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Systematic Review

The Application of Space Syntax to Enhance Sociability in Public Urban Spaces: A Systematic Review

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Abstract: Public urban spaces are vital settings for fostering social interaction among people. However, understanding how spatial layouts can promote positive social behaviors remains a critical and debated challenge for urban designers and planners aiming to create socially sustainable environments. Space syntax, a well-established theory and research method, explores the influence of spatial configurations on social aspects. Despite its significant contributions, there is a lack of comprehensive systematic reviews evaluating its effectiveness in enhancing social interaction within urban public spaces. This study aims to identify the existing scientific gaps in the domain of space syntax studies, with a primary focus on sociability in public urban spaces. Following the PRISMA framework, a thorough literature search was conducted in the Scopus database, yielding 1107 relevant articles. After applying screening and eligibility criteria, 26 articles were selected for in-depth review. This review adopted a novel approach to synthesizing and analyzing the findings for identifying underexplored scientific gaps. The findings suggested a wide variety of research gaps to address, encompassing evidence, knowledge, practical, methodological, empirical, theoretical, and target populations to provide a thorough overview of the current state of knowledge in this field. In conclusion, by exploring the interplay between space syntax and design elements such as the urban infrastructure, landscaping, and microclimate in these areas, future research can bridge this gap, particularly when considering a cross-cultural lens. This study underscores the importance of space syntax in promoting social interaction in urban public spaces, offering a robust foundation for future research and practical applications to create more socially engaging environments.

Keywords: systematic literature review; PRISMA; social interactions; sociability; space syntax; urban public space

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1. Introduction

The design of public urban spaces is widely recognized as crucial for encouraging social interaction. However, the connections between urban spatial configurations and positive social behaviors are still a complex and contentious issue for urban planners and designers who aim to cultivate socially sustainable cities. Sociability in public urban spaces refers to the capability of these areas to facilitate social interaction, communication, and engagement, which play a crucial role in enhancing the quality of life for urban residents. It encompasses aspects such as the ease of meeting and engaging with others, the presence of social activities, and the overall livability of the space [1]. The morphology of an area can significantly influence its sociability by shaping the way people move and interact within the space. However, morphology alone does not fully capture the dynamic nature of social behaviors in these spaces. This makes space syntax particularly valuable for studying sociability, as it can predict how different spatial layouts affect social behavior [2]. In this regard, space syntax is a theory and research method that conceptualizes how the spatial

layout of a built environment influences the social life of people by stimulating walkability, sociability, and mobility [3,4]. In fact, space syntax constitutes a theoretical framework upon which a structured methodology has been constructed [5]. It provides a unique framework that integrates the physical and social dimensions of space, making it particularly effective for studying sociability. While other graph-like urban analysis methods exist, space syntax offers several distinct advantages, including configurational analysis, predictive ability, a wide variety of scopes, and robust empirical validations [6]. Space syntax is a research method that can be applied in various domains of urban planning, including traffic flow [7–11], pedestrian mobility [12–17], land use efficiency [18,19], crime distribution [20–22], sexual violence [23,24], urban regeneration [25–28], cognitive map studies [29–31], mental imagery [32–35], social interactions [36–41], accessibility [42–44], social equality [45], wayfinding [46–48], behavioral studies [49,50], and private territories [51,52].

In addition to its application in urban studies research, space syntax has also been utilized in various architectural contexts, encompassing residential houses [53–56], educational buildings [57–59], shopping malls [60,61], university campuses [62–64], student dormitories [65], public libraries [66–68], offices [69], museums [70], religious buildings [71–73], hospitals, and healthcare centers [74–78]. Moreover, space syntax has also expanded its influence into a broad spectrum of multidisciplinary fields, encompassing disciplines such as lighting design [79–81], planting, and landscaping design [82–85], archeological studies [86–88], tourism studies [89–91], brain activities and stress-related issues [92], and tunneling and underground spaces [93–95]. Although there have been several literature reviews within the domain of space syntax, their focus and scope were limited to healthcare facilities [96,97], socio-spatial experience [98], neighborhood sustainability assessment and revitalization [99,100], conceptual framework development of a scientific theory [101], and geographical distributions and contributions of published space syntax research [102].

Therefore, there is a significant scientific gap in providing a comprehensive systematic literature review on space syntax, particularly with a focus on sociability in urban public spaces. Hence, the present study aims to identify the existing underexplored horizons of space syntax studies for future research agendas with a primary focus on sociability. The following research question is pursued. What are the underexplored scientific gaps in understanding how space syntax might enhance sociability? This research intends to assist urban designers, planners, and architects in unveiling these underexplored areas within the space syntax literature, thereby identifying strategies for creating a sustainably built environment. Based on these premises, this paper will be organized as follows. After this brief introduction, Section 2 will provide a meticulous description of the materials and methods adopted in this study. Following that, Section 3 will comprehensively illustrate the results and discussions. Finally, Section 4 will present the concluding remarks.

2. Materials and Methods

Historically, scholars have commonly employed literature reviews to explore existing knowledge in a particular field, evaluate its limits, and envision potential future advancements [103]. This process is essential for formulating policies and broadening the horizons of current research by extensively leveraging prior research discoveries and highlighting existing scientific gaps [104]. However, recent studies have identified shortcomings associated with conventional approaches used in literature review methodologies, which encompass deficiencies in scientific rigor, inherent biases, and notable omissions [105,106]. In contrast, systematic literature reviews have been esteemed for their distinctive capacity to mitigate biases, enhance reliability, and potentially enhance the dissemination of research outcomes [107]. In the field of social science research, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines have emerged as a leading framework for systematic literature reviews, gaining significant recognition and appreciation. Considering the broad and intricate nature of the topic—applying space syntax to enhance sociability in urban public spaces—the PRISMA framework was chosen due to its rigorous and structured approach, ensuring a comprehensive and unbiased

synthesis of the current literature. The systematic and transparent methodology provided by PRISMA is crucial for identifying all relevant studies, thereby ensuring that the research gaps identified are based on a comprehensive and reliable foundation. The research method for this systematic review adhered to the criteria specified in the PRISMA framework [107].

2.1. Search Strategy

According to the objective of this study, a thorough literature search was performed to identify the existing gaps in the application of space syntax to enhance sociability in urban public spaces. A pre-established protocol was developed to document the methodology of analysis and the criteria for inclusion. Accordingly, a comprehensive search was performed in the Scopus database for all relevant articles up to 10 December 2023. The Scopus database was chosen for its broader coverage compared to other reputable academic databases. The search included a diverse range of publications from sources such as Elsevier (Amsterdam, Netherlands), Springer (Berlin, Germany), Taylor & Francis (London, United Kingdom), MDPI (Basel, Switzerland), Wiley (Hoboken, NJ, United States), Sage (Thousand Oaks, CA, United States), Emerald (Bingley, United Kingdom), etc., ensuring the reliability of the resources. Given the broad nature of the topic concerning the applicability of space syntax on the sociability of urban public spaces, the authors preferred to keep the search items as inclusive as possible to control all the potential articles applicable to this study. Hence, the search protocol for this study included the following terms: (space AND syntax) OR (spatial AND syntax) AND (architect*) OR (urban*). This was performed across the domains of article titles, abstracts, and keywords.

2.2. Inclusion and Exclusion Criteria

Certain limitations were applied to the search protocols to improve the reliability of the obtained literature. For instance, due to the rigorous peer review process of journal papers, the search was restricted to include only articles and review journal papers. Similarly, the language of the search items was limited to English, with other languages excluded. The title, abstract, keywords, and all the required bibliographic properties of the identified records were exported to an MS Excel Spreadsheet 2016. In addition to the Scopus database, the specialized *Journal of Space Syntax*, which was specifically established to advance studies in the field of space syntax, was examined and included in the search protocols. It should be noted that this journal ceased publication in 2017, and its content is now available through online platforms.

2.3. Screening Process

The review process for the identified articles was conducted independently, adhering to the PRISMA flowchart diagram (Figure 1) and its associated checklist. These steps included identification, screening, eligibility, and inclusion. During the initial phase of the search, 1107 articles were identified based on the aforementioned search protocols. In the screening phase, 58 items were deemed irrelevant due to their interdisciplinary approach, 262 items were excluded for their relevance to architectural spaces, and 317 items were excluded because they lacked relevance to sociability and accessibility. In the eligibility phase, 351 items were excluded because they exclusively focused on accessibility, and 44 items remained relevant to the focus on sociability. In this stage, the full texts of all eligible articles were meticulously studied to identify their specific focus. Ultimately, 26 items were identified for scrutiny regarding their focus and gaps.

