Spatial Features and Elements Affecting Indoor Wayfinding—A Case Study in a Transit Hub

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Abstract. Indoor spatial features and elements have been identified as essential points that affecting wayfinding performance of a complex building. This research chose Shanghai south railway station to have a comprehensive understanding on the influence of spatial features and elements on wayfinding. Combination methods of tracking observation and space syntax analysis were introduced.

Decision-making points refer to the positions of access, turning, or going up and down the stairs. The complicity or symmetry of architecture plans are the main causes of dis-orientation. Signage plays a decisive role during the wayfinding process in an unfamiliar environment, especially in the underground corridor of a transit hub. With the combination of subjective observation, isovist analysis can be used as a powerful tool for describing the spatial features, and the plan of the architecture plays an important role on the passengers' mobility.

To conclude, indoor wayfinding performances of a complex building are influenced by both spatial features and elements. Spatial features can determine the indoor mobility pattern; functional elements contribute to the main impression; and the visual elements (especially signage) significantly impact the capture of spatial knowledge during wayfinding.

Keywords: Wayfinding · Spatial configuration · Signage · Decision-making point · Space syntax

1 Introduction

1.1 Wayfinding Factors

As the scale of architectures are getting bigger and complex, wayfinding within a public building such as airport, railway station, shopping mall, or hospital often proves to be a challenge for most pedestrians. The indoor spatial features and elements have been identified as decision-making points that affecting wayfinding performance of a complex building. Decision-making points are the stop points where people pause and confirm their direction, percept the space, choose the destination path in the process of wayfinding. Whether the wayfinding process can be completed or not depends on every

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single decision-making point during the journey. A decision-making point is not only at the intersection or turning point in the path, but also at any position in the wayfinding process that may confuses pedestrians. In general, the more decision-making points in a building space, the more difficult it is to find a way.

Eaton (1991) suggested that the determination of decision-making point is closely related to environmental information, including the effectiveness of the information, relationship between environmental and pedestrian and the personal wayfinding ability of pedestrian. The investigation and analysis of environmental information is particularly necessary to understand the impact on wayfinding behavior. The significance of environment information survey is to help people find the decision-making points and the significant features of spatial cognition. This study divides environmental information factors into spatial features and spatial elements.

The spatial feature includes whether the long or short of an atrium, wide or narrow of a corridor, bright or dark of a room, which is the primary factor to form the spatial image. The characteristic factors of a space such as the volume and size, the shape and proportion, the enclosure and openness, and axial symmetry are the spatial configuration that people initially percept. Moreover, in the process of transfer, pedestrians and passengers usually form memories of the facilities with practical functions, mainly including signages, lighting, arts, advertisements, seats, toilets, ticket machines, convenience stores, newsstands, ATM information service stations and gates.

1.2 Related Works

Pioneering study (Weisman 1996) distinguished the four general classed of environmental variables impacting wayfinding process: visual access, the degree of architectural differentiation, the use of signage or room numbers, and plan configuration. Follow-up studies enrich the theory of wayfinding and closed the gap between architectural design and spatial cognition by adopting both subjective and objective research. Passini (1984) suggested that physical spatial features do not form an impression in the brain, but the function itself is memorable. Three primary ways of human wayfinding were summarized: landmark-navigation, route-navigation, and map-navigation. Human wayfinding require successful wayfinding information to obtain perception of the environment through different levels. Research on the influence of wayfinding behavior (Montello et al. 2006) conclude four main aspects including spatial differences, visual accessibility, complexity of plan and guiding signs.

With respect to methodology, some studies tried to identify some fundamental aspects of a building that impact wayfinding by empirical experiments of wayfinding behavior (Barton et al. 2012; Hölscher and Brösamle 2007), or investigation of spatial perception by adopting tracking observation, spatial layout analysis, and questionnaires to understand the importance of spatial factors affecting wayfinding and orientation (Dogu and Erkip 2000). Meanwhile, a geometric model was also proposed in order to calculate the decision-making point and to create a network of nodes as wayfinding assistances (Makri and Verbree 2014). Space syntax is also a common research methodology in the field of spatial cognition and legibility. Some researches evaluate the wayfinding ability by analysis of spatial configuration and visual form (Abdelbaseer 2012). Long and Baran (2012) obtained the measurement of intelligibility at a

neighborhood scale. Frank and Van (2014) explored the potential use of space syntax to evaluate wayfinding performance in underground space. Most empirical studies were carried in both urban environments or indoor spaces while few relevant researches in a transit hub in China were found.

