Copyright ©2026
National Centre for Energy and Environment,
Energy Commission of Nigeria, University of Benin:
ISSN 2504-9593
DOI: 10.5281/zenodo.21223488
https://ijree.com/index.php/publications/article/view/76

Int. J. Renew. Energ & Environ Vol.4 (2), pp 339-358(2026)

STUDY OF SPATIAL ORIENTATION AND CIRCULATION ANALYSIS FOR IMPROVING WAYFINDING IN BUILDINGS

AKUBUE, Jideofor Anselm
Department of Architecture, Baze University Abuja, Nigeria
Corresponding author email: akjideofor@yahoo.com

Abstract
Understanding the process of wayfinding entails looking at both its academic perspective and the everyday applications, this sets the premise that the collective systems of visual, vestibular, and proprioceptive stimuli differ in magnitude, direction and frequency. The inappropriate coordination of these systems results in spatial disorientation. This paper examines the fundamental concepts of wayfinding relative to buildings and spatial orientation. To do this, a mixed method approach is utilized which involves reviews of the underlying Spatial Cognizance Principles and circulation patterns. It further presents three Case studies and Axial analysis of selected buildings as means of identifying efficient methods of circulation and movement within large building types like Hospitals. The findings derived from this study includes identification of effective patterns of circulations as well as deductions indicating that the challenges of wayfinding are reduced through the adoption of less complex layouts with more linear sightlines that enable visual connectivity to destinations.

Keywords: architectural design, axial analysis, circulation analysis, hospital design, spatial orientation, wayfinding

1.0 INTRODUCTION

Wayfinding is about the first step towards efficient flow and movement in buildings. Wayfinding around public buildings such as airports, museums, hospitals, office buildings, or university buildings often proves to be challenging and frustrating. Wayfinding design and spatial orientation may be viewed as the critical system that translates architecture into intuitive human movement. Without this system, complex built environments may become stressful to users as well as alienating functional spaces; hence resulting in huge loses in time and costs of place identification.

A typical scenario may be perceived in the condition of a frantic traveler at a huge airport or a first time visitor trying to navigate a massive/complex hospital maze like the Lagos University Teaching Hospital (LUTH), where patients and visitors frequently become disoriented in labyrinthine hallways and confusing signage. These experiences create immense anxiety for visitors or patients as major medical appointments are missed or delayed. Understanding the process of wayfinding entails looking at both its academic perspective and the everyday applications. The studies adopted in this paper, amongst other things, aim at developing appraisal techniques which could be applied as a tool for assessing the wayfinding performance and circulation efficiency in notable public buildings like hospitals, where primary human comfort in terms of wayfinding is vital.

Wayfinding can be defined as the process people adopt for purposes of orientation, route selection, navigation through spaces, and recognizing arrival at destinations (Al-Alwan & Al-Azzawi, 2014). This process goes beyond just the use of signage, rather it functions as the complete system that adopts signage, maps, colors, symbols, and in modern times, it includes digital tools that make navigation instinctive (Jamshidi & Pati, 2025). The term was first created by Kevin Lynch in his book "The Image of the City" in 1960 and has since expanded to accommodate other aspects of the built environment, especially public spaces like hospital corridors, university campuses, and other smart buildings.

Historically, Wayfinding can be associated with the ancient human navigation system. One of the earliest documented instances of wayfinding is attributed to Polynesian navigators, who crossed thousands of miles of Open Ocean with no maps or compasses, but rather used stars, patterns of sea waves, and bird migration as means of location and bearing (Inman, 2022). Modern concepts of wayfinding became formalized in 1960 when Architect and Planner Kevin Lynch published The Image of the City (Lynch, 1960), in which he identified five fundamental elements adopted by humans for mental mapping of surroundings as illustrated in Figure 1. These he described as:

i. paths,
ii. edges,
iii. districts,
iv. inodes, and
v. landmarks.

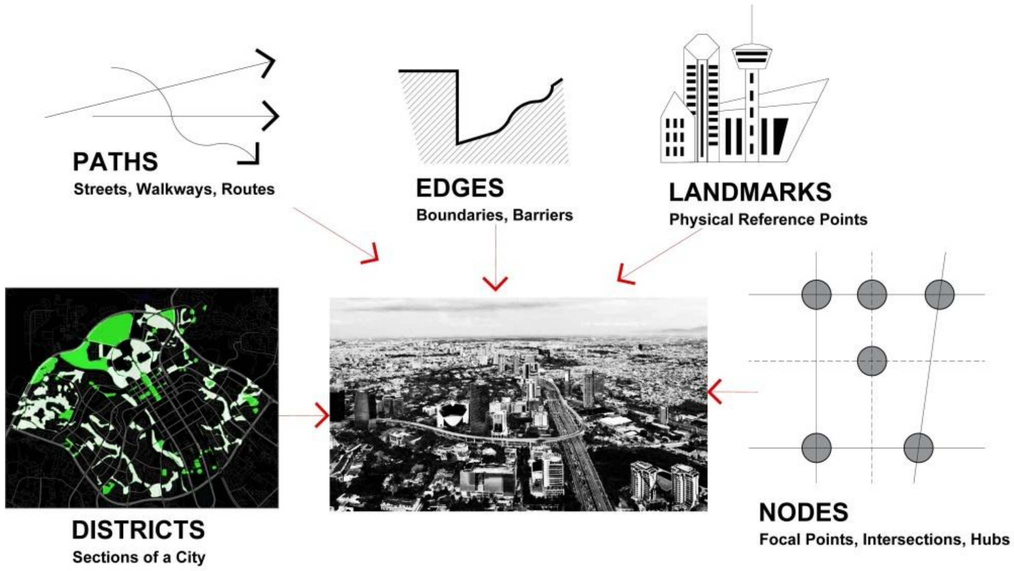


Figure 1. Kevin Lynch's framework showing the five elements of urban design paths, edges, districts, nodes, and landmarks. Source: Lynch (1960)

In 1981, it was expanded by researchers like Romedi Passini into a formal framework that thus defined wayfinding as a cognitive process rather than just a set of signs (Romedi, 1984). In contemporary times, wayfinding has advanced into the combination of cognitive principles with physical designs and digital technologies to aid in guiding humans through advanced complex spaces.