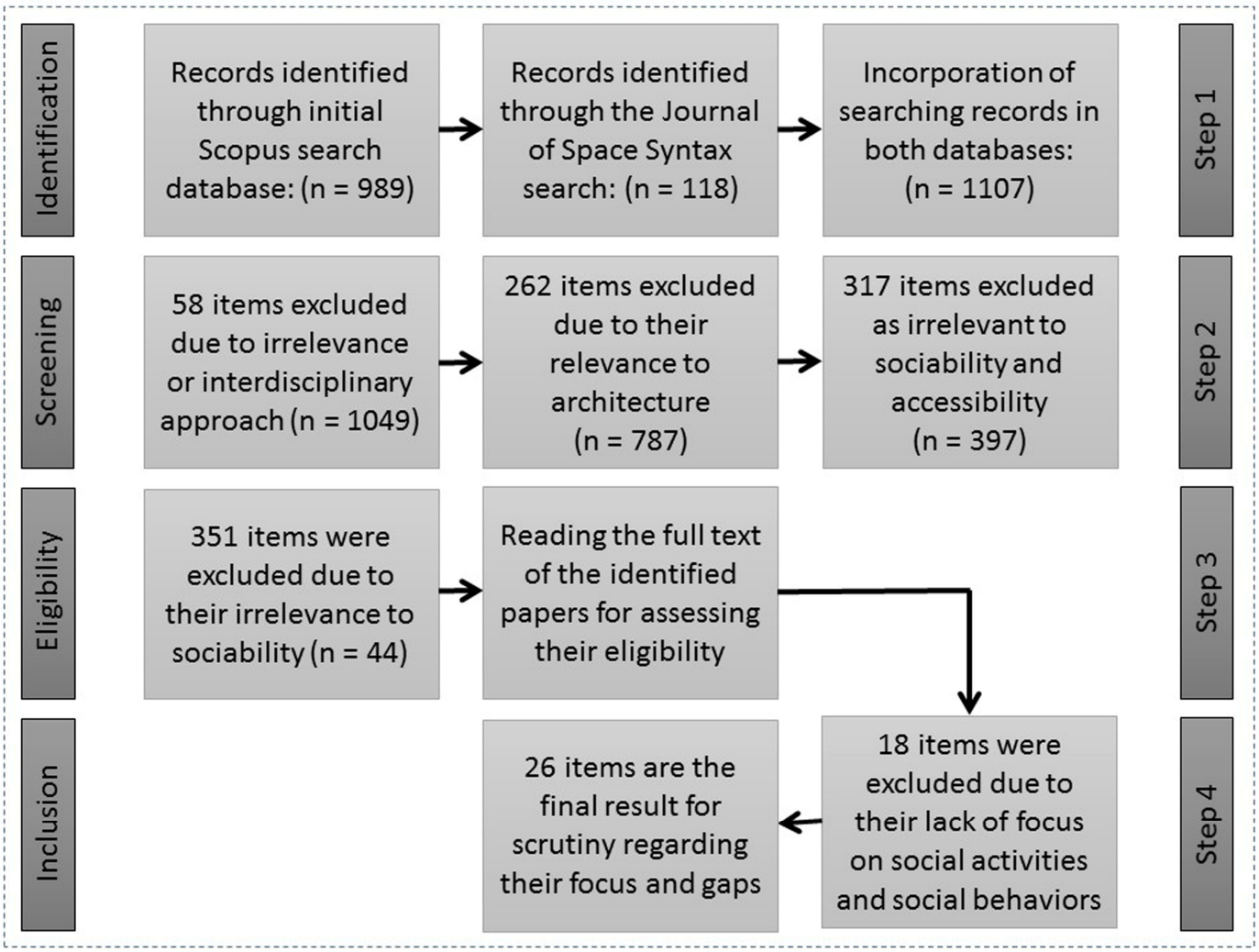


Figure 1. The flowchart of PRISMA framework.

2.4. Data Analysis

A comprehensive examination of the selected papers was conducted to acquire crucial data for the analysis. In order to assess the current state of knowledge [108], a wide variety of research gaps were explored, including the evidence gap, knowledge gap, practical gap, methodology gap, empirical gap, theoretical gap, and population gap (Figure 2). An inductive analysis was employed for the content analysis of the identified papers, aiming to convert the extracted data into the categorized items of research gaps. Put differently, initial evaluations were made by extracting information from the content of the first paper under review. Subsequently, additional assessments were incorporated into the data extraction sheet as deemed relevant after reviewing each subsequent paper. This iterative process persisted until all papers in the database were examined. Following this, the gathered data were synthesized to address the previously mentioned research questions.

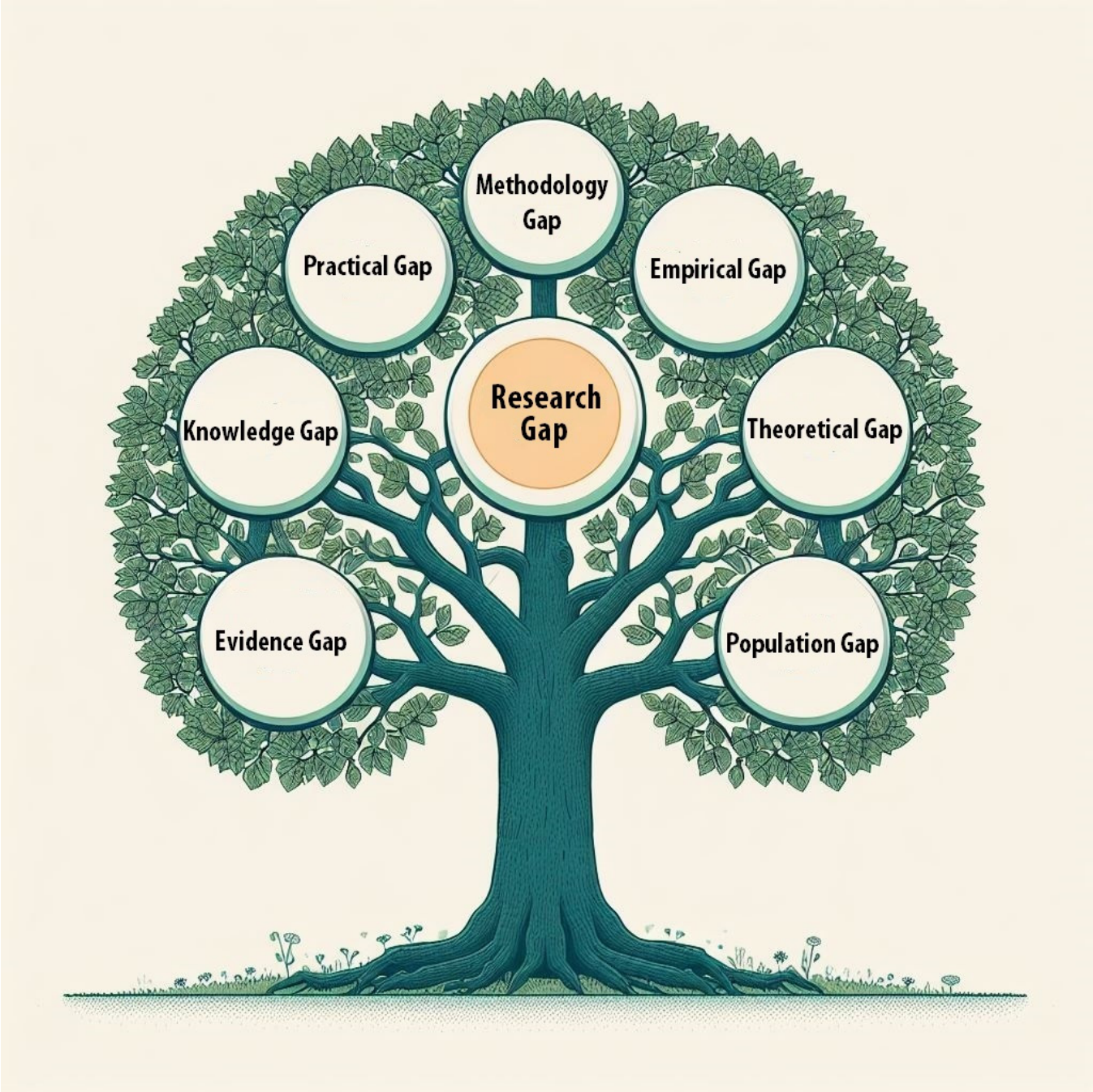


Figure 2. Tree diagram indicating constituent components of research gaps in this study.

The risk of bias in the included studies was assessed by independently evaluating each study by two reviewers, with discrepancies resolved through discussion to achieve consensus. Effect measures like risk ratios or mean differences were employed for each outcome during the result synthesis or presentation, aiming to maintain clarity and coherence in data interpretation. Apart from the systematic review, an analysis of term co-occurrence was performed using the VOS-viewer software 1.6.20 to acquire a comprehensive insight into the reviewed papers. This software was utilized to visualize the knowledge structure across various fields. The results generated by the software comprise networks featuring nodes and links, with the size of the nodes corresponding to the frequency of term occurrences and the width of the links reflecting the strength of their connections. A term map proved valuable in comprehending dominant topics, thus serving as a complement to this system-

atic review. Finally, sensitivity analyses were conducted to assess the robustness of the synthesized results, ensuring the reliability and validity of the systematic review findings.

3. Results and Discussion

3.1. General Overview of the Relevant Literature

The process of publishing studies within the theme of space syntax in journal articles has indicated a cumulative trend within academic databases, and specifically, over the past four years, relevant publications have risen dramatically. Statistics indicate that scholars in China, the United Kingdom, and the United States have the highest contributions in this field, respectively. Among them, University College London, Istanbul Technical University, and Delft University of Technology have had the highest rates of contribution in this area thus far. The top three journals with the highest number of published papers within the domain of space syntax are *Sustainability*, *Buildings*, and *Cities*. In addition, among the most contributors in the field of space syntax in journal articles, Professors Bill Hillier, Michael Ostwald, and Laura Vaughan rank among the top three scholars according to the Scopus database (Figure 3). These data may provide valuable insights for junior researchers to recognize the most frequent journals that publish syntactical research and the most recognizable scholars in this field.

In the next step, the obtained keywords were collected from articles on space syntax studies obtained from the Scopus database. The results indicated that space syntax was significantly associated with terminologies commonly used in urban studies, including spatial configuration, urban morphology, street network, accessibility, movement patterns, pedestrians, social activities, architecture, housing, planning, sustainable development, and public spaces (Figure 4). In this context, space syntax can be used to analyze the accessibility and visibility of different parts of a space, which can, in turn, affect how people are likely to move through it and encounter each other. In addition, the terms "behavior" and "social" suggest an ever-growing interest in the social and psychological effects of space syntax. In general, the word cloud suggested that this literature review was investigating an intricate and significant topic, namely the usage of space syntax as a powerful tool for designing urban public spaces that are more sociable and inviting.

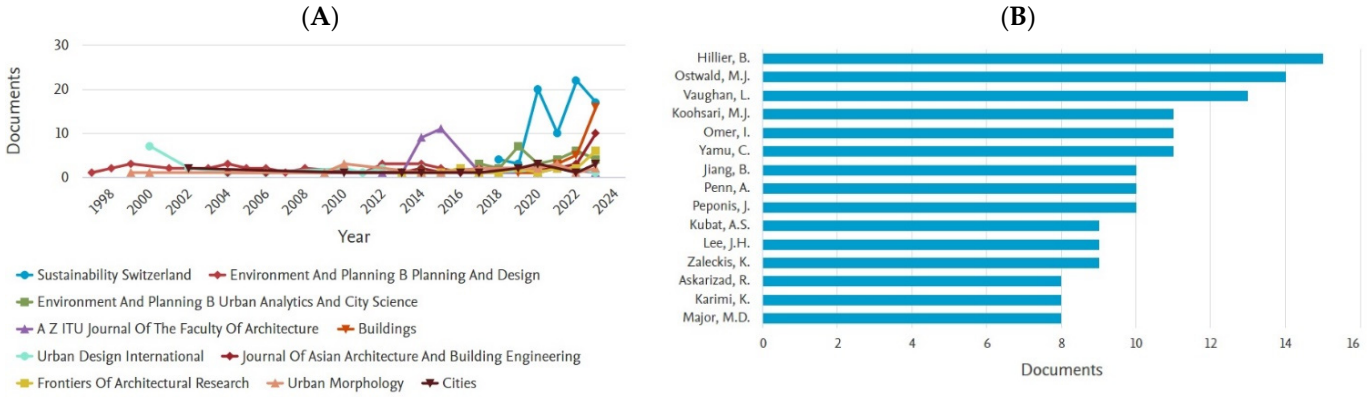


Figure 3. (**A**) The journals with the highest contributions publishing space syntax studies; (**B**) The top 15 scholars in space syntax, who have published their work as journal papers based on Scopus database.

