**Urban Form and Wayfinding: Review of Cognitive and Spatial Knowledge for Individuals’ Navigation**

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Abstract

This paper provides a systematic review of recent progress in spatial cognition and wayfinding behaviour research. The aim is to provide an up-to-date understanding of how theory drawn from different fields of research may explain how people perceive the urban environment and find their way in and through it. Google Scholar, TRID, Scopus and other datasets were searched using prescribed terms, identifying studies of human spatial cognition and wayfinding from 1960 till the present. Wayfinding is today an essential part of the transport system, both on- and increasingly off-road. In addition, urban legibility plays a crucial role in encouraging people to use active transport like navigation on foot rather than using a motor vehicle. In this regard, set of key relationships between wayfinding, navigation behaviour and urban form are identified. In order, a set of theoretical and conceptual issues are outlined, including Lynchian theory, Semiotics theory, the *flanêur* in urban navigation, and the theory of space syntax and its role in prediction of people’s route choice and wayfinding behaviour. The role of new technologies and its implications for human navigation provides additional concerns. Numerous research gaps are identified including how visitors make sense of an urban environment, create mental imagery and then use that image to navigate through the city. There remains little research on how ubiquitous smart phone technology and global positioning systems (GPS) are complementing or disrupting those processes. The paper concludes with suggestions of new research methods that may help fill these gaps in knowledge and in turn help planners assist visitors in their urban navigation and wayfinding.

1. Introduction

Wayfinding and navigation is a spatial behaviour in individuals’ everyday lives. It can be understood as spatial problem solving. Various disciplines incorporate wayfinding, including transport, tourism, urban and architectural design. But perhaps most prominent is the field of environmental psychology, which seeks to understand how people interact with their surrounding environment and make sense of it, such as while performing a wayfinding task. As Kevin Lynch (1960, p. 3) noted, during wayfinding “there is a consistent use and organization of definite sensory cues from the external environment”. This paper is a systematic literature review of previous studies related to a set of inter-related terms including wayfinding, urban legibility and spatial cognition. It seeks to draw out the main conceptual and theoretical issues, identify gaps in knowledge and help frame a future body of research.

The paper begins with theoretical background to the study of spatial cognition and cognitive mapping. Second, the paper looks at existing theories on the creation of urban image in individuals’ minds. This includes Lynchian theory, urban semiotics, the *flanêur* and the theory of space syntax.As will be shown, all these theories attempt to investigate how people interact with their surrounding environment and make decisions during their wayfinding processes. A particular focus of the review is on how urban form affects individuals’ wayfinding behaviour. Third, a set of research gaps are identified in terms of human wayfinding. We still do not know fully how visitors make sense of an urban environment, create mental imagery and then use that to help navigate the city. In addition, we aren’t fully aware of how way-showing aids such as maps, signs, GPS devices and smartphone apps are affecting mental image creation, differently from each other; and whether such technology is complementing or disrupting processes of spatial knowledge acquisition. The paper concludes by identifying possibly new methods and a research program to fill these. This includes the use of ‘*Think aloud’* methodology with GPS tracking and cognitive mapping to observe and analyse wayfinding behaviour in the field, and to correlate this information with existing urban form through using space syntax analysis.

2. Spatial Cognition

The basic meaning of cognition refers to “The mental action or process of [acquiring](http://www.oxforddictionaries.com/definition/english/acquire#acquire__2) [knowledge](http://www.oxforddictionaries.com/definition/english/knowledge#knowledge__8) and [understanding](http://www.oxforddictionaries.com/definition/english/understanding#understanding__4) through experience, and the [senses](http://www.oxforddictionaries.com/definition/english/sense#sense__5)” (2010). Broadly speaking, the cognitive can be considered as a common system among humans, animals and intelligent machines, which includes several skills like thinking, perception, imagination, sense making and problem solving. Regarding humans, the brain and internal nervous system of their body can process and make sense of their surrounding social and physical world (Montello, 2001, p. 14771). In cognitive studies, different pioneers use the two terms of ‘cognition’ and ‘perception’ to describe a human’s ability to acquire knowledge of the physical environment surrounding them. Although these terms’ distinctiveness vanished over time, in experimental psychology they are used in different subject areas (Yadav, 1987, p. 1). The term cognition is broader than just perception. Cognition refers to the larger frame of memory and mental representation and includes mental process that are absent of an actual object. Cognition involves different experiences like observing, feeling, memorizing, perceiving, deciding and any other mental actions (Gold, 1980, p. 20). Perception, in general, is more about observation of objects and responses to them. Perception involves real elements such as information and experience as well as fear, hope, values and other imagined elements.

