of a constructed environment affects people's views and engagement with historic sites. Later, the experiential and emotional aspects were explored, integrating other methods to qualitatively assess these latent parameters, which remains a limitation of this method. A thorough, systematic literature review of the application of space syntax constraints to cognitive-based experiences of heritage sites is lacking. However, it has made a substantial contribution to our understanding of spatial analysis-based research. The results and identified gaps regarding various scientific areas are summarized in Section 3. The purpose of the study's final remarks was to identify uncharted territory in the field of spatial analysis-based research on cognitive experiences of heritage. The study began by examining the breadth and relevance of previous evaluations of space syntax, with a particular emphasis on social interactions and behaviours in these settings. Second, by integrating the well-known PRISMA flowchart with the identification of unexplored research needs, it provides a more robust framework for subsequent review studies while addressing its limitations through a thorough systematic review. This study does have certain drawbacks, though the search was limited to English-language sources. Important studies in other languages might have gone unnoticed. Furthermore, the review was restricted to journal articles and the Scopus database, omitting other important sources such as book chapters and conference proceedings. Future studies can address these constraints by using a broader range of databases and literary genres.

The study field could be further enhanced by broadening its focus beyond spatial applications of space syntax to include accessibility, security, navigation, spatial sequence, layout, pattern, and movement. In conclusion, the existing literature offers invaluable insights into the importance of comprehending cognitively based experiences in and around historical places. Our research suggests that adopting a tailored approach can enhance the validation of historic places in their current context, taking into account their spatial characteristics and their impact on cognitive and behavioural studies, thereby contributing significantly to a sense of community and to authentic, integrated experiences. The study will address diverse populations, contributing to a culturally rich body of knowledge that can be explored subjectively and objectively through historic places.

### Abbreviations

PRISMA=	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
MCDM =	Multi-Criteria Decision Making
GIS =	Geographic information system
AR=	Augmented Reality
ALA=	Axial line analysis
CSA=	Convex space analysis
ISA=	Isovist analysis
JPG=	Justified plan graph
VGA=	Visibility graph analysis
ASA=	Axial segment analysis
ABS=	Agent-based simulation

VOS viewer = Visualization of Similarities

TCPG= Traditional Chinese private garden

GPS= Global Positioning System

TOPSIS= Technique for Order Preference by Similarity to Ideal Solution

EFA= Exploratory factor analysis

POI= Point of Interest

CFA= Confirmatory Factor Analysis

## Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Authors' contributions

Mishra Jaishree prepared the initial draft, an overview, conceptualisation, methodology, writing review, and editing by Srikonda Ramesh, as well as a systematic literature review, software, resources, drawings, and tabulations on a particular subject.

## ACKNOWLEDGMENTS

This research is part of a PhD coursework in the research methodology subject, serving as a literature review to understand methodological tools for potential future research in the context of conservation and planning.

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