For a more nuanced analytical approach to the keywords, the datasets containing the obtained keywords were transferred to the VOS viewer software to assess the co-occurrence of each keyword. This provided an opportunity to classify how frequently certain words or terms appeared together within a given context. In other words, it measured the frequency with which two or more keywords appeared alongside each other within a set of documents. The obtained results revealed that the co-occurrence of two main variables, namely space syntax and social interaction, which were the main focus of the current literature review, had drawn less attention thus far from academics compared to others, as shown in Figure 5.

It should be noted that in density visualization, dark colors indicate higher density among keywords, while light colors reveal lower density among keywords. Hence, the need for increased attention to the interaction between space syntax and social activities became even more apparent. Concerning the close association between space syntax and urban morphology, it should be noted that they are related fields, and the co-occurrence graph reflects this connection. In simple terms, urban morphology examines the form of a city, while space syntax looks at how this form influences the way we experience the city.

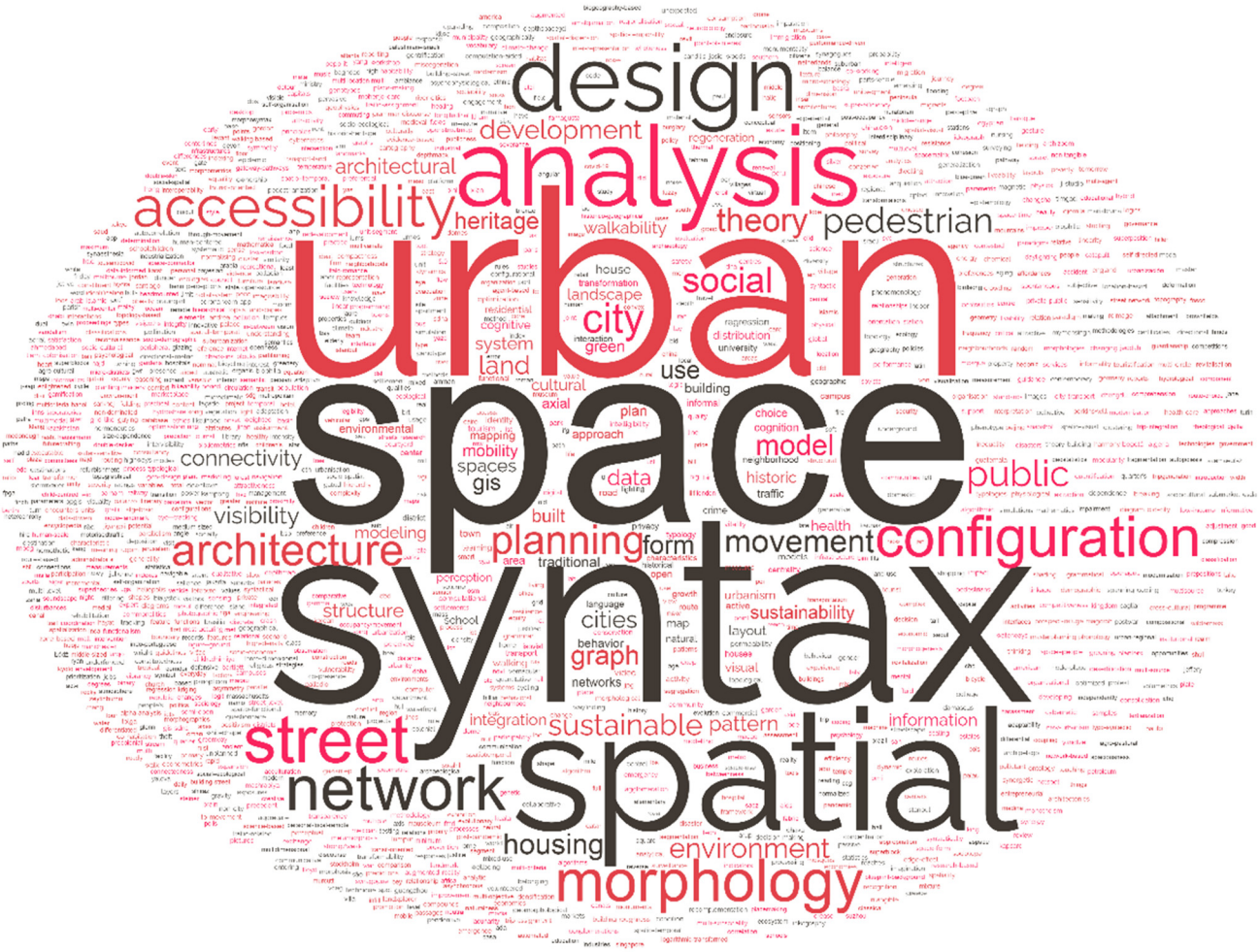


Figure 4. Word cloud showcasing keywords of space syntax studies, obtained from 989 articles sourced from the Scopus database.

After screening and excluding irrelevant articles, an examination of the target papers was conducted to scrutinize as much detail as possible, aiming to identify existing gaps in the field. The findings indicated that among the case studies that adopted the space syntax technique to measure social activities, Iran, Turkey, Algeria, China, and Egypt were among the top chosen study areas within such empirical analyses. In terms of the most frequent land uses, urban squares were considered the most common for capturing social activities using syntactical analysis. Subsequently, historical districts, neighborhoods, and streets emerged as the most frequent land uses in previously published studies (Figure 6).

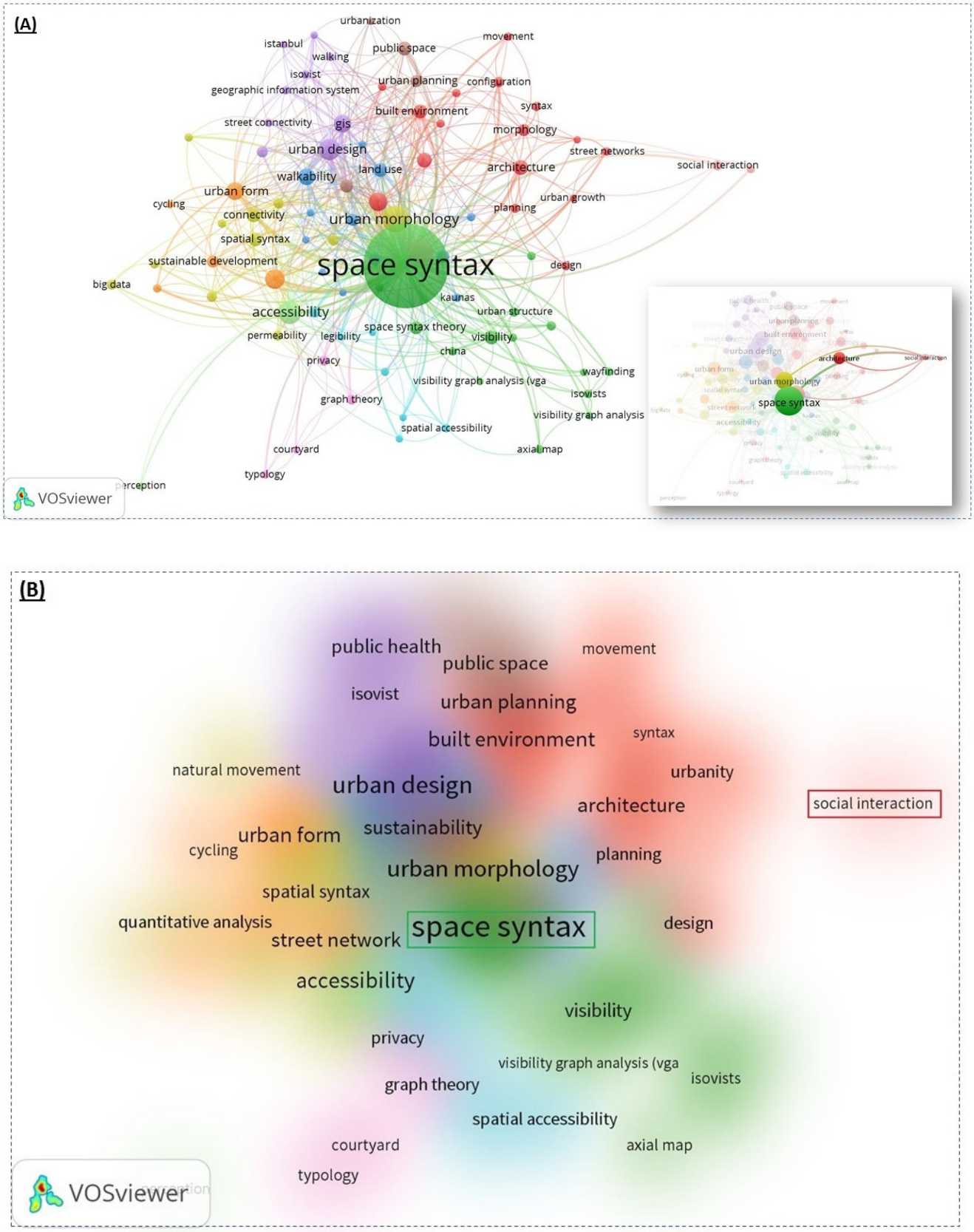
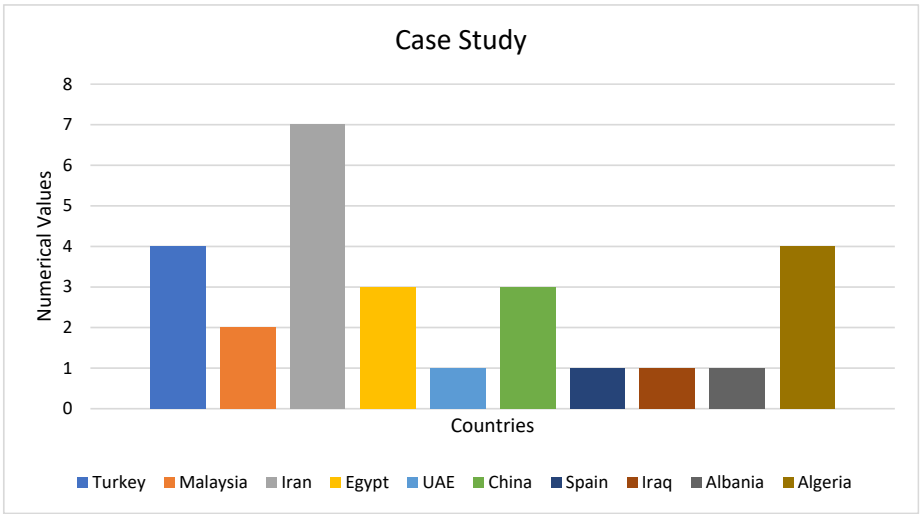
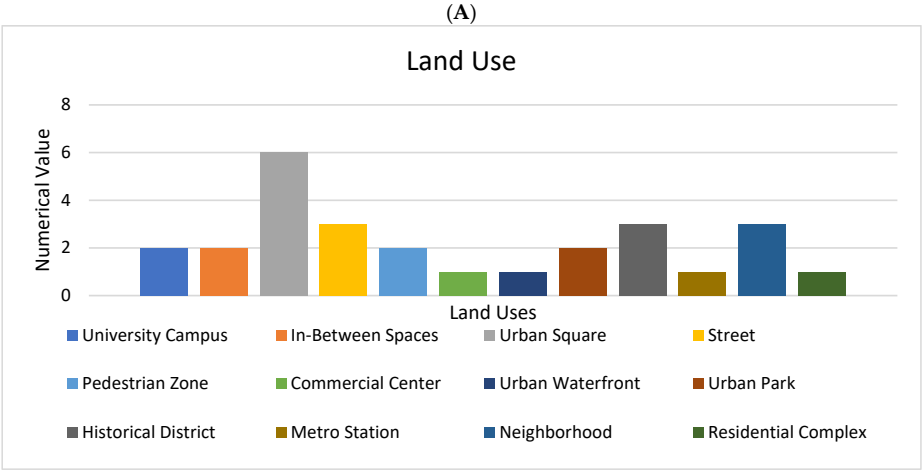