2 Research Design

2.1 Investigation Site

This research chose Shanghai south railway station as a case study (Fig. 1), which is a typical multifunctional transit hub including railways, three metro lines, two bus centers, and a coach station. All these multimodal transports are connected by a winding underground corridor with over 20 exits. As one of the most important transfer hubs in Shanghai, the average daily flow of passengers reaches 300,000 in Shanghai South Railway Station. However, the problem of spatial legibility in the process of wayfinding becomes increasingly prominent. Volunteers at the station had to answer more than 100 questions a day about directions. Through the investigation and analysis of the current situation of the site, it is found that the current problems of Shanghai south railway station are as follows:

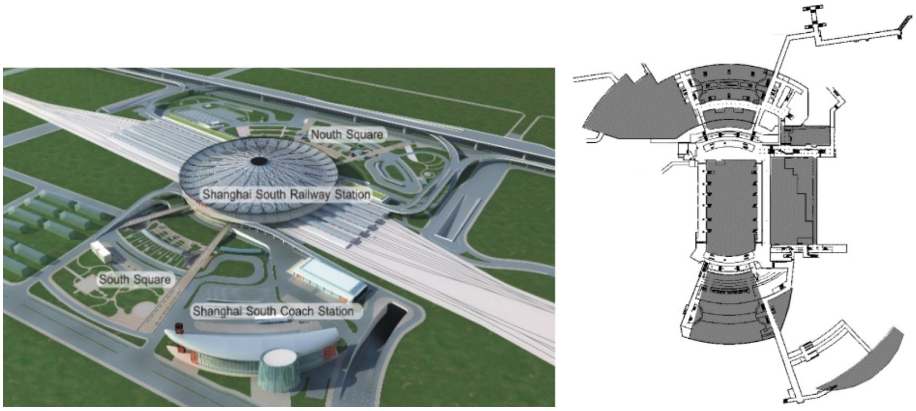

Fig. 1. Study areas of Shanghai South Railway Station.

- Circular symmetrical buildings reduce pedestrians' orientation;
- Station exits are located on the ground floor, making it difficult for pedestrians to find their way;
- Numerous passageways and exits lead to confusion of pedestrian positioning;
- There is a large amount of traffic at the main node, and the readability of signage is not enough;

- The coach station and the bus station are located on the south and north sides of the main building respectively, which are connected by a long, irregular shaped underground passageway.

Table 1. Spatial features and elements.

Categories		Contents	Descriptions
Spatial features		Layout, scale, direction, proportion, etc.	Fundamental factors impacting spatial cognition, location, and movements
Spatial elements	Functional elements	Toilet, shops, kiosks, escalators, ticket vending machines, etc.	Functional elements related with passengers' transfer
	Visual elements	Lighting, color, planting, arts, signage, etc.	Visual elements during passengers' mobility

According to the above problems, it is necessary for this study to observe and analyze the spatial characteristics and elements of Shanghai South Railway Station, as well as the wayfinding behavior of pedestrians, so as to find out the rules of transit hub design, to improve the legibility of transfer space and the enthusiasm of people to participate in the use of public transportation.

For transit hubs, the interior plan configurations, including size scale, form, and spatial components are the fundamental features impacting pedestrians' cognition and movements. Besides, compared with physical configurations, functional and visual elements remain the more profound impressions in people's mind (Passini 1984). We took both spatial features and elements as environmental factors affecting wayfinding behavior (Table 1).

2.2 Methods

Both methods of observation and spatial analysis were introduced in this study to have a comprehensive understanding on the influence of spatial features and elements on wayfinding.

Tracking observation is a kind of non-participatory observation, which generally hopes to record the real behavior of pedestrians in a completely natural state. Researchers track and observe all wayfinding behaviors of pedestrians from the starting point to the destination, such as turning, stopping, and looking for signs. In order to record the detailed details of the behavior of the test subjects, it is usually adopted to track and record the video after the test subjects. If necessary, interview and questionnaire survey can be conducted to obtain more detailed information after follow-up observation, such as the visual perception and the distance in the transfer process, or the difficulty of wayfinding.