Cognition is dependent on personal and cultural aspects because it is the result of mental action and process of knowledge acquisition. As a result, different people might have different judgments toward the same object (Rapoport, 1977).

Spatial cognition is a major focus of many geographers for three reasons; first, they believe that the cognition of space or place represents the relationship between human and environment. Second, transport geographers have expected that spatial cognition would assist them get a better understanding of individuals’ interests; for example, where people choose to shop depends on what spatial characteristics they prefer. Finally, learning about cognition processes that assist people to understand spatial relations would be helpful in improving the use and design of way-finding tools like maps and other geographic information products. Maps, images, 3D models and language are indirect ways of knowledge acquisition that people may use to get information about their surrounding environment. Therefore, transport geographers may be interested in understanding the effects of different way-showing tools on acquired spatial knowledge (Montello, 2001, p. 14772). We turn now to look at a particular issue of spatial memory that is an essential component of human wayfinding.

3. Cognitive Maps

Maps are wayfinding aids that help people know and remember their environment. In the absence of these way-showing tools, humans and other animals use their acquired knowledge of environment as stored in their memories – their ‘cognitive map’ (Golledge, 1999, p. xi). The process of using stored spatial knowledge to form a mental map and the use of this map in wayfinding and route selection or other spatial behaviours, is called “cognitive mapping” (Golledge, 1987, p. 143). Tolman (1948) identified this term to suggest that rats in his experiment were able to create a mental map of their acquired spatial knowledge; and now is used widely in various human environment-behaviour studies. After Tolman’s experiment, many other researchers have worked on the nature of cognitive representation of environment. Urban designer and planner Kevin Lynch, in his seminal study *Image of the city* (1960) showed that while people move through an urban environment they interpret spatial knowledge obtained through observation and convert them into mental images. He argued that these mental maps consist of five urban elements: landmarks, paths, nodes, edges and districts. These urban elements play an important role in interaction between urban environment and urban navigators. In this regard, Siegel & White (1975) defined three types of knowledge leading to generation of cognitive maps: *landmarks* – point-like elements; *routes* – line-like elements; and *survey* knowledge, which unifies landmarks and routes with metric survey information. As pointed out by Appleyard (1969, 1970) the unique structure and visible form of landmarks, and sometimes their sociocultural significance, makes them recognizable and memorable in observers’ minds. People use these unique spatial features when they enter a new environment to remember the location of places they want to go (Siegel & White, 1975). For example, when a woman arrives in an unfamiliar city she may decide to have dinner in a restaurant on her way from the airport to the hotel. To recall the location of that restaurant she would memorize that it was after the park and around the corner somewhere from a particular statue. After searching and finding the restaurant by this method several times, she will begin to use route knowledge (Dillon & Vaughan, 1997).

Route knowledge is based on the knowledge acquired by travelling from A to B through paths, that connect landmarks and places (Siegel, Krasic, & Kail Jr, 1978; Thorndyke & Hayes-Roth, 1982), and consequently may develop a *network*. For humans this urban network will be developed in a hierarchical order such as from freeways, highways, roads, streets, lanes and eventually down to alleyways. The most-often-used path segment will be represented by using lines in cognitive maps (Golledge, 1978). Now, our woman begins to make sense of the location of her hotel. She knows that the hotel is almost located at the corner and up that road away. After several times visiting the particular restaurant, she will begin to make sense of existing environmental features – in two or three dimensional layouts – in her way from the restaurant to the hotel. In other words she begins using her previously observed/survey knowledge to generate a mental map of that environment (Dillon & Vaughan, 1997; Golledge, 1999). Survey knowledge refers to the co-ordinates of routes between different locations which are converted into a Euclidean cognitive map (Siegel & White, 1975; Thorndyke & Hayes-Roth, 1982).

In summary, a cognitive map is the result of a set of psychological processes through which individuals will code, store, remember and decode their acquired knowledge about elements, locations, distances and directions, or the general pattern, of their surrounding environment (Rapoport, 2013, p. 120).