Wayfinding performance in buildings can be attributed majorly to circulation and spatial configurations. Successful wayfinding only occur when the navigator makes correct navigation decisions that may take him/her from present location to a final destination which must fulfill the intended purpose of movement (Arthur & Passini, 1992). According to studies from (Vaez et. al, 2016), other principles that assist in successful wayfinding are listed as follows:

i. Location Distinctiveness
ii. Landmarks and Orientation
iii. Pathways or circulation configuration
iv. Zoning (Areas of Different visual characters)
v. Signage with Decision Points
vi. Sight Lines for Visibility

These principles all play intrinsic roles in assisting the wayfinding process. However, the dominant element of spatial configuration must firstly be established appropriately in building design before the adoption of assisted principles like signage (Jamshidi & Pati 2025). This is critical, as not all information is available in signage designs. This dominant element (spatial configuration) is the primary tool utilized by designers principally in defining the wayfinding process at the point of design and configuration of building layouts. The study of spatial configurations for purposes of improving wayfinding in building and city designs has evolved over the years. Modern tools and concepts like Space syntax theories (from where axial analysis and isovists are generated) are amongst the most popular tools used for analyses of spaces and layout configurations (Meeks et. al, 2023). Space syntax utilizes a set of theories and techniques for the analysis of spatial and layout configurations. It incorporates both evaluation of the applications and the adoption of the analytical techniques and theoretical ideas associated with the syntactic study of architectural spaces (Nes, 2014). According to Bill Hillier, space should be translated into graphical measures. However, in order to apply graph theoretic measures, geometries of a space must be read firstly and then translated into patterns that would support the type of analysis to be executed. This process encompasses the formation of spatial networks, which invokes syntactic properties of global and local spatial systems with the aid of syntactic axial and convex maps (Hillier, 1996).

1.2 SIGNIFICANCE OF THE STUDY

It is evident that the larger buildings get, the more the challenges of spatial orientation for its users. Likewise, building forms and configurations impact significantly on the course of wayfinding. Spatial configuration has been identified as significant in influencing human movements, performances of users and efficiency of services. This study thus provides strategies that could be adopted by scholars and building designers for analyzing layout configurations relative to spatial orientation and wayfinding process. This is intended to assist in building design processes while aiming to reduce the challenges of spatial disorientation for building users and visitors.

2.0 THEORETICAL REVIEW OF SPATIAL COGNIZANCE PRINCIPLES (SCP)

Studies on human behaviors in built up spaces show that orientation problems do not often originate at the front doors; rather, orientation challenges starts long before people enter a facility and may often continue long after they have arrived at their destination again. This is due to the fact that wayfinding capabilities are shared across numerous mediums, including through visitors who eventually pass on their experiences (emotionally) to friends and relatives, and the process continues downwards until each individual, in turn, develops their own expectations (Hashim & Said, 2013; Ullas & Aju, 2014).

One of the most common SCP principles for successfully navigating through the course of wayfinding is the generation of 'Pathways'. Tolman defined Pathways as routes to locations. This concept suggests that every individual employs cognitive maps for wayfinding. This concept defines 'Cognitive Maps' as mental representations which are utilized to obtain, store, memorize, code, and decode spatial information about the relative locations and features of phenomena in the environment (Delmore, 2025). Analyses of the impact of layout organization on wayfinding performance, alongside user-cognitive representation of real-time spatial information, identify pathways as fundamental components of the spatial cognition process. The analogy of cognitive wayfinding describes the human ability to make use of long-term spatial memory to guide wayfinding. The process describes the originated mental map that resides in the head and examined by the mind's eye, as functionally identical to the graphical map that is inspected in the physical environment (Russell et. al, 2017). Kuipers (1982) suggests that cognitive map information is likewise isomorphic to data held in a graphical map; further information added to, or retrieved from, the cognitive map is considered same as that processes used for the adding and retrieval of information from a physical graphical map. Although this characterization does not imply the existence of a region in the physical brain where the entire environment is physically mapped, nevertheless, it indicates the availability of correspondence between the products of information input and output behaviors of the storage (visual data) and retrieval functions (Osman & Suliman, 1994). When related to wayfinding in built environments, it is believed that the layout of spaces influences the accuracy of the actual cognitive representations in real-world spatial configurations (Brunye et al, 2018). These layouts of spaces eventually form pathways or network structure used in our everyday spatial activities, and they, in turn, develop into critical elements of the mental image of the spatial environment (Golledge & Stimson, 1997).

Spatial cognition comprises the human brain's capability to process, encode, decode, and mentally manipulate spaces in terms of location, size, distance, and movement of objects within the space. The principles of spatial cognizance are initiated from fields like cognitive psychology, which guides how humans navigate environments and interact with digital or physical spaces/systems (Werner et al, 1997).