Space Syntax theory, first forwarded by Hillier and is team (Hillier and Hanson 1984), has been developing more than thirty years. It has been widely applied in the field of urban study and complex buildings to assess the spatial structure of street

network, parks, neighborhoods communities, offices, universities, shopping malls, hospitals, museums, railway stations, and other public facilities. According to space syntax, analysis of spatial structure includes three basic concepts: the axial line, the convex space, and the isovist field. The axial line analysis adopts the longest sight line within a space to represent people's movement in straight lines along streets, rooms and corridors. The convex map means all points within a space that can be joined to all others without passing outside the boundary of the space (Hillier 1985). In later development, convex space analysis turned to point depth and the all-lined analyses. Isovist analysis offers a way of geometrically describing the spaces and forms of a space which can be seen from a particular position. It is part of visibility analysis and combines a consideration of environmental factors and human experiences, such as the relationship between space form and visibility, as well as its impact on peoples' movement. Therefore, isovist analysis is an effective method to quantify the relationship between vision and behavior and commonly used for orientation and wayfinding.

This study applies both objective (tracking observation) and subjective (space syntax) methods to survey the indoor environmental feature of a complex building and the impact on human wayfinding behavior. The main purposes of this study are: (1) to understand the main factors of spatial features and elements that influence indoor wayfinding behavior; (2) to determine impact of signage on pedestrian within an unfamiliar environment; (3) to exam the efficiency of space syntax to support the investigation on indoor wayfinding performance.

3 Results and Discussion

3.1 Tracking Observation

As can be seen from the plan, Shanghai south railway station is a circular building with two squares from north to south. The symmetrical distribution of the space may cause confusion in the direction. The underground floor is connected to the traffic mode through the corridor. The space of the corridor is not high enough, and artificial lighting is adopted to achieve general visibility. There are plenty of shops and restaurants along the corridor. As the main transfer corridor, the underground passageway and the ground floor are connected by multiple elevators, escalators and stairs. According to the field observation, the station has a huge number of passengers during the day, and the escalator is the most popular vertical mode of transportation for pedestrians and passengers. Obviously, the ends of the main passageway connecting the railway station entrances and exits with metro line 1 and 3 are the key areas of wayfinding and spatial cognition.

In the station, especially the underground passage, there are complete catering shopping and other service facilities. The shop's signboard lighting and color are eye catching, which may have certain influence on the direction identification and wayfinding. There are three main types of functional facilities; basic functional category, including shops, restaurants, banks, ATMs and kiosks; ride functional category, including information office ticket office brake automatic door; and transportation functional category, including elevators, stairs and escalators. In addition, like most

airports and stations, Shanghai south railway station adopts guidance signs recommended by national standards. These signs reasonably set in the intersection of the entrance and exit of the elevator and other important decision-making points, played a necessary role in wayfinding and providing information.

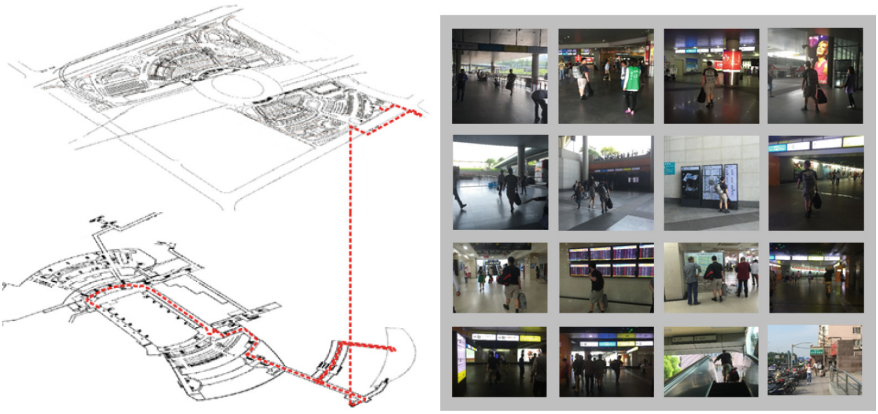

Fig. 2. Record of a passenger's mobility, including his moving route (left) and main behaviors (right).