Figure 5. (**A**) The co-occurrence of the space syntax and social interaction keywords based on the obtained data from 989 previously published journal articles indexed by Scopus; (**B**) The density visualization of the identified keywords and their relationships among others.



(**A**)



(**B**)

Figure 6. (**A**) The most frequent case studies; (**B**) The most frequent land uses.

In terms of the adopted methods, over 90% of the target studies utilized mixed methods, highlighting the predominant preference for combining mixed methods along with space syntax to capture social activities in urban spaces. Interestingly, evidence has shown that the studies that implemented a single method of space syntax were related to a couple of Q2 and Q4 journals. This highlights the significance of implementing mixed methods for capturing social activities in high-impact journals. Most frequently, space syntax was combined with empirical observations, questionnaires, and interviews, respectively. Nonetheless, the particular focus on methodological gaps is further discussed in the following subsections.

3.2. Previous Achievements in the Field

An overview of the current state of knowledge in the field revealed substantial outcomes in terms of the latest achievements that contribute to understanding social activities and behaviors that can take place in public spaces. For instance, Yaylali-Yildiz et al. [109] found that university campuses, despite originally being designed for academic isolation, should prioritize fostering community interaction through their spatial design. This finding emerged from space syntax analysis and student surveys. It was substantiated that the spatial configuration of university campuses plays a crucial role in shaping campus life and fostering a sense of community among students. This study suggested that campus design, especially the arrangement of open spaces, should promote interaction and community engagement alongside academic pursuits. Can & Heath [36] declared that the spatial configuration of intermediate spaces between buildings and streets stimulates social inter-

action in urban areas, with street connectivity playing a crucial role. In addition, the study emphasized the importance of in-between spaces in promoting community engagement, especially in more integrated neighborhoods.

Safari & FakouriMoridani [43] discovered that a lack of visibility and cognitive mapping difficulties presented challenges for wayfinding and social interaction. Space syntax analysis highlights shifts in accessibility within a city, with a proposed square potentially serving as a context-enhancing feature of sociability. Overall, their research emphasized the significance of effective spatial factors, such as regular geometry, in creating sustainable and sociable urban spaces. Bendjedidi et al. [110] clarified that the quality and functionality of urban plazas are significantly influenced by spatial properties, particularly visibility and connectivity, as analyzed through space syntax methods. Their study demonstrated a strong correlation between human behavior and syntactical properties, suggesting that integrating space syntax analysis into plaza design processes can lead to more functional and user-friendly public spaces.

Amiriparyan et al. [111] substantiated that there is a significant relationship between the value of integration in urban configuration and the sociability potential of urban spaces. Furthermore, descriptive statistics and Pearson correlational analysis supported the strong correlation between integration value and sociability potential, highlighting the importance of spatial configuration in fostering social interactions and community engagement in urban environments. Zerouati & Bellal [38] elucidated that the configuration of in-between spaces significantly influences users' social practices, with varying degrees of permeability affecting social interactions among inhabitants. Their study suggested that spatial configuration impacts the utilization of in-between spaces, with connectivity and clustering coefficients emerging as important indicators of social activities. Contrary to previous assumptions, their research demonstrated that social interaction tends to increase in less connected areas and more closed spaces, highlighting the dependence of social activities on the degree of permeability.

Askarizad & Safari [37] discovered that social interactions significantly influence behavioral patterns in urban spaces. This effect results in the development of positive behavioral norms and contributes to the overall well-being of citizens. Their study adopted syntactical techniques and employed various observational and analytical techniques that facilitate social interactions. These factors include urban designs that encourage social gatherings, the presence of focal spaces like fountains, and the inclusion of cultural elements. Hamdoon & Ahmed [112] advocated for the critical role of an urban waterfront in shaping a city's image and enhancing the quality of life for residents and visitors. Their research underscores the importance of designing the project to create a vibrant, safe, and culturally integrated environment, thereby aiming to enhance social life and well-being.

Sheng et al. [39] observed that a space's configurational attributes, such as its pathway length, zone area, depth to the main road, and connectivity, significantly influence social interaction behaviors in urban parks. Specifically, their study revealed that certain attributes, like normalized angular choice, were positively associated with personal interactions, while factors such as space scale and depth to the main city road affected social interaction intensity. Xu & Chen [95] suggested that the spatial vitality of urban underground spaces was influenced by various environmental factors such as accessibility, visibility, spatial scale, business distribution, and physiological and traffic environments. Tahroodi & Ujang [113] argued that designated paths with higher accessibility attributes, particularly those with visually enriching spaces and adjoining activity nodes, were associated with an increased intensity of passive social interactions in urban parks. Their findings suggested that urban planners and designers can enhance the local integration and visual accessibility of paths by enriching them with salient landmarks, views, and activity nodes, thereby promoting passive social interaction among park visitors.

Roosta et al. [114] showed a strong relationship between spatial configuration and social sustainability metrics, particularly in terms of security and social justice. Eltarabily [115] identified the key quality indicators for urban open spaces, including attractiveness, vi-

tality, clustered and integrated activities, visual appeal, safety, people connectivity, and accessibility. She concluded that the integration of placemaking and space syntax approaches provides a conceptual framework for enhancing urban open spaces and ensuring they remain vibrant and responsive to evolving community needs. Barkani & Abdelouahab [116] identified that conservation and restructuring works on traditional urban systems have a significant impact on their configurational properties. After conservation works were formed, there was an increase in intelligibility values, which significantly stimulated social behaviors.

Mohamed et al. [27] discerned that using a combined morphological approach, encompassing street network accessibility, building density, land use diversity, and a transformability index, can effectively measure and improve the urban vitality and sociability of informal settlements. They demonstrated that this approach serves as a diagnostic tool for identifying development potential and cost-effective ways of intervention to enhance vibrant urban environments. Mojaveri et al. [117] revealed significant correlations between walking and sitting behaviors and the physical environment across different neighborhood contexts, emphasizing attributes such as integration and mean depth. Specifically, organic settings show stronger correlations, while orthogonal contexts are more conducive to walking and sitting. Likewise, the correlation between the integration value and sitting or gathering behavior is direct, while it is inverse with walking behavior.

Studies also found that urban landscapes and façades have a significant impact on the establishment of social activities within an urban context. It was confirmed that social and behavioral activities in front of double-skin facades are significantly higher compared to single-skin facades. In addition, the behaviors observed in front of double-skin facades tend to be more social and optional [49]. Askarizad & He [35] clarified that there is a significant association between spatial legibility and human mobility patterns within historical districts. In historical districts, the incorporation of objective factors, such as integrated morphological characteristics, and subjective factors, such as the saliency of landmarks with historical values, encourages physical activities and social interactions among visitors, thereby contributing to the creation of a livable urban environment.

Studies also advocated for the importance of providing gender equality in privacy protection to promote social justice and fair interactions within urban spaces [52]. Tedjari & Abbaoui [118] revealed that the space syntax method revealed causes of the differences in attractiveness and visit frequencies between open public spaces. Yıldırım & Çelik [50] found that pedestrian behavior in pedestrianized areas is influenced by the spatial configuration of the environment, as well as by factors such as the sense of place and content, which affect vitality and sociability. Bayoumi et al. [119] stated that enhancing a university's open spaces by retrofitting may improve their potential for social interaction and occupancy distribution. Additionally, the integration of space syntax methodology as both a computational and observational method helped identify areas for social improvements in the university's open spaces.

Baiz & Atakara [120] stated that visitors to historical sites can engage in non-tangible conservation if architects enhance their attraction to the sites, encouraging them to explore different areas rather than focusing solely on prominent buildings and monuments. The researchers identified that space syntax is considered a prominent tool for identifying areas neglected by visitors, leading to the gradual deterioration of these spaces. Yunitsyna & Shtepani [121] demonstrated that there is a correlation between the type and location of activities and spatial and visual integration. Zhang et al. [122] confirmed that public spaces in urban areas can play a crucial role in promoting close social interactions among the elderly, which have positive effects on their physical and psychological well-being. The research identified three principles for improving public space qualities to facilitate age-friendly social interactions: ensuring safety, incorporating greenery, and providing suitable spaces for close social interactions. In the following, the correspondent characteristics of the previous studies are formulated in Table 1.

Table 1. The characteristics of the previous literature.