4. Spatial Layout and Wayfinding Behaviour

We now turn to the question of how spatial layouts, and the legibility of the built environment, influences one’s wayfinding ability. In this study wayfinding refers to a person’s ability, both cognitive and behavioral, to travel from an origin to a destination, which is out of sight, by following the paths and routes between them (Blades, 1991; Garling, Book, & Lindberg, 1984; Gluck, 1991; Golledge, 1992). An individual’s wayfinding behaviour is the result of interactions between environment characteristics and his/her attributes (Allen, 1999). Passini (1984, p. 153), suggests that wayfinding includes several processes such as spatial problem solving, making decisions and then executing them effectively, as well as information processing.

Success in wayfinding reflects a person’s ability to reach his or her destination by dealing with the environmental restrictions and the many risks and uncertainties in the environment. Urban form characteristics of the built environment play an important role in this. As will be shown, certain aspects of urban form can improve ability and performance in spatial cognition. By ‘urban form’ we mean the natural and man-made features of the neighbourhood environment, such as landscape (natural and man-made) include buildings, parks, streets and pathways. Our particular interest is in the man-made features that improve or limit the wayfinding behaviour. The next section examines different theories of the relationship between urban enviornment charactersistics and spatial cognition and wayfinding performance of urban users.

4.1. Legibility/Imageability and Wayfinding

* + 1. Urban Legibility

In considering the role of the legibility of urban form, one of Lynch's key innovations was the concept of ‘place legibility’, by which people can understand the layout of a place easily. According to Lynch the city’s paths, edges, nodes, districts and landmarks are all important urban elements that shape the urban space. Lynch (1960, p. 96) defined ‘paths’ as providing directional movement through urban environments for navigators, including sidewalks and streets. He defined ‘edges’ as certain boundaries surrounding a particular district with a continuous certain form; such as rivers or highways (Lynch, 1960, p. 99). The junction of paths will form ‘nodes’ that tend to be more identifiable if they have a sharp and closed boundary and can be used as a public space (1960, p. 102). Districts are large areas that have homogeneous characteristics, including physical characteristics such as colour, texture, façades of buildings, materials and patterns of pavement, that consciously can be observed in one district area (Lynch, 1960, p. 103). Landmarks are distinctive features that by their uniqueness makes them memorable in urban users’ minds. If they are observable from near and far, they play the role of reference points during navigation through an urban environment (De Jonge, 1962; Gulick, 1963; Heft, 1997; Jones, 1972; Lindberg, 1984; Lynch, 1960). In this regard, Beattie (1990, p. 113) suggests that: a “comprehensible environment [is] one which has a discernible structure and the structure is based on a network of paths punctuated with orientating devices in the form of nodes and landmarks and discriminated into districts which are clearly defined by boundaries and edges”.

Weisman (1981) built on these understandings, identifying four environmental variables that influence an individuals’ wayfinding behaviour: 1) visual access, 2) differentiation, and 3) layout configuration and 4) signage. Visual access refers to the degree to which an observer is able to see different parts of a place from various view-points. The second factor, differentiation, is the degree to which different parts of a built environment are similar or different. Well-differentiated urban elements make wayfinding performance easier because the unique characteristics of differentiated parts of the city make them memorable and distinct in individuals’ minds. Weisman and others (Gärling, Böök, & Lindberg, 1986; O'Neill, 1991) note the particularly influential role of layout on improvement or deterioration of wayfinding behaviour. Navigation and wayfinding in areas where layouts are complicated, as found in pre-modern cities, is both more difficult and confusing.

Signage, using symbols or texts, is used to convey meaning to navigators and facilitates their orientation. Many signs aren’t explicitly designed for wayfinding; they may be advertisements for a product not even available in the neighbourhood. But the design and location of signs plays an important role in guiding people through a built environment (Arthur & Passini, 1992). Lynch (1960, p. 3) described a legible city as one whose urban components – paths, districts and landmarks – “are easily identifiable and are easily grouped into an over-all pattern”; and he believed that such a well-planned city is more memorable and imageable for urban users, simplifying the wayfinding process.

* + 1. Urban Imageability: Definition and Thoughts

We now turn to a set of theories that help us to understand how and why people make sense of the city and develop cognitive maps and other understandings of it.