This study invited twenty-six volunteers (average age 21; equal numbers of male and female) to achieve a wayfinding task from one of the railway station exit to coach station within Shanghai south railway station. Some basic demographic information about our subjects was collected. All participants has been well educated with a bachelor's degree or higher, and are rarely visiting or not familiar with Shanghai south railway station. Each of the behaviors, such as moving, pause, turning, looking around, or asking for directions, as well as the moving routes, were recorded by a non-participant observation. Some detailed information was also collected including:

- Origin-destination;
- Mobility routes;
- Time;
- Main behaviors;
- Achievements;
- Assessments.

Figure 2 shows one of the participants' completion of wayfinding task. Participants were asked to walk from the exit of the train station to the ticket office of the coach station in the south square. According to the path and behavior record, the subject completed the transfer task, but made several mistakes. After getting out of the railway station, he hesitated at the entrance of subway line 1 for a moment and observed the sign. Then he went through the transfer channel of B1 floor and entered the underground passage of south square. By asking, he turns into the passageway that connects the coach station, walks to the end but turn back, then go up to the opposite side of the

street by the elevator of the main passageway, cross the street, enter the waiting hall from the ground entrance of the coach station, and finally arrive at the ticket office.

Table 2. Record of behavior (4 of 26).

Participants	Time	Main behaviors	Achievement	Assessment
A	9:27	Look at the signage	Yes	Smoothly
B	12:25	Look at the signage, pause	Yes	Normal
C	15:20	Look at the signage, pause, ask for direction, return	Yes	Tedious
D	11:09	Look at the signage, pause	Yes	Normal

This subject had a longer path and took slightly longer time than others (Table 2). The information of wayfinding reference by most subjects is basically the same. In addition to looking through the end of the corridor to identify the location at the beginning, the other process is almost supported by guidance sign information. Figure 4 records all the signs observed during wayfinding. It is interesting that at the turning point of stairs and escalators, all participants carefully observed directional signs, while in the process of long-distance linear walking, it is also necessary to further determine with the help of signs. The utilization rate of suspension type of guidance signs is very high, but not those on the ground. More detailed information signs are frequently observed during the pause.

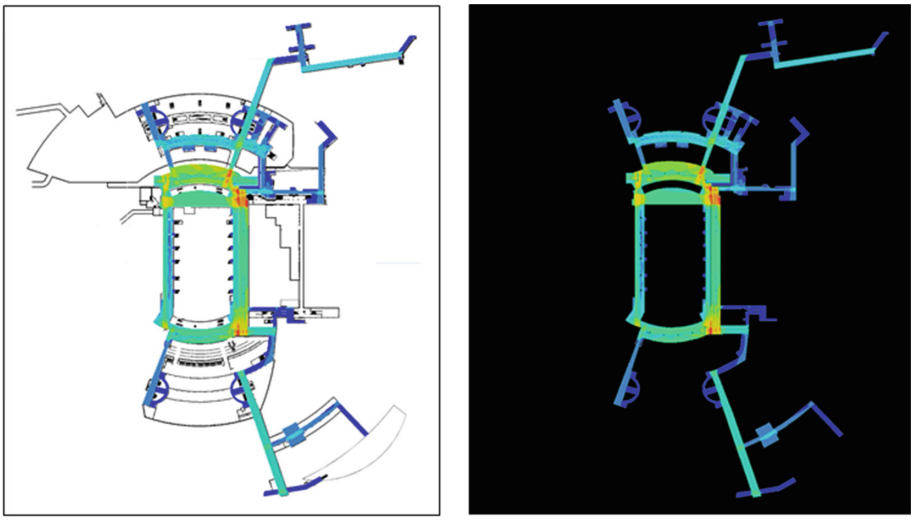

Fig. 3. Isovist analysis of the underground corridor in Shanghai South Railway Station. (Color figure online)