Author(s)	Topic	Land Use	Location	Methodologies
[109]	Exploring the effects of spatial and social segregation	University campus	Izmir, Turkey	Space syntax, observation, questionnaire
[36]	In-between spaces and social interaction	Intermediate spaces	Izmir, Turkey	Space syntax, snapshot observations, questionnaire surveys
[43]	Syntactical analysis of the accessibility and sociability	Urban square	Kuala Lumpur City Center, Malaysia	Space syntax, observations of gate counts, snapshots, directional splits, people following
[110]	Urban plaza design process	Urban plaza	Biskra, Algeria	Space syntax, behavioral and mental mapping, questionnaire
[111]	Analyzing sociability potentials	Street	Kermanshah, Iran	Space syntax, questionnaire
[38]	The impact of in-between spaces on users' social interaction	Mass housings' in-between spaces in neighborhoods	Setif, Algeria	Space syntax, snapshot observations
[37]	The influence of social interactions on behavioral patterns	Pedestrian zone	Rasht, Iran	Space syntax, GIS, observations of gate counts, snapshots, directional split, people following
[112]	Towards socially sustainable waterfront urban regeneration	Urban waterfront	Abu Dhabi, UAE	Space syntax
[39]	Effect of space configurational attributes on social interactions	Urban parks	Beijing, China	Space syntax, observations
[123]	The impact of spatial changes on perceived anti-social behavior	Historical district	Shiraz, Iran	Space syntax, questionnaires
[95]	Spatial vitality and spatial environments	Underground metro station	Shanghai, China	Space syntax, field observation, cross-sectional pedestrian count
[113]	Engaging in social interaction	Urban park	Kuala Lumpur, Malaysia	Space syntax, gate counts, GIS, correlational analysis
[114]	Spatial configuration and social sustainability	Urban neighborhood	Shiraz, Iran	Space syntax, questionnaires, Pearson correlation
[115]	Evaluating the quality of urban open spaces	Urban open spaces	Port Said, Egypt	Space syntax, face-to-face interviews, field observations
[116]	Correlation between spatial configuration and potential human behavior	Urban open spaces	Kenadsa Ksar, Algeria	Space syntax, interviews, observations

Table 1. *Cont.*

Author(s)	Topic	Land Use	Location	Methodologies
[27]	Morphological evaluation and regeneration of informal settlements	Urban neighborhood	Cairo, Egypt	Space syntax, space matrix, mixed use index
[117]	Neighborhood syntactical properties and walking and sitting behaviors	Urban neighborhood	Tehran, Iran	Space syntax, questionnaire surveys
[49]	The impact of double-skin façades on social activities	Urban neighborhood	Barcelona, Spain	Space syntax, gate and snapshot observations
[35]	Spatial legibility and its association with human mobility patterns	Urban square	Rasht, Iran	Space syntax, cognitive sketch maps, time-lapse method
[118]	Evaluating attractivity and visit frequency	Urban square	Setif, Algeria	Space syntax
[124]	Urban vitality and the accompanying social and economic phenomena	Old town vs. new town	Cairo, Egypt	Syntactic analysis, place syntax and field observation
[119]	Social retrofitting design through occupancy pattern	University campus	Tanta, Egypt	Space syntax, observations
[52]	Gender equality of privacy protection	Urban square	Rasht, Iran	Questionnaire, space syntax
[120]	Reshaping the tourist movement	Historical district	Koya, Iraq	Questionnaire, observations, space syntax
[121]	Socio-spatial relations of the built environment	Residential complexes	Tirana, Albania	Space syntax, GIS
[122]	Close interaction analysis between the elderly	Public spaces	Shanghai, China	Questionnaire surveys, space syntax

Heterogeneity among Outcomes of Reviewed Results

The findings from the reviewed studies revealed a rich diversity of perspectives and insights into the relationship between spatial configuration and social dynamics within urban environments. Each study offered a unique lens through which to explore this intricate connection, leading to a multitude of observations and interpretations. Across the spectrum of urban settings investigated, from university campuses to historical districts, parks, and informal settlements, researchers have uncovered nuanced relationships between spatial characteristics and sociability. For instance, studies have highlighted the significance of intermediary spaces in fostering community engagement in urban areas, emphasizing the role of street connectivity and in-between spaces in promoting social interactions [36,38]. Methodologically, studies have employed a variety of approaches, including space syntax analysis, surveys, observational techniques, and correlational analyses. These diverse methodologies contributed to the richness of the findings but also introduced variability in the interpretation of the results. Furthermore, the focus of each study varied, with some examining the influence of spatial visibility and connectivity on social interaction, while others explored the impact of urban landscapes, historical preservation efforts, or gender equality initiatives on sociability within public spaces [39,52,116,123]. This breadth of focus underscores the multifaceted nature of urban sociability and highlights the importance of considering various environmental, social, and cultural factors. As a result of these varied

approaches and focuses, the findings of the reviewed studies offered a range of insights and recommendations. While some studies emphasized the role of spatial design in promoting community engagement and well-being, others highlighted the importance of historical preservation, greenery, or age-friendly design principles in facilitating social interactions within urban spaces. Overall, the heterogeneity among the findings reflects the complexity of urban environments and the multifaceted nature of sociability, underscoring the need for comprehensive and context-specific approaches to urban design and planning.

3.3. Analyzing the Existing Gaps for Future Directions

3.3.1. Evidence Gap

This kind of gap refers to a lack of sufficient or appropriate data, information, or evidence to support a particular claim, argument, or conclusion. An evidence gap often suggests the need for further research or data to strengthen the foundation of a study. The fundamental research evidence for the reviewed studies referred to the application of space syntax in analyzing social interactions among people. However, there could still have been a lack of evidence both in terms of simulation studies and empirical studies, based on the nature of the research.

One of the most fundamental strategies that could enrich the evidence of such studies is to provide a thorough analytical approach to assessing the correlation between space syntax measures and the actual activities of pedestrians and their associated social behaviors within the area under study. Another potential factor could be the alignment between environmental issues and the empirical studies conducted. For instance, the appropriateness of weather conditions for establishing social behaviors is considered a crucial step to ensuring the validity of findings. Proper weather conditions are one of the most important prerequisites of establishing social communication. Therefore, it was indispensable to consider this factor throughout the data gathering process.

In addition, the more frequent the repetition of acquiring empirical data, the higher the dependability of the evidence that may be gained. For example, the procedure of conducting empirical observations for capturing social behaviors could be accomplished at several hours of the day and on several days of the week. Alternatively, one of the common methods for preventing biases within the data collection process is to conduct empirical observations both on weekdays and weekends.

One potential evidence gap could be the lack of detailed information on the existing problems or deficiencies in the layout of the study area. On the other hand, the lack of meticulous information on the profile of the participants, such as their age group, gender, ethnicity, etc., could mitigate the reliability and accuracy of obtained data. The validity testing of the questionnaire and interview results used in field surveys is considered another important criterion in the evidence gap. More importantly, their relationship with the findings obtained from space syntax analysis had to be discovered to obtain more precise data.

Providing statistical tests or significance levels to the correlation results of observed social activities and syntactical measures is another significant notion that needed to be taken into consideration to reinforce the evidence of the obtained data, which was normally ignored in previously published papers. It is important to note that, based on the research aims of studies, providing the static and/or dynamic nature of social behaviors is worth being collected with detailed behavioral mapping. Moreover, providing excerpts or illustrative quotes from participants could enhance the evidence base and provide a richer understanding of pedestrian experiences. These quotes or excerpts can offer firsthand perspectives, emotions, and details that may not be captured through data or analysis alone, thereby enriching the evidence base and contributing to a more robust interpretation of pedestrian experiences.

In sum, the necessity of empirical evidence regarding the level of consistency between syntactical and morphological analysis, and tangible empirical evidence, seems to be indispensable in urban social and behavioral studies. In addition, presenting detailed

evidence on the causality or mechanisms underlying these correlations needs to be taken into consideration.

3.3.2. Knowledge Gap

A knowledge gap exists when there is a lack of understanding or information on a particular topic or issue. It signifies the need for additional research or exploration to fill the void in existing knowledge. While space syntax effectively analyzes spatial configurations, there is a gap in incorporating social and cultural factors that influence sociability. Studies could explore how cultural norms, demographics, and traditional customs interact with spatial design to influence social interaction.

Research could delve into how public spaces are used across different times (day/night), seasons, spatiotemporal, and weather conditions. Studying how these factors influence social interaction would be valuable. Public spaces engage users through various senses (sight, sound, smell, tactile, and taste). Studies could explore how these senses may affect social interaction in public spaces. Future studies could explore how space syntax can contribute to designing public spaces for specific activities, such as community events, festivals, exhibitions, markets, or children's play areas.

Although there is a suitable range of studies on urban squares, there is still some room for compensating knowledge gaps, focusing on establishing sitting areas and arranging furniture as focal points for stimulating social interactions. While there are some published works concerned with streets and their sidewalks, most of them focus on their mobility and walkability. They are considered well-suited infrastructures for studies on temporal and dynamic factors, including how pedestrian traffic patterns influence social interaction across different times of day or seasons.

In relation to alleys and dead ends, there is a conspicuous knowledge gap in assessing their capability to facilitate social interactions, despite being considered crucial parts of neighborhood units. In-between spaces still hold potential for research on multi-sensory experiences, investigating how elements such as lighting or street furniture affect their social use. Urban parks possess potential to be explored in terms of how specific spatial layouts can contribute to activity-based design, focusing on how space syntax can be used to design areas for social gatherings or events within parks.

While previous studies have suggested that waterfronts and landmarks have the potential to offer opportunities for stimulating social mobility, there remains an under-explored gap in social interaction around these unique spaces. Iconic bridges could be interesting for studies on user experience, particularly if they connect distinct areas with different social atmospheres. Although metro stations are considered perennial spaces for commuting many people, in most cases, they remain simply functional urban spaces solely for transportation purposes. However, they also have a lot of potential for research on user experience, especially when examining how social interaction differs between above-ground and underground spaces, providing insights for improving social ties. Overall, incorporating user experience, temporal dynamics, multi-sensory factors, and specific activity design, researchers can gain a richer understanding of how to design these spaces for optimal social interaction and community well-being.

3.3.3. Practical Gap

A practical gap refers to a deficiency in the real-world application or implementation of knowledge. It indicates that there may be challenges or shortcomings in translating theoretical concepts into practical solutions or actions. In general, there are two main categories within the existing literature for showcasing practical gaps. The first one refers to a group of studies that suffer from a lack of clear guidance for designers and planners. These articles lack practical recommendations to clarify how to use space syntax analysis to create urban public spaces that promote social interaction.