* Lynchian Theory

The first theoretical framing we explore comes from Lynch, who invented the word imageability, “It is that quality in a physical object which gives it a higher probability of evoking a strong image in any given observer” (Lynch, 1960, p. 9). Imageability is the visual aspect of an urban environment, which helps an observer generate an image of his surrounding environment and create meaning of it. In other words, the image of the city is the result of a two way process between observed environment and observer (Lynch, 1960, p. 6). Generally, these visual elements of a city can make an image of it in visitors’ minds, which helps individuals’ navigation behaviour and sense making of that city. Building of this image is the result of a two-way interaction process between the environment and its visitor (Lynch, 1960). As mentioned before, urban components in a legible city are organized in a readily identifiable form. In Lynch’s later work, he argued the role of spatial structure like location of landmarks and arrangement of pathways in a strong hierarchical pattern makes for a recognizable image of a city (Lynch, 1984).

Researchers have followed this approach seeking to explore how people make images of their surrounding environment, using studies of urban perception to understand different methods of mental image generation (Yadav, 1987, p. 3). To obtain a comprehensive understanding of how images of the urban environment can be generated, Appleyard (1973, p. 97) has defined three coherent classifications:

1. *Operational:* in this method citizens get familiarwith various city elements, through using them repetitively, such as key buildings, landmarks, bus stops, signs, etc. These elements play the role of reference points in their everyday life. People remember them and their role within urban form and build a mental image of it.
2. *Responsive*: in this method unique and unusual buildings become more memorable for observers, rather than buildings with ordinary features. Distinct and unusual elements catch the eyes of travellers. Some buildings have imageable features that create responses beyond the mere operational.
3. *Inferential*: in this method people develop a coding system to relate and understand the concepts of urban elements as they experience them repeatedly in cities. It means that people have a unique personal urban model, which helps them understand concepts and relationship of urban elements. When people move to a new city, their personal urban model-which is created through their past experiences- helps them make sense of new environment surrounding them.

Some scholars have identified limitations of Lynch’s theory on urban form and cognitive mapping. “Urban structures act as stimuli because they have become symbols and not because they support behaviour by facilitating movement. Thus we can say that the image of the city is a conceptual rather than perceptual one”. (Gottdiener & Lagopoulos, 1986, p. 8) This is where scholars proposed the somewhat alternative theory of socio-semiotics.

* Urban/Socio-Semiotics

The study of a sign system is called semiotics. This investigates how text, signs and symbols make meaning. Semiotics is not an independent discipline by itself; it is an interdisciplinary science in art, literature, anthropology and the mass media (Chandler, 2007, p. 4). Saussure identified two components for each sign: the signifier and the signified. The first refers to sound, image or word, and the latter is the concept or meaning that the signifier comprises. In semiotics, there are two types of signified: the denotational and connotational. The literal translation of a sign is called its denotation, whereas finding out the associated meanings of a sign is its connotation. However, the Saussurian model only focuses on denotative meaning and ignores connotations. Different from this model, Barthes (1972) [1957], the cultural theorist, focuses on the crucial role of connotative meaning of each signified according to each country’s culture.

Semiotics also studies non-linguistic signs; in the urban semiotics field, any urban elements like streets, lanes, squares, buildings and façades are all considered as signs and significations (Jencks, 1969; Venturi & Brown, 2004; Venturi et al. 1972). Urban semiotic analysis relies on key social sciences and other disciplines such as architecture, urban planning, sociolinguistics and social geography. Lynch (1960) was one of the first theorists worked on the semiotics in urban space by investigating the role of different environmental signs (paths, districts, landmarks, edges, nodes) on people’s spatial cognition, he believed that the arrangement of these urban elements in the city can make it a text that can be read with ease and make it more memorable in individuals’ minds. However, this theory was criticised by some other theorists who believed in the role of social codes in urban semiotics (Eco, 1976; Gottdiener & Lagopoulos, 1986; Krampen, 1979; Ledrut, 1986).

Eco (1976) proposed a comprehensive theory and applied it to the architecture discipline. That is, people interact with these building blocks of the city through their denotational and connotational meanings. And the existing social values in that society play an important role in understanding connotational meanings of urban elements. (Linda & Kolomyeytsev, 2014, p.125). What looks like an alleyway to be avoided in one culture may be an entryway to an important part of the city in another culture.

It is for this reason that Lynch’s cognitive mapping ideas have been criticised by some semioticians. Gottdiener and Lagopoulos (1986) make three key critiques of Lynchian notions of legibility and methods of developing cognitive maps:

1. For Lynch, cognitive mapping methodology is based on perception rather than conception. However, urban image creation is a conceptual process rather than just a perceptual one;
2. Lynch therefore reduces the urban environment to only perceptual knowledge; and,
3. Lynch and his five elements focus mostly on movement activity in urban environments, to the exclusion of other aspects of urban use.