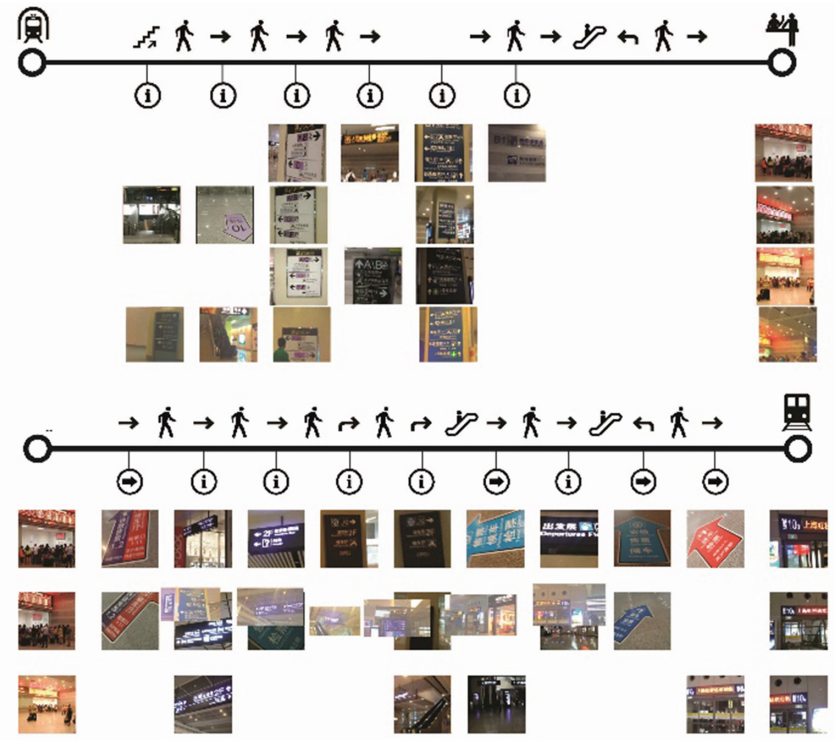

Fig. 4. Signage is the main information source during wayfinding.

During observation, the behavior of looking at signage almost took place in every step of every participant within the task. However, there remains a series of problems:

- Insufficient continuity of information content of guiding signs;
- Lack of surrounding public transport information and entrance and exit information content;
- The small font of the sign makes the visual distance shorter;
- The location of some signs are unreasonable;
- Some informational signs are less readable;
- Signs are severely disrupted by advertisement.

Signage plays a decisive role during the wayfinding process in an unfamiliar environment, especially in the underground corridor of a transit hub where is difficult to orientate in the case of catching trains. The continuity of signage information requires special attention when signposting as a spatial knowledge supplier.

3.2 Space Syntax

The isovist analysis is useful for analyzing the degree of visibility of a panoptical view of a space from a particular position, and weather an obstacle can increase or decrease

peoples' view. In the software of Depthmap, we can calculate the degree of integration of each isovist root within a room. Spaces are divided into small grid cells. The more precise of the division, the accurate the results will be. With the purpose of understanding the spatial features of Shanghai south railway station, we also adopted the isovist analysis of the Space Syntax theory and applied in quantitative analysis.

The underground space of Shanghai south railway station can be translated into accurate mathematical diagrams and the visual access can be colored in different degrees of hues (Fig. 3). We can describe the spatial environment in terms of comparing the conditions of different points within the same space.

The cold color indicates a lower level of visibility. Clearly, color of blue, green and cyan obviously dominate in the result, implying the wayfinding performance of the underground passageway perform poorly. The green corridor means the spaces are not well visible and can orientate themselves poorly but better than blue ones. Especially at the end of south square and north square underground corridor, there are several segregated spaces connecting to street-level stairs and escalators. The segregation of these irregular turning points is the result of the poor configuration of the underground corridor of Shanghai south railway station. In addition, four semicircular branch way also appear blue, indicating the lowest visibility. The poor visibility of these areas makes the passageway difficult to access.

The color of red, orange and yellow indicate a higher level of visibility. In Shanghai south railway station, the areas of visual accessibility are only a few and concentrated, and are mostly located near the exit of the railway station. Coincidentally, these locations also serve as connections between train entrances and taxi stands, subway stations, and north or south squares.

4 Implication and Conclusion

4.1 Decision-Making Points

During the wayfinding task, all subjects tended to choose shorter path and time to walk towards brighter space, and all of them tended to complete the pathfinding task mainly depending on their personal ability. It is essential to emphasize the decision point of the indoor environment. For transit hubs, decision points refer to the positions of access, turning, or going up and down the stairs, such as;

- Intersections;
- Linkage spaces (e.g., main entrance, metro exit);
- Longitudinal connections (e.g., elevator hall, escalators, stairs);
- Platforms (e.g., train platform, taxi stands);
- Entrances of each transport mode;
- Bends of linear spaces.

Decision points are the important evidences of signage settlement, information arrangement, and should be highlighted in map design as well.