The second group refers to studies that address a variety of practical gaps. These studies offer concrete suggestions for designers and policymakers. They use space syntax

analysis to inform design recommendations for plazas, parks, streets, and other public spaces, with the aim of improving social interaction and community life. One of the major problems associated with the current literature is the focus on theory over its pragmatic application. While some studies establish correlations between space syntax and social interaction, they do not delve into how these findings can be used to develop specific urban design strategies. Thus, there is a need for research that bridges the gap between theoretical concepts and practical applications.

On the other hand, missing precise details for implementation practices for urban design can be pointed out as yet another crucial item that has been neglected thus far. Many studies discuss how space syntax can inform urban design, but they do not provide specifics on how to translate those findings into actionable plans. There is a lack of discussion on budgetary constraints, logistical challenges, feasibility studies, and real-world examples of successful implementation. Considerations regarding limited groups of users are another notable issue associated with the previously conducted literature. Although there are several studies focusing on spatial analysis, they normally did not consider how people from different backgrounds, demographics, ethnicities, or cultures might use the space. Hence, there is a gap in understanding how space syntax can be used to create inclusive and equitable urban public spaces for everyone.

According to the findings, regardless of the phenomenal potential of space syntax as an instrument to facilitate socio-spatial analysis, translating these analyses into actionable recommendations remains a challenge. Future research can focus on creating practical urban design guidelines based on space syntax findings. These guidelines could specify metrics, configurations, or design elements, including urban furniture, that promote social interaction in different contexts such as plazas, neighborhoods, parks, residential areas, and so on. Documenting successful implementations of case studies using space syntax-informed designs can be considered as yet another valuable suggestion for delving into pragmatic insights. Case studies that display real-world projects and their impact on social interaction would provide designers with priceless practical examples to be emulated and inspired by successful projects.

Collaboration between designers and analysts is yet another paramount and indisputable factor that ought to be realized to have successful practical insight. Although space syntax analysis is often conducted by separate specialists, encouraging collaboration between analysts and designers throughout the design process can ensure that analytical findings are effectively translated into design decisions. Overall, by applying these strategies, space syntax analysis can move beyond theory and become a practical tool for creating sociable urban public spaces.

3.3.4. Methodology Gap

This term denotes a shortfall or inadequacy in the research methods employed in a study. A methodology gap suggests that there may be flaws, limitations, or room for improvement in how the research was conducted. As noted in the final paragraph of Section 3.1, the majority of the examined studies employed mixed methods, underscoring a clear preference for integrating mixed methods with space syntax to understand social activities within urban environments. Accordingly, the most frequent and common methods that tend to be incorporated with space syntax are empirical observations, questionnaires, and interviews, in that order.

Generally, the methodological approach of the reviewed studies can be categorized into various deficiencies. These include limited details in the adoption of specific methods, as well as restrictions imposed by exploring the strengths, weaknesses, and potential biases of the chosen methods. There is also a lack of critical reflection on the appropriateness of the chosen methods concerning the research aims, alternative approaches for more robust analysis, detailed information on data collection methods, potent statistical analysis for outcome validation, and comparative analysis for strengthening generalizability.

In regard to the latest novel method that could be applicable in the analytical procedure, previously published research [35] has elaborated on and implemented the time-lapse photography or video-recording methods for capturing societal mobility during different times of the day. Thus, they could be applicable in some iconic and target areas that are considered as major destinations of social communities with higher pedestrian traffic. These approaches could be developed by a system for categorizing observed behaviors such as basic demographic information, types of behaviors, and enjoying any types of urban infrastructure.

In addition, there are a bunch of novel materials and methods that could enhance syntactical analysis to contribute to the sociability of urban public spaces. Analyzing anonymized location data from smartphones such as Google Street View and social media platforms can help in understanding movement patterns and social interactions in public spaces. Moreover, analyzing online reviews of specific locations on platforms like Google Maps, as well as social media posts from platforms such as Instagram or Facebook, could potentially contribute to gauging the public perception of sociability in different areas.

Engaging inhabitants in mapping areas identified as conducive to social interaction through analytical procedures or utilizing mobile apps for crowdsourced data collection on user behavior and social interactions could potentially contribute to the sociability of urban public spaces. Using data from noise sensors, temperature sensors, and light sensors to explore the relationship between environmental conditions and sociability can significantly contribute to understanding the interplay between these two key aspects of environmental and social sustainability.

Using data on Wi-Fi usage or phone call activity to distinguish between individuals engaging in face-to-face interactions and those engaged in virtual interactions can help identify areas with higher levels of sociability. Developing virtual reality or augmented reality simulations of urban public spaces to study how different design configurations influence social behavior in a controlled environment can contribute to gathering data on user preferences and identifying potential spaces for promoting social interaction.

Combining eye-tracking technology to understand how people navigate and interact with public spaces, along with physiological measurements such as heart rate or skin conductivity to assess emotional responses related to sociability in different areas, can also provide a set of novel insights for future studies. Last but not least, integrating image semantic segmentation with deep learning into data collection coupled with creative usage of GIS holds promise for more thorough insights towards sociable urban areas. Deep learning models can automatically segment images into different categories like people, benches, trees, or open spaces. This eliminates the need for manual annotation, saving time and potential bias. By identifying specific elements within the public space, researchers can analyze how these elements influence social interaction patterns.

In a nutshell, combining these approaches with methods like space syntax analyses, observations, and surveys can provide a multi-layered and more comprehensive picture of the factors influencing sociability in urban public spaces. It should be noted that ethical considerations regarding the data collection and anonymization of individuals captured in methods associated with photography need to be addressed.

3.3.5. Empirical Gap

An empirical gap arises when there is a lack of empirical evidence, which includes data collected through observation or experimentation. Researchers may identify an empirical gap when there is a need for more direct evidence to support or refute a hypothesis. According to findings, empirical evidence is considered an inevitable procedure for conducting robust research through space syntax, with a particular focus on capturing the social behaviors of people.

Reviewing the previous literature indicated that studies in several cases analyzed spatial configurations using space syntax but lacked a clear connection to how people actually used the space. This gap calls for more detailed observations of user behavior,

their preferences for social interaction in a space, and how usage patterns relate to spatial configurations. Limited data or reporting in studies often manifests through insufficient methodological details, data collection descriptions, and findings. This includes inadequate data presentation in studies encompassing the impact of spatial layouts on social behavior, along with insufficient details regarding observed social activities, interactions, and the absence of necessary statistical quantitative data, such as correlation coefficients, to strengthen the connection between space syntax measures and social interaction.

In addition, the results from crucial methods like behavioral mapping, questionnaires, and mental and cognitive mapping are often overlooked in reporting. Studies most often conducted in specific contexts (single city, district, or neighborhood) raise concerns about generalizability. A broader range of case studies from diverse locations could strengthen the validity of the findings. There might be a lack of detailed information on how observation methods were applied and potential biases addressed for self-reported data.

Moreover, there is a need for studies to incorporate a more comprehensive qualitative analysis, particularly focusing on examining the types of social interactions and the sense of community within spaces, as well as delving into specific sociability-related activities occurring within those spaces. In relation to novel empirical approaches, converting behavioral mapping with specific interaction codes can be considered for future studies. This method consists of mapping observed behaviors in a space, but with additional coding to capture the nature of interactions. Codes could represent solitary activity, dyadic or group forms of conversation, greetings, or other forms of social interaction.

Analyzing the proximity between individuals—whether standing or sitting—can reveal insights into their interactions or preferences for their desired realm of privacy. Adjusting the orientation of research to identify interactions for people who are familiar with each other and for those who are not is essential. Such analysis aims at identifying and tracking pre-existing social tie networks within a space, revealing how spatial configurations could influence interactions between individuals who already know each other and those who do not.

Combining space syntax analysis with data from wearable trackers or anonymized phone location data to understand how people actually move through a space and interact with different areas may open a new avenue to delve into empirical evidence based on another perspective. The method of people following or tracing is another form of rigorous empirical evidence that was typically neglected in previous studies, which can offer very particular datasets to analyze the personal behaviors of people. In addition to providing insights regarding usage patterns, potential social hotspots could also be revealed through the application of this empirical and dynamic method of observation.

Event sampling allows for focused observations on specific time periods or events known for high social activity, such as Christmas events and markets and New Year's Eve, or religious events like Easter. This approach enables targeted data collection on social interactions during peak usage times, capturing specific behaviors of people at such events. Conducting brief exit surveys with users as they leave the space, asking about their experience in establishing social interactions, perceived comfort with socializing, and overall satisfaction, could enrich qualitative observations. Overall, the best-acquired empirical approach substantially depends on the specific research questions and aims, intertwined with a dash of creativity from the researchers. Combining multiple empirical methods can provide a richer picture of how spatial configuration and user behavior interact in urban public spaces.

3.3.6. Theoretical Gap

A theoretical gap exists when there is an absence of well-developed theoretical frameworks or models to explain a phenomenon. It signifies the need for theoretical advancements or the exploration of alternative theories to better understand a subject. Concerning the theoretical gaps in the previous literature, many studies acknowledged space syntax as an independent theory and its impact on sociability, but they failed to deeply inte-

grate it with existing theories or frameworks in the urban design literature for a broader holistic understanding.

To comprehensively understand how space influences sociability, it is imperative to delve deeper into sociological theories related to social interaction. This exploration should incorporate the insights of pioneering theoreticians and urbanists such as Jan Gehl, Jane Jacobs, William Whyte, Kevin Lynch, Jon Lang, Jonathan Montgomery, and Christopher Alexander, among others, while also emphasizing the incorporation of space syntax theory. On the other hand, combining the theories of space syntax and environmental psychology, such as spatial design, lighting, noise, aesthetics, human perception, security, cognition, emotions, and behaviors, can enrich and compensate for a great portion of theoretical gaps in this field to enhance the subjective facets of such theories.

Space syntax can identify areas with high potential for encounters, while environmental psychology can explain why or why not those encounters may actually lead to social interaction. Thus, the combination of these two factors provokes a novel vision on theoretical gaps. As a result, through mixing the "where" (space syntax) with the "why" (environmental psychology), researchers can better comprehend the factors that promote or prevent social interaction in public spaces. Combining space syntax analysis with the concept of a 15-min city, territoriality, and proxemics to understand how different users and age groups (e.g., children, elderly) or genders may navigate and interact with space can promote equal and inclusive designs for different social groups.

One of the critical points that can be inferentially recognized by the space syntax method is delving into the role of culture and context on sociability. This fact has been substantially highlighted in architectural spaces, but in urban spaces, very limited studies have paid attention to this crucial item so far. Hence, considering cultural differences within societies, particularly focusing on their social behaviors, could enhance the literature in this area of study. The majority of space syntax studies have primarily focused on analyzing the physical layout. Considering the gap in understanding how other design elements such as furniture arrangement, materials, particularities in landmarks, or activities offered in a space might influence social interaction, it is essential to provide a wider perspective for exploring beyond the physical configuration of cities.