2.1. CORE COGNITIVE SKILLS

These are the fundamental mental processes that are applied during the process of human interaction with spaces. They include the process of acquisition, organization, usage, and alteration of information about spatial environments. The basic cognitive skills adopted when interacting with the environment are discussed below:

2.1.1 Mental Rotation:

According to Göksun et. al, (2013), mental rotation is described as the capacity to visualize, as well as rotate, 2-dimensional and 3-Dimensional objects in the mind's eye in order to understand how they look from different angles. This is demonstrated in the sample task presented in Figure 2, where two sample items presented on the left are described using the four figures on the right to depict the figure on the left in alternative positions. Originally established by psychologists Roger Shepard and Jacqueline Metzler, mental rotation is a core skill for basic spatial reasoning, mathematics, and navigation. This is a basic skill required in modern times as the task of spatial recognition evolves into more complex understanding of built environments.

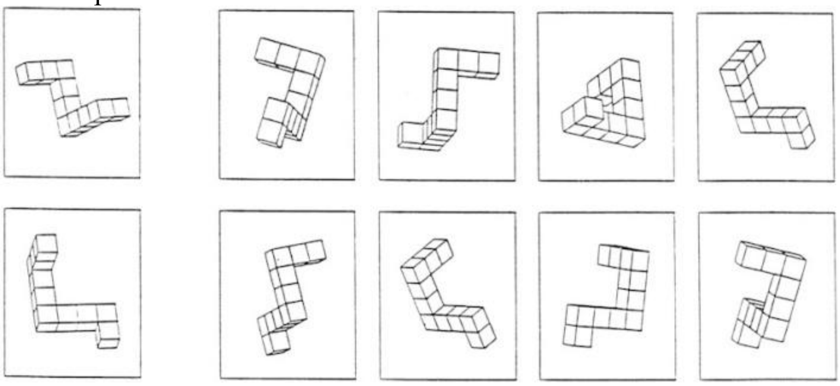


Figure 2. Two sample items from a mental rotation test.
(Source: Silverman, et. al, 2000)

2.1.2 Spatial Perception:

Gori et al, (2026) defined spatial perception as the exteroceptive and interoceptive process. While the exteroceptive process is the ability of humans to be aware of their relationships with the environment around them, the interoceptive processes, on the other hand, relates to the awareness of the relationship with oneself. This awareness is comprised of representations about our space through feelings, and representations about our body as with respect to position or orientation. Spatial perception aids in the accuracy of gauging distances, relative positions, and the spatial layout of your surroundings

The core components of Spatial perception include the following:

i. Depth & Distance Perception: Where the brain estimates how far away objects are and how they move through space. This component heavily relies on visual cues, sound localization, and tactile reactions.

ii. Mental Rotation: The ability to visualize and manipulate 2D or 3D objects in the mind’s eye without physically touching them. This basic component enables the understanding of objects through mere visual contact.

iii. Navigation & Orientation: This is regarded as the process of mentally mapping routes, understanding topographical maps, and orientation within an environment.

2.1.3 Spatial Visualization:

Abdo et. al, (2024) defined this principle as the ability to imagine the actual look of an object or a complex 3D shape when its parts are disfigured, rotated, or folded. This involves the mental simulation of the real natures of objects when undergoing multi-step changes. Such skills are used in the arrangement of furniture to fit into rooms or arrangement of puzzle pieces to fit into accurate forms. A basic spatial visualization skill is experienced in the arrangement ability utilized in the game of "Tetrix," as seen in Figure 3.

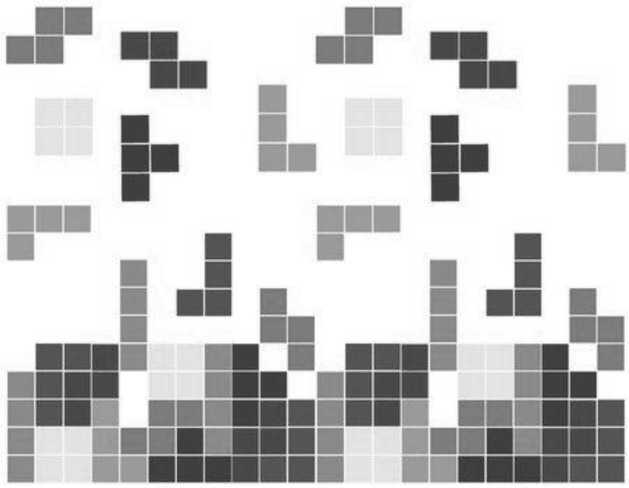


Figure 3. Tetrix used to exemplify the Spatial Visualization skill (Source: Author's sketch)

2.1.4 Spatial Memory:

McAfoose & Baune, (2009), noted the ability to temporarily hold, while at same time processing the locations of various objects or landmarks in one's head while conduction other daily tasks as a fundamental spatial memory process. Such skills are exemplified in the activities like the tracking a set of directions without the use of a map. This skill assists in remembering locations of stored objects, the creation of cognitive maps, or the use of landmarks to navigate through spaces. The primary principles associated with this process as shown in Table 1 include the Allocentric Memory, which is utilized in remembering the location of objects relative to external landmarks, irrespective of current location, the Egocentric Memory, that deals with the process of recollecting object locations relative to one's current bodily position and perspective: as well as the Visuospatial Working Memory, which is used for temporarily holding and manipulating visual and spatial information. Spatial working memory is illustrated in Figure 4, with the Visual depiction of the Brooks spatial working memory task.