Gordon Cullen (1961), just a year after Lynch, published his famous book “*The Concise Townscape*”, within it he proposed new ways to interpret the city. According to him, the creation of urban image is a result of movement within the environment. “Serial of Visons” could be revealed through urban strolling. Consequently, the existing vivid contrast among urban components (the street and the courtyard), when they are observed at the same time would attract humans’ minds and produce an urban image. He also believed that urban environment should be designed according to the position of the urban strollers’ bodies in urban context; therefore, they can have a better understanding of their surrounding environment. He added that vision is not only useful for urban image creation, but to provoke emotion in people toward their surrounding environment. He stated that there is always a “here” where people are and an attractive “there” that encourages them to walk toward during their navigation process.

However, Cullen’s way of city interpretation could no longer be referred in modern urban environments. Due to urban modernity movement crucial changes occurred in the organic fabric of old cities and cities were planned in a homogeneous and organized pattern, so the natural contrast of old cities disappeared.

Changes in urban fabric and urban elements (as urban signs) that carry old meanings result in changes of urban semiotics. In this regard some urban theorists like Jane Jacobs (1961) Mumford (1961), Venturi (1972), Jenks (1969, 1973, 1978), Cullen (1961), Sennett (1994) and Alexander (1964, Alexander et al., 1977) investigated the modern urban policy after World War II and its influences on urban semiotics.

Jane Jacobs (1961) in her famous book, *The* *Life and Death of the American Cities*, wrote a strong critique on what American cities had experienced through modernism movement. She believed that modern cities failed to provide liveability in cities due to the problem of ordered pattern (in architecture and urban design); in other words, the organic disorder of old cities could provide more liveability for urban users (p. 50). Then, Robert Venturi (1966), in *Complexity and Contradiction in Architecture,* coined the *messy complexity* term to advocate that buildings need to have a complex structure as a whole. He had a semiotic approach toward architectural meanings and believed that people would interpret both functional and structural meaning of buildings in the social context. Influenced by the theory of semiotics, venturi et al. proposed a “linguistic turn” in architectural theory in *Learning from Los Vegas* (1972). They studied the urban image of the contemporary American city of the early 1970s, which was influenced by the widespread use of automobile. They believed that the spatial cognition of urban users was affected negatively due to their travel behaviour change from walking to driving.

Christopher Alexander (1964; Alexander et al.,1977) also had a linguistic approach to form. Like Jacobs and Venturi, he believed in the important role of messy complexity in architecture and urban design. He attempted to recognize the “natural human language of form” (Alexiou et al., 2009, p. 27).

The effects of modernity on urban semiotics were also studied by Charles Jencks, American architectural theorist and designer. He studied the influence of structuralism development, which occurred after World War II, on the semiotics interpretations. In this regard, he coedited an essay entitled *Meaning in Architecture* (Jencks & Baird, 1970), which was one of the first works to study the important role of semiotics theory into architecture. In *Modern Movement in the Architecture* (1973), Jencks investigated the radical changes in architecture and feature of buildings influenced by postmodernism. His researches came to this result that modern movement in architecture created a new urban image affected by the process of commodification failed to provide a legible language for buildings (as urban signs) to communicate with urban users ( Jencks, 1978).

In summary, urban socio-semioticians suggest we must look to the deeper readings of urban landscapes, and to understand the connotational aspects of the city, to really understand urban wayfinding. This may be especially true in pre-modern cities, but the degree to which it holds in more homogenous international cities, with standardised grid layouts and more uniform built elements, is less certain.