4.2 Spatial Features

All participants described the spatial characteristics of Shanghai south railway station as long and complex. In this huge space with multiple functions, the pedestrians who visit for the first time often feel confused. Because most passengers do not have basic concept to the whole space, long and symmetrical corridor space with similar floor, interior design and shops largely weakened spatial individual characters. Field observations have shown that many pedestrians are unable to locate themselves quickly even after looking at the floor plan.

The complicity or symmetry of architecture plans are the main causes of disorientation. For Shanghai south railway station, the circular spatial structure with same north-south squares makes passengers confused. On this occasion, the differences of interior design, such as color, material, lighting, or landmarks would contribute as reference substances for direction identifying or memory points during wayfinding.

4.3 Signage

In transit hubs, the guidance sign system is the main and most important way for pedestrians to determine their orientation and find their destination. The accuracy and continuity of signage and the rationality of sign position are particularly important. Incorrect sign information can cause pedestrians' confusion.

Directional sign, providing orientated information at decision-making points, is highly applied by pedestrians. Directional sign should be set along the pedestrian path at the critical decision-making point turning point. Directional sign should be set according to the principle of hierarchical. The design of signage system based on the user's demand satisfies the pedestrian's wayfinding behavior and plays a positive role in sustainable mobility. Effective signage provides useful information at a suitable position for pedestrians to quickly obtain useful path information.

In a word, wayfinding behavior is affected by various factors, such as age, gender, education background, personality and habits of pedestrians, as well as the spatial and environmental characteristics and elements such as signage system (Montello and Sas 2006). In transit hubs, pedestrians and passengers are comprehensively affected by the spatial features, visual elements and functional facilities of the spatial environment, as well as the guidance sign system, so as to form a complete spatial cognition and meet people's needs for safe, convenient and comfortable transfer.

5 Conclusion

To conclude, indoor wayfinding performances of a complex building are influenced by both spatial features and elements. Spatial features can determine the indoor mobility pattern; functional elements contribute to the main impression; and the visual elements (especially signage) significantly impact the capture of spatial knowledge during wayfinding in the context of unfamiliar environments.

Finally, in respect of methodology, with the combination of subjective observation, isovist analysis can be used as a powerful tool for describing the spatial features, and the plan of the architecture plays an important role on the passengers' moving patterns.

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References

Passini, R.: Wayfinding in Architecture, p. 111. Vand Reinholdn Nostra, New York (1984)

Eaton, G.: Wayfinding in the library: book searches and route uncertainty. RQ **30**(4), 519–527 (1991)

Montello, D.R., Sas, C.: Human factors of wayfinding in navigation. In: International Encyclopedia of Ergonomics and Human Factors, 2nd edn., pp. 2003–2008. CRC Press, Taylor and Francis, Ltd., London (2006)

Long, Y., Baran, P.K.: Does intelligibility affect place legibility? Understanding the relationship between objective and subjective evaluations of the urban environment. Environ. Behav. **44**(5), 616–640 (2012)

Hölscher, C., Brösamle, M.: Capturing indoor wayfinding strategies and differences in spatial knowledge with space syntax. In: Proceedings of the 6th International Space Syntax Symposium, Istanbul (2007)

Abdelbaseer, A.M.: Evaluating way-finding ability within urban environment. In: Proceedings of the Eighth International Space Syntax Symposium, Santiago De Chile (2012)

Makri, A., Verbree, E.: Indoor signposting and wayfinding through an adaptation of the Dutch cyclist junction network system. In: Proceedings of the 11th International Symposium on Location-Based Services, Vienna, Austria, 26–28 November 2014

Dogu, U., Erkip, F.: Spatial factors affecting wayfinding and orientation a case study in a shopping mall. Environ. Behav. **32**, 731–755 (2000)

Weisman, J.: Evaluating architectural legibility: way-finding in the built environment. Environ. Behav. **13**, 189–204 (1996)

Frank, V.D.H., Van Nes, A.: Improving the design of urban underground space in metro stations using the space syntax methodology. Tunn. Undergr. Space Technol. **40**, 64–74 (2014)

Hillier, B.: The nature of the artificial: the contingent and the necessary in spatial form in architecture. Geoforum **16**(2), 163–178 (1985)

Hillier, B., Hanson, J.: The social logic of space. Elementary Build. transform. (5), 176–197 (1984). https://doi.org/10.1017/CBO9780511597237