Table 1. Comparison between the Allocentric and Egocentric cognitive memory paths.
Source: Ring et. al (2018)

Feature	Egocentric Memory	Allocentric Memory

Definition	Locations are coded in relation to observer's body, head, or eyes.	Locations are coded based on external landmarks or relative to objects.
Perspective	Perceived as "To my left", "behind me", "within arm's reach"	Viewed as "North of the park", "between the building and the tree".
Navigation Style	Follows a memorized sequence of turns based on individual’s perspective, thus Route based.	Understanding a broader layout of an area, independent of individual’s current position, thus Map based

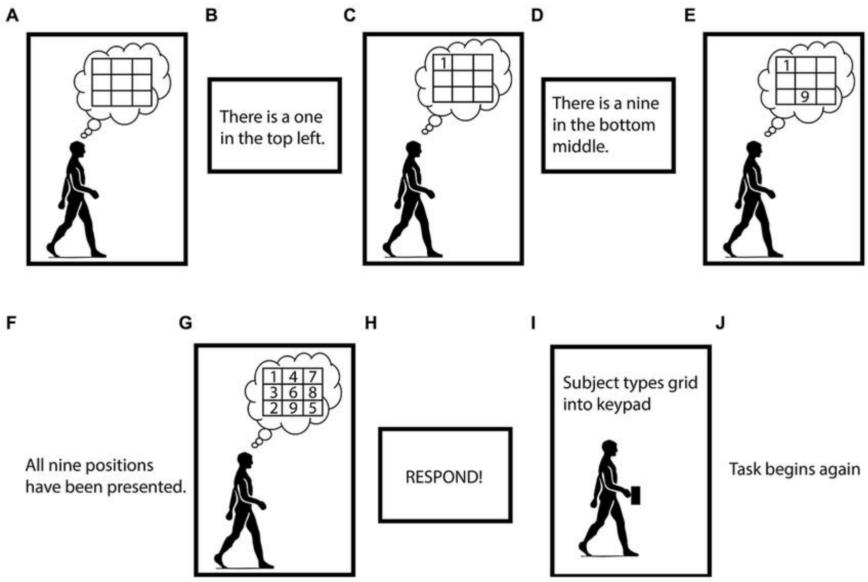


Figure 4. Visual depiction of spatial working memory task.
(Source: Kline, et. al, 2014)

2.2 CONCEPT OF SPATIAL THEORIES

Spatial theories in architecture involve the application of traditional theories and normative theories, respectively. Whilst traditionally, space is interpreted as a homogeneous structure of its own and exists independently of things, absolute space serves as the ultimate framework for the positions and motions of objects and the relative space within it. According to Arisaka (1996), noteworthy metaphor normally used to describe this interpretation of space in architecture is a “container” or “arena”;, objects and events occur “in” space, but space itself is independent of them In the normative sense, however, space is mathematical and can be controlled (Campbell, 2016). Hillier et al. (1984), believes that, in order to design harmonious buildings, designers should aim for the mathematical order found in nature. This offers a method of calculating proportions to serve as a technique for realizing this aim in architectural terms. The Space Syntax approach quenches the most common architectural theories that leaned more on the normative. It rather presents a stronger analytical approach, which is lacking in most spatial theories of the past.

Studies on the human cognition values suggest that configuration process of any environment possesses significant cognitive consequences. According to Hillier, spatial configuration on its own could become constraints on spatial experience because its elements may improve or impede aspects of human activities through spatial cognition and behaviors. Consequently, the spatial layout of every built environment influences the accuracy of cognitive representations of real-world spatial information

(Brunye et. al, 2018). Furthermore, pathways or network structure as identified by Golledge & Stimson, (1997) are used in our everyday spatial behavior eventually becomes critical elements of the image of a spatial environment. More so, Lynch (1960) suggests that images of spatial environments can be achieved only if they are configured as patterns of high continuity with a number of distinctive but interconnected parts. However, in the case of buildings, patterns of circulation define the intrinsic systems for wayfinding, and to understand the concept of wayfinding in buildings, the process of circulation must be comprehended.

2.3 GAPS AND CHALLENGES OF SPATIAL COGNIZANCE/DISORIENTATION IN BUILDINGS

Spatial orientation in a large space is attributed as fundamental for the organization of all meaningful behavior within the space (Tragantzopoulou & Giannouli 2024). Since wayfinding is defined as the process of identifying locations and navigating to a destination using mental environmental information, the ability to comprehend one's environment by way of spatial cognizance is the first principle towards successful wayfinding spaces (Kwon, 2025). Degrees of place capacity or volumes of functional spaces affect people's capabilities to mentally grasp the composition of the environment (Halawani, 2024). One of the major gaps identified through studies show that the ability to control space is achieved either through the process of habitual occupation, by personalization, or by mere marking (Gifford, 1997). The composition of modern large buildings has evolved over the years, resulting in complex environments comprising lengthy and confusing pathways and corridor systems with bends, turns and confusing signage systems (Bernardo, 2023), (Rooke, 2012). These types of settings pose enormous challenges as well as frustrations for visitors and building users. Most significant in the classification of modern large buildings are Hospital buildings. Figure 5 illustrates the comparative value of building space weights to wayfinding cum-spatial-orientation difficulty levels. As shown in the illustrations, when building spaces grow larger, the spatial orientation and wayfinding difficulty grows.