### Urban Flâneur

### An alternative theoretical approach comes from a set of scholars who argue that the city is like a story and a stroller can narrate and describe its different parts and events, and to understand both its layout and social relations. They suggested the metaphor of the *urban flâneur* making sense of the city. The word flâneuris a French noun, originally coined by Baudelaire meaning “stroller” and refers to the very act of strolling. To take on the pose of the *urban flâneur* isan experiential method introduced in the nineteenth century by German philosopher Walter Benjamin to examine new urban relations in Paris after the birth of modernity. In that time Paris was developing new arcades for strollers to walk slowly, to cluster, to shop and to look at the contradictions of the post-modern city (Featherstone, 1998). Walter Benjamin used the metaphor of *the botanizing on the asphalt* to suggest a kind of method for people to create a mental urban image and be socialized into the post-modern urban society (1973). He was concerned with the effects of capitalism on urban image, and believed that the post-modern city is a commodity and that urban strollers are consumers of excessively spectacular images and signs existing in the city. In addition, in his point of view, objects and the structure of the city can provide legible form for urban strollers who try to decode them and conceive their meaning. Therefore, according to Benjamin, the city can be considered as a *semiotic universe* or a cultural text to be read (Elliott & Turner, 2001, p. 79). In this regard, Balzac’s *flâneur* “maps the city’s terrain and evokes its living qualities. The city is thereby rendered legible for us in a very distinctive way”. (Harvey, 2003, p. 55)

The urban flâneur is an unstructured method of interpreting the city. On the contrary to the Lynchian method that argues mental image is made through predictable ways with five main urban elements, the image in urban flâneur is shaped through walking freely and aimlessly around the city. In addition, the mental image created through urban flâneur method is a result of both perceptual as well as conceptual processes. On the other hand the personality of urban stroller plays an important role in this process which is one of the noticeable distinctions of urban flaneur method from urban semiotic and Lynchian methods. In Urban flâneur method the stroller writes himself in his report of the modern city.

In more recent times the role of the flâneur has also been recognised as a distinct point of view in modernist societies. Given most trips are by car in many modern cities, the act of exploring city image formation by persons on foot becomes in itself a political act. But what is less clear is how the understandings of the flâneur can be harnessed meaningfully as a method to resolve and improve wayfinding issues. The tendency of social geographers in more recent times to use this approach for higher-brow investigations of urban social relations, rather than to explore the internal processes of image creation, suggests the approach has its limitations.

### In summary, these three theoretical interpretations (Lynch, the semioticians and the flâneur) help to explain spatial cognition/perception by humans and how they create a mental image and cognitive map of their surrounding environment, which plays an important role in their wayfinding behaviour. People develop mental maps based on both perceptual and conceptual elements. Somehow, in some way, the operational, responsive and inferential are all important. And the very vantage point of the observer matters.

4.2. Cognitive Mapping and Wayfinding

But how do people translate their cognitive map into actual route-choice decisions whilst travelling? They use their cognitive maps to decide where to go and which path to choose (Mondschein, Blumenberg, & Taylor, 2013). Downs & Stea assume that a cognitive map is an environmental representation in individuals’ minds which guides them during their wayfinding and decision making behaviour; this is not a constant process and cognitive maps can evolve over time due to usage and experience. People with strong wayfinding ability tend to memorize the existing basic elements in complex large scale environments, such as the main routes and important places to solve their wayfinding problems (Lynch, 1960). In this regard, Kuipers (2001) proposed a hypothesis that people create a mental *skeleton* of existing major paths and places and their relationships together. He believed that, when a wayfinder wants to travel from an origin to a destination, at first he recalls the route from his location to the nearest point on the skeleton, then finds the correct path from that point to the nearest point to the destination. Paths which are used frequently will become even more popular overtime, therefore popular paths become dominant in cognitive maps of urban users and the skeleton emerges. Some cities have more obvious skeletons than others.

To help make sense of how cities compare, a science-based theory called space syntax has been developed to investigate the relationship between what are termed the syntactic properties of streets and their potential to be used more frequently by people. We now turn to examine space syntax methodology.

4.3 Urban Configurational Features and Wayfinding Behaviour: Space syntax

Space syntax is a science-based approach that can measure topological relationships between one specific point in urban space to any other existing point. This theory and the related methodology was conceived by Hillier and Hanson in their famous book *The Social Logic of Space* (1989) in which they examine the relationship between urban network structure and social behaviour of urban users. Most importantly they suggest that urban form and function are not independent. Hillier showed that this relationship can be represented as a mathematical graph that can be translated into quantitative based measurements by using space syntax methodology. This quantitative representation of spatial layout is called spatial configuration and can be described by various values: integration, connectivity, intelligibility, control, and visibility.

*Axial map* is the basis map for analysing urban network representing the longest distance that a person can see while moving through an urban space. The *Connectivity* of an axial-line measures the number of lines that directly intersect that given axial line (Figure 1).