In addition, further focus on exploring and predicting the quality of encounters that take place among users to understand the nature of their interactions—whether positive, negative, or neutral—holds significance. This provides a better insight into designing urban spaces for the desired outcomes. Moreover, recent studies have drawn particular attention to short-term interactions. Exploring the gap in how space syntax can be used for building social cohesion over time could also yield valuable outcomes. Understanding the fact that any specific spatial layout may encourage the formation of regular social groups to promote social solidarity can promise sustainable urban spaces for future generations. Lastly, it is important to note that with the rise in smart cities and interactive technologies, exploring how these elements might be incorporated with space syntax to enhance sociability in urban spaces could offer unique outcomes.

3.3.7. Population Gap

A population gap occurs when a study's findings, conclusions, or recommendations may not be generalizable or applicable to a broader population due to limitations in the sample size or characteristics of the participants. It suggests a need for caution when extending results to larger populations. Reviewing the related literature highlights that there is a significant population gap in the application of space syntax on the sociability of urban public spaces. Most studies lack details about the participants' demographics including their age, gender, ethnicity, socioeconomic background, and so on. This makes it difficult to understand if the findings apply to a broader population or if specific groups might have different experiences in these spaces.

Multiple studies tend to concentrate their investigations on specific locations such as university campuses, neighborhoods, streets, or cities, or they may target particular

user groups like youngsters, students, or the elderly. While these focused examinations provide valuable insights within their respective contexts, their applicability to broader settings remains restricted. As a result, the broader implications and generalizability of their findings to diverse environments or populations may be compromised. Some studies may delve into social aspects such as user needs or interactions within a specific context but might not explicitly delve into the representativeness of the sampled population.

Thus, there is a clear call for studies to broaden their participant pools, encompassing a more diverse array of individuals. Doing so would not only enrich the understanding of the subject matter but also ensure that findings resonated with a wider spectrum of society. Recognizing the significance of context is paramount. While certain studies may be insightful within their confined environments, it is essential to acknowledge the limitations inherent in extrapolating findings to different settings or demographics. Thus, there is a need for research to not only contextualize its findings but also suggest avenues for exploration in different environments or among diverse user groups. Overall, current research often overlooks the diversity of urban populations. Encouraging studies to include a broader range of demographics—such as age, socioeconomic status, and cultural background—will provide a more thorough understanding of how different groups interact with urban spaces. A summary collection of actionable research gaps in this study is demonstrated in Table 2.

Table 2. Summary of actionable related research gaps that need to be explored in future studies.

Research Gap	Summary of Actionable Related Research Gaps in the Field
Evidence	1. Need for thorough analysis to correlate space syntax measures with pedestrian activities and social behaviors. 2. Alignment of environmental issues (e.g., weather conditions) with empirical studies to ensure validity. 3. Importance of frequent and varied empirical data collection (different times of day, weekdays, weekends) to enhance dependability. 4. Lack of detailed participant profiles (age, gender, ethnicity) reducing data reliability and accuracy. 5. Relationship between survey findings and space syntax analysis. 6. Need for statistical tests or significance levels for the correlation results between observed social activities and syntactical measures. 7. Collection of detailed behavioral mapping data to capture both the static and dynamic natures of social behaviors. 8. Inclusion of illustrative quotes from participants to enhance the qualitative evidence base and provide a richer understanding of pedestrian experiences. 9. Need for empirical evidence on the consistency between syntactical/morphological analysis and tangible empirical evidence.
Knowledge	1. Incorporation of cultural norms, demographics, and traditional customs in spatial design to influence social interaction. 2. Study of public space usage across different times (day/night), seasons, and weather conditions to understand their impact on social interaction. 3. Exploration of how senses (sight, sound, smell, touch, and taste) affect social interaction in public spaces. 4. Use of space syntax to design public spaces for specific activities (community events, festivals, exhibitions, markets, children's play areas). 5. Establishment of sitting areas and arrangement of furniture to stimulate social interactions. 6. Research on temporal and dynamic factors, including how pedestrian traffic patterns influence social interaction. 7. Assessment of the capability of alleys and dead ends to facilitate social interactions in neighborhood units. 8. Investigation of multi-sensory experiences, such as the effects of lighting or street furniture on social use. 9. Underexplored social interaction opportunities around some unique spaces such as waterfronts, iconic bridges, and landmarks. 10. Research on social interaction differences between above-ground and underground spaces, with potential to enhance social ties in metro stations.

Table 2. *Cont.*

Research Gap	Summary of Actionable Related Research Gaps in the Field
Practical	1. Insufficient practical recommendations for designers and planners on using space syntax to create sociable urban spaces. 2. Lack of focus on practical applications, with few studies detailing how findings can develop specific urban design strategies. 3. Missing precise details on implementation practices, including budgetary constraints, logistical challenges, and feasibility studies. 4. Need for guidelines specifying metrics, configurations, and design elements (e.g., urban furniture) that promote social interaction. 5. Scarcity of case studies showing successful space syntax-informed designs and their impact on social interaction. 6. Need for collaboration between designers and analysts to ensure analytical findings are effectively translated into design decisions.
Methodology	1. Lack of detailed explanation of specific methods and exploration of their strengths, weaknesses, and potential biases. 2. Insufficient critical reflection on the appropriateness of chosen methods concerning research aims and alternative robust approaches. 3. Need for more detailed information on data collection methods and potent statistical analysis for outcome validation. 4. Lack of comparative analysis to strengthen the generalizability of findings. 5. Use of time-lapse photography or video recording to capture societal mobility at different times of the day. 6. Categorization of observed behaviors using demographic information and types of behaviors. 7. Analysis of anonymized location data from smartphones, Google Street View, and social media platforms to understand movement patterns. 8. Analysis of online reviews and social media posts to gauge public perception of sociability. 9. Using noise, temperature, and light sensors to explore the relationship between environmental conditions and sociability. 10. Using Wi-Fi usage or phone call activity data to differentiate face-to-face and virtual interactions to identify sociable areas. 11. Development of VR/AR simulations to study design configurations' influence on social behavior in controlled environments. 12. Combining eye-tracking and physiological measurements (heart rate, skin conductivity) to assess emotional responses related to sociability. 13. Integrating image semantic segmentation with deep learning to analyze elements influencing social interaction patterns.
Empirical	1. Need for more detailed observations of user behavior, preferences for social interaction, and how usage patterns relate to spatial configurations. 2. Overlooking results from crucial methods like behavioral mapping, questionnaires, and mental/cognitive mapping in reporting. 3. Studies often conducted in specific contexts (single city, district, or neighborhood) limit the generalizability of findings. Broader case studies from diverse locations are needed. 4. Future studies should include behavioral mapping with specific interaction codes to capture the nature of social interactions. 5. Analyzing the proximity between individuals to understand their interactions and privacy preferences. 6. Identifying interactions between people who know each other and those who do not, to reveal how spatial configurations influence these interactions. 7. Combining space syntax with data from wearable trackers or anonymized phone location data to understand movement patterns and interactions. 8. Employing the method of people following or tracing to gather data on personal behaviors and identify social hotspots. 9. Focused observations during specific time periods or events known for high social activity to capture specific behaviors.

Table 2. *Cont.*

Research Gap	Summary of Actionable Related Research Gaps in the Field
Theoretical	1. Need for deeper integration of space syntax with existing urban design theories (e.g., theories by Jan Gehl, Jane Jacobs, William Whyte, Kevin Lynch, Jon Lang, Jonathan Montgomery, and Christopher Alexander). 2. Combining space syntax with environmental psychology theories (e.g., lighting, noise, aesthetics, human perception, security, cognition, emotions, behaviors) to enhance social interactions in public spaces. 3. Delving deeper into sociological theories related to social interaction to provide a broader holistic understanding of how space influences sociability. 4. Combining space syntax with theories on territoriality and proxemics to understand how different users (e.g., children, elderly, genders) navigate and interact with space, promoting inclusive designs. 5. Considering cultural differences and contexts within societies to enhance the understanding of social behaviors in urban spaces. 6. Exploring how other design elements (e.g., furniture arrangements, materials, landmarks, activities) influence social interactions, beyond just the physical configurations of cities. 7. Focusing on understanding the nature of social interactions (positive, negative, neutral) to design urban spaces for desired social outcomes. 8. Exploring how space syntax can be used to build social cohesion over time, encouraging the formation of regular social groups to promote social solidarity. 9. Investigating how smart cities and interactive technologies can be incorporated with space syntax to enhance sociability in urban spaces.
Population	1. Most studies lack comprehensive details about participants' demographics (age, gender, ethnicity, socioeconomic background), making it difficult to generalize findings to a broader population. 2. Studies often concentrate on specific locations (e.g., university campuses, neighborhoods, streets, cities), limiting the generalizability of findings to diverse environments. 3. Research frequently targets particular user groups (e.g., youngsters, the elderly), restricting the applicability of findings to broader populations. 4. Some studies do not explicitly address the representativeness of their sampled population, making it challenging to determine if the findings apply to larger and more diverse groups. 5. There is a clear need for studies to broaden their participant pools to include a more diverse array of individuals, enriching the understanding of urban sociability. 6. Recognizing the significance of context is crucial, as findings from specific environments may not be easily extrapolated to different settings or demographics. 7. Encouraging the inclusion of a broader range of demographics (age, socioeconomic status, cultural background) will provide a more thorough understanding of how different groups interact with urban spaces.

3.4. The Role of Space Syntax in the Study of Sociability in Urban Public Spaces

The role of space syntax in the study of sociability in urban public spaces represents a significant advancement in understanding how spatial configurations influence social interactions. Space syntax, as a theoretical framework rooted in urban design and planning, provides analytical tools to dissect spatial layouts and their impact on human behavior. However, while existing studies highlight its potential, several gaps and opportunities for further exploration emerge.

Initially, empirical evidence is crucial for substantiating claims about the correlation between spatial layout and sociability. Many studies acknowledge the use of space syntax to analyze spatial configurations but lack detailed empirical data linking these configurations to actual social behaviors. Addressing this gap requires more robust methodologies that integrate behavioral observations, surveys, and possibly emerging technologies like wearable trackers or smartphone data analysis to capture real-time user interactions in diverse urban contexts. By doing so, researchers can provide concrete evidence of how spatial designs facilitate or inhibit social interactions across different demographic groups and environmental conditions.