Figure 5. Building sizes relative to Spatial Orientation difficulty levels. Source: Author's illustration

According to Meeks et. al (2023), in order to achieve adequate orientation, the human body depends on accurate perception and cognitive integration of these systems. Study also agrees that the collective systems of visual, vestibular, and proprioceptive stimuli differ in magnitude, direction and frequency, and the inappropriate coordination of these systems result in spatial disorientation (Sworowski-Rondeau, I. (2026). The Study of human body interaction also justifies the relationships of these systems for appropriate spatial orientation (Burak & Şermin, 2020). While the human eye provides visual and spatial orientation, with about 80% of the sensory inputs required for maintaining spatial orientation, other systems, like the vestibular system, which lies in the inner ear contributes about 15%, the proprioceptive sensory system, composed of receptors located in the skin, muscle, tendons, and joints, is responsible for the remaining 5% of the total sensory information required to establish spatial orientation (Chamizo & Rodrigo 2022), (Stott, 2013). The interactions of these systems also produce near to complex coordination between all the sensory inputs, which are relatively translated and interpreted by the human brain, and the case of misinterpretation or inaccuracy resulting from three sources of information consequently produce sensory mismatch, resulting in varieties of visual or vestibular illusions (hence disorientation).

According to studies by Carlson, et. al (2014) and Mastrodonato, et. al (2016), Major gaps that define the architectural and cognitive factors which drive Spatial Disorientation in buildings includes:

i. **Complex or Symmetrical Layouts:** Extremely complex building layouts often severely inhibit user's ability to predict navigation routes. Likewise, the application of geometric symmetry without unique architectural features in building design has been identified to cause building users to revolve repeatedly in an attempt to orient themselves within built spaces.

ii. **Poor Visual Accessibility:** Similarly, the lack of clear sightlines or destination points from locations and decision-making nodes often cause disorientation, thereby compelling users to depend exclusively on signage rather than natural navigation skills.

iii. **Vertical & Inferential Disorientation:** In environments with Multi-level spaces, poorly positioned staircases often heavily disrupt spatial memory. Users of such buildings often struggle to align mental images as they arrive on different floors, thereby getting lost as they transition between different levels.

iv. **Feature Similarity & Repetitiveness:** The adoption of identical-looking corridors (circulation pathways), elevator lobbies, or undistinguished lengthy walls, as mostly observed along lengthy hospital corridors, is known to deny the environment distinctive reference points, thereby resulting in failures in the cognitive mapping process (hence disorientation).

Other factors that may predict successful navigation in buildings, as illustrated in Figure 6, includes correspondence between the building and the cognitive map; compatibility between strategies, individual differences, and building; completeness of the cognitive map as a function of strategies and individual differences; and finally, the complexity of the interaction between the structure, map, strategies, and spatial abilities (Carlson, et. al, 2014).

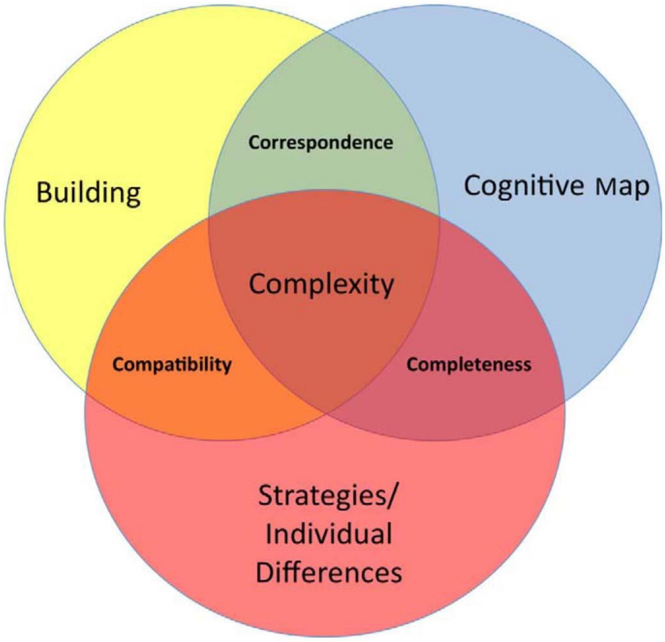


Figure 6. Factors predicting navigation in buildings
(Source: Carlson, et. al, 2014)

2.4 METHODOLOGICAL REVIEW OF WAYFINDING ANALYSIS

Studies by Yamu et. al (2021), Nes, (2014) and Khoshrooy & Safari, (2026), identify Space Syntax factors as the major technique for wayfinding analysis. Space syntax encompasses a set of theories and techniques for the analysis of spatial configurations. This involves both exploration of the applications and extension of the analytical techniques and theoretical ideas associated with the syntactic analysis of architectural spaces. The major objective of Space syntax is providing a systematic and quantitative account of building configuration in order to support the understanding of how buildings function.

In application, space must be translated into graphical measures. But in order to apply graph theoretic measures, the geometry of a space must first be read and translated into a pattern that supports the type of analysis to be performed, for example, the process of intersecting lines of movement, connected 2-D convex spaces, or intersecting visual polygons. This involves the establishment of spatial network invoking syntactic properties of the global and local systems with the aid of axial map and convex maps.