Figure 1- (a) A fictive urban system, its (b) axial map, and (c) connectivity graph. After (Jiang & Claramunt, 2002)

*Integration* is the main concept of space syntax methodology refers to the mean number of turns need to be taken to go from one specific point to all other points in the network system. When a place in a network system is well integrated, it means people do not need to take many turns to travel from that point to any other points in the system (Turner, 2004). Hillier defined intelligibility as “the degree to which what can be seen and experienced locally in the system allows the large-scale system to be learnt without conscious effort” (Hiller, 1996, p. 215).

Researchers have used space syntax analysis to understand the influence of spatial configuration on spatial cognition and individuals’ movement patterns. Hillier (1985) made a comparison of syntactic values of spatial configuration and the number of pedestrian movements along street lines, finding a strong positive correlation between integration value and density of movement. The first study on the influence of spatial configuration of a building on wayfinding behaviour of people was done by Peponis et al. (1990), who reported that in a wayfinding process if people get lost they return to the more integrated spaces of the city, although those spaces are not located in the shortest path between their location and destination. In later studies, Haq (1999a, 1999b, 2003) and Haq & Zimring (2001) found the important role of connectivity in choosing routes during wayfinding process and cognitive map formation. Kim (2001) concluded that cognitive maps drawn by people living in areas with what the analysis suggests is a high value of intelligibility are better representors of their surrounding environment in comparison to cognitive maps produced by residents in areas with low intelligibility value. Tzeng and Huang (2009) used space syntax to choose the best locations to put hospital signage to guide people through healthcare facilities. Their research confirmed the results of previous studies that the most segregated areas in the plan are the most difficult places for people to find their way so people need directional signage to solve their wayfinding problems in these locations. Another study by Kubat et al. (2012), reconsidered the relationship between built environment and wayfinding performance. Their findings implied that people prefer to choose road segments with higher values of visual connectivity and spatial accessibility.

The limitations of the space syntax approach are that though it derives in part from earlier theoretical conceptions, it is not yet tested whether the elements it measures match well with actual image creation in human wayfinders. It is also subject to the same criticisms made by the semiologists of Lynch’s work in that it struggles to encapsulate issues of the conceptual. Space syntax is a useful technique in the broad field of environment-behaviour research, but more is required to understand the effects of built form on an individual’s way-finding.

5. Discussion

This paper reviewed the main theory relating to spatial cognition and the creation of mental images of cities, in how individuals are perceiving and conceiving the urban environment. Previous studies on the role of cognitive mapping and urban form in wayfinding behaviour of people were also examined.

Cities and societies change, and it may be well time for a much sharper analysis of how mental images of cities are created in a world replete with ubiquitous information systems technologies. Way-showing aids such as digital maps, signs, GPS tracking devices and smartphone apps all help people use navigate and find their way. Each of these tools provides specific spatial information in particular ways to wayfinders. One of the remaining gaps in spatial cognition and wayfinding behaviour literature is the role of what we might term way-showing aids on the creation of cognitive maps in individuals’ minds. We don’t know quite how mental image created through using each of these tools (paper map, GPS, none-mapping) may differ from each other; whether smart phone technology and global positioning systems (GPS) are complementing or disrupting processes of spatial knowledge acquisition.

In addition we still do not know fully how visitors make sense of an urban environment, create mental imagery and then use that to help navigate the city. And there are particular spatial problems that transport and planning agencies may wish to address.

To answer such questions a range of research approaches may be considered. The authors are preparing a research framework using research methods like *Think aloud* in conjunction with GPS tracking and smartphone recording, space syntax analysis, and post-event interviews, to observe and analyse the wayfinding behaviour of different people in different parts of cities. Using Think-aloud methodology, in which the participants are asked to think aloud of what they observe and how they navigate themselves while exploring the city. This method could enable us to investigate the wayfinding and spatial cognition of a wayfinder as a flâneurwhile strolling through the city and reading it as a text.

That is, we hope to construct a research program, developed on a sound theoretical basis that may help overcome the limitations of previous work, allow for the conceptual as well as the perceptual issues to be considered, and help us understand what wayfinders are actually doing in today’s world. An early part of that program may be to compare cognitive maps drawn by three groups of way-finders who used specific way-showing tools (paper maps vs. GPS and smart phone apps vs. no mapping aids) to find their way. This should help clarify a number of remaining issues in helping understand human navigation and wayfinding in our urban world.

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