Moreover, while space syntax excels in analyzing physical layouts, there remains a theoretical gap in integrating sociocultural factors into its framework. Sociability in public spaces is not solely determined by physical structure but also by the cultural norms,

community dynamics, and socioeconomic backgrounds of users. Future studies could enrich this theoretical underpinning by incorporating insights from sociological theories and environmental psychology, which explore how these factors influence social interaction patterns. By bridging these disciplines, researchers can develop a more comprehensive understanding of how to design inclusive and culturally resonant public spaces that foster social cohesion.

Practically, there is a gap in translating theoretical insights into actionable urban design strategies. While some studies offer recommendations, there is a need for clearer guidelines that urban planners and designers can implement. This involves not only refining space syntax methodologies for practical application but also addressing logistical challenges, budget constraints, and community engagement strategies to ensure that designed spaces meet the diverse needs of urban populations. In sum, while space syntax provides a powerful lens for understanding spatial configurations and their implications for sociability, future research should focus on filling the identified gaps. By doing so, urban designers and policymakers can leverage space syntax as a transformative tool to create more socially cohesive urban public spaces.

3.5. The Contribution of This Systematic Review

The novelty of the present study lies in two main factors, both technical and general. In technical terms, the approach of this review differs significantly from previous reviews in the field of space syntax [96–98,101,102], with a particular focus on social interactions and behaviors among people. In addition, this study provides a wider range of suggestions and recommendations based on underexplored areas of research for future research orientations. On the other hand, this study offers a new insight into a general approach to systematic review papers, combining the PRISMA flowchart with seven scientific gaps to provide a more comprehensive and systematic approach for review studies, enabling future research to explore the horizons of knowledge more effectively. We acknowledge that although the focus of this study was on identifying research gaps, the risk of bias was also addressed during the review process. Assessments of risk of bias due to missing results, particularly arising from reporting biases, were conducted for each synthesis assessed, ensuring thorough consideration of potential biases in the review process.

There are a set of limitations in the search protocols employed in this study, including the language, which was restricted to English, considering the fact that there might be valuable data in other languages such as Chinese, Latin, Arabic, Persian, etc. Other restrictions consist of the exclusivity of the Scopus database and journal articles applied in this review. Future reviews may consider other valuable databases, including Web of Science, and other forms of articles, including book chapters and conference proceedings, specifically the International Space Syntax Symposiums. Last but not least is the limitation of this review to the issue of sociability in public urban spaces, which, albeit holding substantial significance, could be compensated by a wider range of space syntax applications in other forms of socio-spatial sciences influential in urban spaces, such as accessibility, security, wayfinding, and placemaking.

Overall, the findings suggested that although there are valuable studies for understanding how people encounter each other in urban public spaces, social interaction extends beyond high-movement areas. Plazas and seating areas also play a crucial role in fostering connections. Future research can bridge this gap by exploring the interplay between space syntax and other design elements in these less mobile areas. This might involve analyzing how furniture arrangement, landscaping, and even microclimatic considerations influence how people interact within plazas and seating areas. Furthermore, incorporating a cross-cultural lens into the research on space syntax and social interaction in these areas holds immense potential. Different cultures have varying preferences for personal space, comfort levels, and preferred modes of social interaction. By delving into these cultural variations, researchers can gain a deeper understanding of how people from diverse backgrounds utilize plazas and seating areas.

This knowledge can then be applied to design plazas and seating areas that are welcoming and promote social interaction for a wider audience. Comparative case studies analyzing plazas or seating areas in different countries can reveal design elements that function universally in promoting interaction, alongside those that might be culturally specific. Additionally, surveys and user interviews conducted with people from various backgrounds can provide valuable insights into their preferences for furniture arrangements, landscaping elements, and microclimatic considerations. Ultimately, by embracing a cross-cultural perspective, research can move beyond a one-size-fits-all approach. This shift will lead to a more nuanced understanding of how design can foster a sense of community and social connection in public urban spaces, ensuring that plazas and seating areas are truly inclusive and promote social interaction for everyone. A summary of the research outcomes is illustrated in the following diagram (Figure 7).

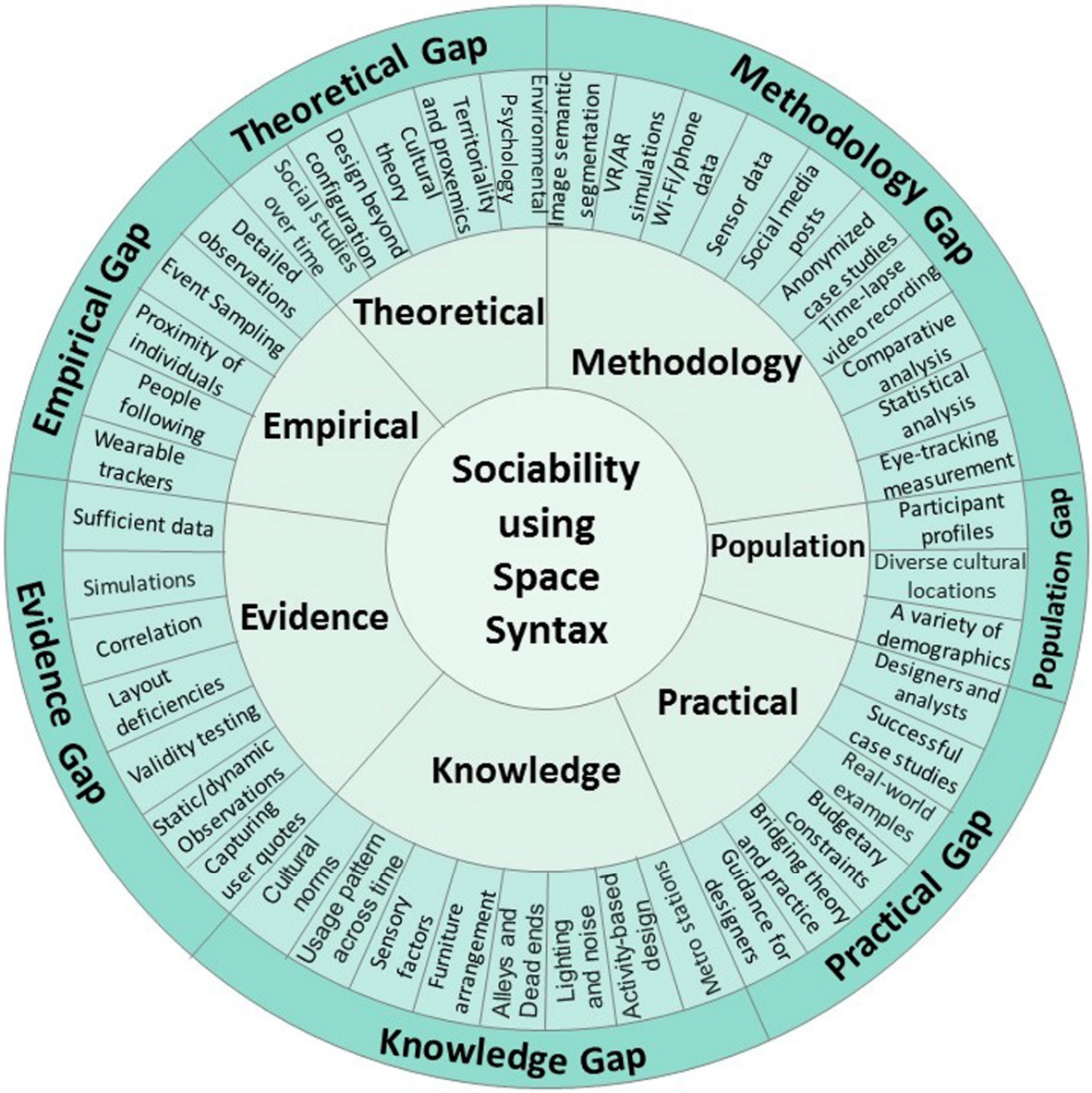


Figure 7. A summary of the findings and identified gaps according to different areas of scientific gaps.

4. Conclusions

This study sought to uncover underexplored avenues in the domain of space syntax research, specifically to provide insights for future research agendas centered on the concept of sociability. Space syntax is a theory and research method that conceptualizes how

the spatial layout of a built environment influences the social life of people, and it is predominantly considered as an indispensable tool for measuring the impact of spatial configuration on the sociability of a built environment. Despite the significant contribution of space syntax to the understanding of social interaction, there is a lack of a comprehensive systematic literature review on its application to sociability in urban public spaces.

The findings of this systematic review revealed that plazas and seating areas, despite the possibility that they may limit mobility, have a substantial impact on promoting social interactions. By exploring the interplay between space syntax and design elements like the furniture, landscaping, and microclimate in these areas, future research may bridge this gap, particularly when taking a cross-cultural perspective into account. Understanding how cultural preferences for personal space and social interaction influence the use of these spaces is crucial for designing public urban spaces including plazas and seating areas that are truly inclusive and promote social connections for a wider audience.

The originality of this study resides on two fronts. Initially, it diverges from past space syntax reviews by specifically focusing on social interactions and behaviors within these spaces. Secondly, it proposes a more comprehensive systematic review methodology by combining the established PRISMA flowchart with the identification of underexplored research gaps, offering a more robust framework for future review studies. By incorporating space syntax with a cross-cultural understanding of social preferences, future research can guide the design of public spaces that promote connection and interaction for a wider audience. This shift in focus, from solely high-traffic pedestrian areas to all public spaces, has the potential to create more vibrant and socially enriching urban environments for all.

However, this research is not without its limitations. The search was restricted to English language sources, potentially overlooking significant studies in other languages. In addition, the review was limited to the Scopus database and journal articles, excluding other valuable sources such as book chapters and conference proceedings. Future research should consider these limitations by incorporating a broader range of databases and literature types. Expanding the focus beyond sociability to other socio-spatial applications of space syntax, such as accessibility, security, wayfinding, and placemaking, could further enrich the field.

In summary, while the current body of research provides precious insights into social interactions in urban public spaces, our findings suggest that social interactions extend beyond high-movement areas. Future research should delve into the interplay between space syntax and design elements in plazas and seating areas, emphasizing a cross-cultural approach to fostering inclusivity and social connections. By moving beyond a one-size-fits-all approach, this research can inform the design of public spaces that promote a sense of community and social interaction for diverse populations, contributing to the creation of vibrant and socially enriching public urban spaces.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/ijgi13070227/s1, detailed PRISMA checklist table used in the study [125].

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