Space syntax applications involve three basic elements of space:

i. **Isovist,** referred to as viewsheds or visibility polygon. This is the field of view from any particular point in a space.
ii. **Axial space,** which is mostly a straight sight-line and possible path.
iii. **Convex space,** which is an inhabitable void where (if imagined as a wireframe diagram), no line between two of its points goes outside its perimeter, in other words, all points within the polygon are visible to all other points within the polygon.

The most popular Space Syntax analysis methods include Integration, Choice, and Depth Distance. The circulation system in buildings can be compared to the veins of organisms. The veins create a network in the body, and it arranges the flow of blood through pressure. In Space Syntax analysis, the shape of these veins and their integration with cells is compared to the spaces in a building. Be it a linear or circular architectural geometry, the shape of the building affects the legibility of the spaces. The justified graph developed from the layout of the building, the architectural form, the space and circulation relationship, the linearity or centrality of spaces is interpreted with the language of Space Syntax using depth or shallowness as "relative asymmetry" (Hillier & Hanson, 1984). According to studies on space syntax (Osman & Suliman, 1994), the fundamental formula for calculation of the Relative asymmetry is generated as follows:

Mean depth (md) = I/ (K - 1). ∑ (all depth values between a point & all other points in a graph)
(1)

The depth value between two points in a graph is equal to the minimum number of connections that must be taken to reach from one point to the other (the shortest path). K is the total number of nodes in a graph, including the outside node.

Relative Asymmetry (RA) = 2 (md - 1)/ (K - 2)
(2)

2.5 CIRCULATION AND MOVEMENT CONFIGURATIONS WITHIN PUBLIC BUILDINGS

Hessari & Chegeni (2022) defined configuration simply as a set of relationship among things, all of which are interdependent in an overall structure. Understanding the idea of relationship is to redefine spatial relation as existing when there is any type of link, adjacency, or permeability between two spaces. Subsequently, configuration only exists when relations between two spaces are changed according to how we relate one to the other or both to at least one other space (Lynch & Hack, 1984). Additionally, it is possible that our normal experience of buildings is affected by the way in which spaces are connected to each other. The changes of direction imposed by the circulation system, the creation of room sequences, the distribution of branching points, the availability of alternative routes, and the relations of visibility between and across spaces all sum up the define the configuration (Peponis, 2012).

Any interaction with a space begins with the access. Accessibility is the prerequisite to using any space; thus without the ability to enter or move within it, or to receive and transmit information or goods, space is of no value, however vast or rich it may be. In architectural practice, there is no finitely established circulation principle. While some studies suggest that simpler layouts improve way-finding and cognitive process, others believe in the combination of patterns from various geometric rules or elements for navigation (Hölscher & Brösamle, 2007). Conversely, interconnected buildings, typical of large hospital buildings and educational settings, are generally not understood as forms. A good form of a circulation system, such as simple geometrical forms like Squares, Cruciform, or an L-shaped form, aids in understanding the complexity of layouts as soon as the cognitive response of a person recognizes or notices the specific shape as an underlying principle in the order of its configuration. This action, in turn, can inform and consequently support wayfinding and circulation performance (Passini, 1996).

Primarily, all paths of movements are linear in nature. Likewise, all paths emanate from a starting point, from which we are taken through a sequence of spaces to a destination. Nonetheless, paths can also be segmented or curvilinear. they can also intersect to branch into other paths, or form a loop. The type of configuration of a path influences and is impacted by the organizational pattern of the spaces it is made to link. The configuration of a path often reinforces a spatial organization by reiterating its pattern. It may also contrast with the form of the spatial organization and serve as a visual counterpoint to it. By so doing, we are able to cognitively map out in our minds the overall configuration of the paths in a building, our orientation within the building, and eventually the understanding of its spatial layout (Ching, 2007). A path may be made radial when multiple paths culminate or extend from a shared central point. It may also be a continuous path revolving around a central point, forming a spiral. Path networks can take one of several general forms, such as the grid, radial and linear.

As a factor of fundamental criteria in public building design, like hospitals, circulation zones are treated as the most fundamental features of the functional environment. A typical instance in this case is the hospital Building design, where the fundamental features relate to the healthcare environment. The complexity of hospital circulation configuration is often compounded by the variety of users/traffic (movements) with interweaving paths of flows. Volume of circulation activities in hospitals are determined primarily by the following category of traffic:

i. People;
ii. Material Supply and distribution;
iii. Ancillary Services.

Hospital designers are often faced with the challenges of minimizing patient travel distances to this end, hospital layouts are configured to ensure the reduction of operational time, which impacts delays in patient care and patient flow.

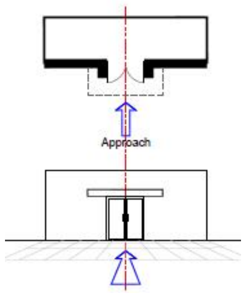
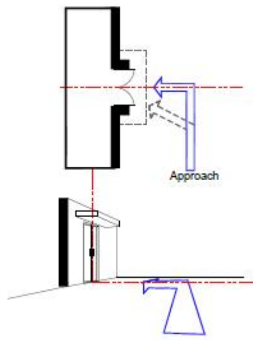
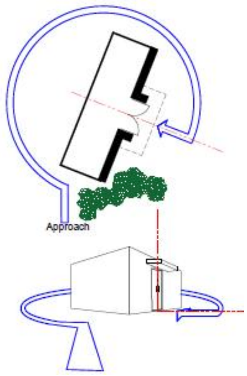
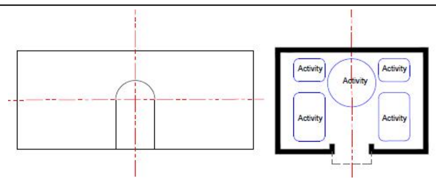
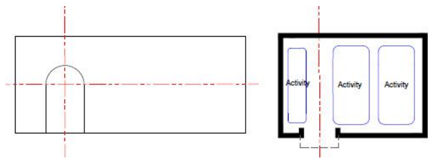
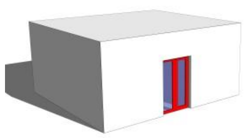
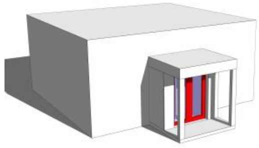
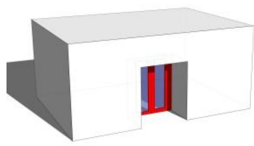
In the discourse of public buildings, Ching (2007) expressed the character of a circulation space to assume any of the following forms:

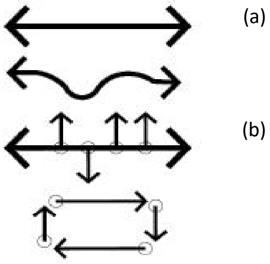
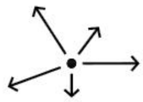
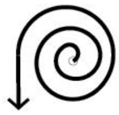
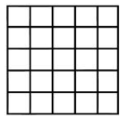
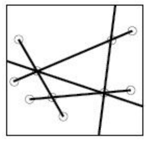
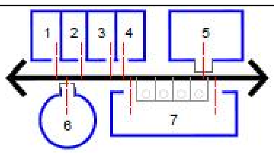
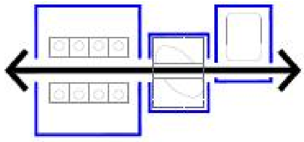
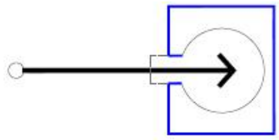
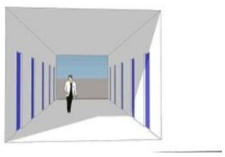
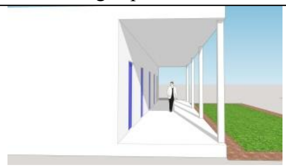
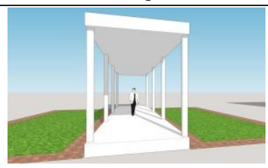
a. Enclosed
b. Open on one side
c. Open on both sides
d. Random

While the configuration of a space can vary from being enclosed, for corridors, it may be open-on-one side for open areas like a balcony or gallery, or totally open-on-both sides in the case of colonnade passages. In the case of large spaces, a path can be random, without form or definition, and be determined by the activities within the space.

Generally, the geometrical proportion of a circulation space can be manipulated to handle the volume of circulation as well as the functional use of the space. For instance, a narrow enclosed path naturally encourages forward directional movement, whilst wide and tall spaces tend to encourage the more random movement. Ching further disclosed the relevance of levels of circulation elements in order of progression (as presented in Table 2) for organization of movement and way-finding in large public buildings.

Table 2. Layers of Circulation Elements in order of progression for organization of flow and way-finding

ORDER OF FLOW	LAYERS OF CIRCULATION	DESIGN SCHEMES
1st	**Approach**	 Frontal  Oblique  Spiral
2nd	**Entrance**	 Centered along Plane of entry  Offset from Axis of Entry
		 Flushed  Projected  Recessed

3rd	**Path Configuration**	 Linear Path Configurations	 Radial Path Configurations	 Spiral Path Configurations	 Grid Path Configurations	 Network Path Configuration
4th	**Path-Space Connector**	 Pass by spaces	 Pass through spaces	 Terminate in a space		
5th	**Circulation Element**	 Enclosed	 Open on one side	 Open on both sides		

3.0 METHODOLOGY FOR AXIAL ANALYSIS OF PUBLIC BUILDINGS

For the purpose of this study, this paper uses Axial line analysis (developed by Turner et. al, 2005) to examine selected public building configurations. For more definitive study, a typical building type (Hospital buildings) is utilized for the comparative analysis. Axial analysis which is a way of analyzing a spatial layout represented by an axial map with simplified connections between spaces in urban or architectural morphology will be used to identify the longest visibility lines between convex spaces within the selected hospitals. This study utilized simple Autocad (CAD) drawing tools, and outlined the building forms in order to identify the layout configurations used in design. Finally axial lines were drawn across each nodes in the layout to connect visibility lines across various location/destination points.

To further actualize the objective of this study, several large scale hospitals in Nigeria were visited. It was observed that the large sized hospital complexes were the ones classified under the Specialist and Teaching Hospital category. These classifications of hospitals are mostly government owned and strategically located across the various geopolitical zones of Nigeria. The selection criterion for this study thus intended to cut across and represent the three major geopolitical zones of Nigeria (Northern, Western and Eastern regions).

The three selected Hospitals for this study includes:

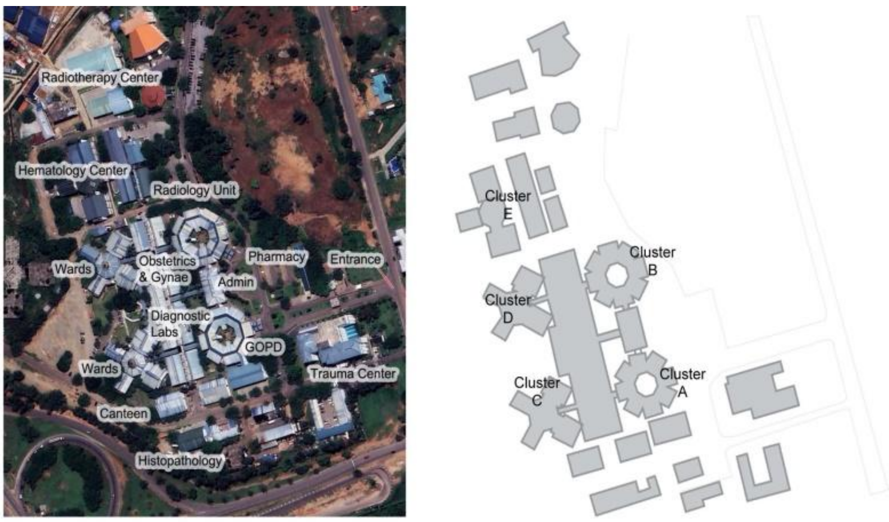
i. National Hospital Abuja (NHA), located in northern Nigeria
ii. University of Nigeria Teaching Hospital Enugu (UNTH), located in southern Nigeria
iii. University College Hospital Ibadan (UCH), located in western Nigeria

The axial maps of each selected hospital outlines the visibility context (using axial lines to indicate lines of sight) when one travels along pathways on the layouts. The connections of the red lines (lines of sight), in the analysis signify the effectiveness of each type of "Building Form" and layout in organizing the flow of visitors along these pathways. The number and distances of connectivity in straight/linear unobstructed lines of sight observed in each case indicates the level of difficulty visitors will face in seeing or identifying the next nodal point (functional location/destination).

4.0 AXIAL ANALYSIS OF FOR WAYFINDING IN SELECTED HOSPITALS

A review of the idea of modern hospital buildings across the globe indicates massive and highly sophisticated establishments with diverse functional areas located at various points where administration, medical care and treatments are carried out. Recorded experiences in these class of large medical centers identifies a number of negative effects on patients and users resultant in stress, anxiety, wayfinding difficulties and spatial disorientation (Jiang & Verderber, 2016). A review of the major large hospital buildings in Nigeria visited for this study identifies this same pattern of design which suggests significant intentions to create large accommodations with limited consideration for users and patient/visitor wayfinding complications.

Study shows that the gaze bias identifies that people pay attention to structural elements in the built environment. According to Martinez-Conde et al (2019), study of visitors' behavior in memorized spaces identified that tiny gaze shifts disclose people's familiar locations in a memorized space rather than that of visual space. This discovery indicates that the oculomotor system may be engaged in the process of focusing attention within the internal space of the memory. These studies are in line with the suggestions for the use of Axial Lines and Isovists fields in analyzing perception in the wayfinding process. A typical case is the real-time view of the National Hospital Abuja, where the general configuration of the complex leading from the entrance indicates the lack of vistas to destination points from any point of location during the process of wayfinding. Even the general directory signage (as shown in Figure 7) which presents a guide to users and visitors requires extensive mental mapping to acquire satisfactory spatial cognizance for recognition of destinations within the facility.



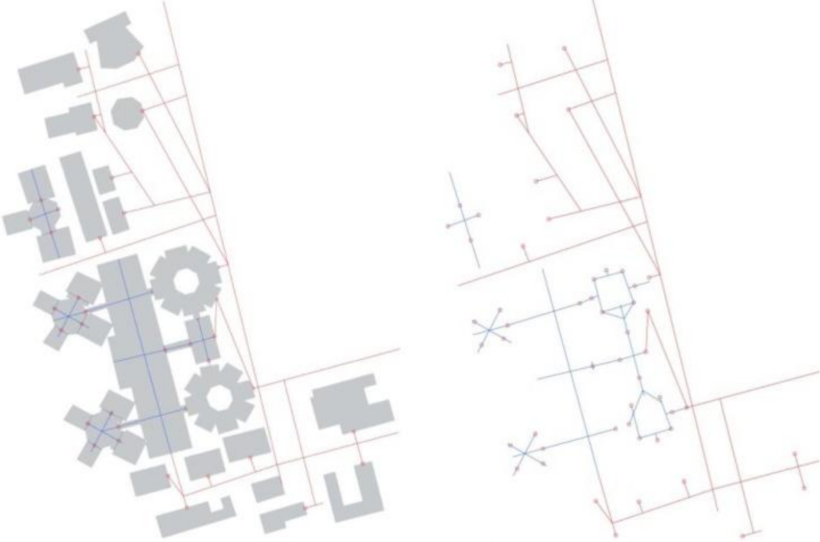
(a) Google map/layout National Hospital Abuja (b) Outline/layout of National Hospital Abuja

Figure 7. Google map of the National Hospital Abuja (NHA), showing the major spatial units/functions. Source: Google map view of NHA (2025)

For the wayfinding analysis of the three selected hospitals, the axial ma of each hospital is outlined to demonstrate the VISIBILITY context (using axial lines to indicate lines of sight). The connections of the red lines (lines of sight), in the analysis signify the effectiveness of each type of "Building Form" and layout in organizing the flow of visitors along these pathways. The number and distances of connectivity in straight/linear unobstructed lines of sight observed in each case indicates the level of difficulty visitors will face in seeing or identifying the next nodal point (functional location/destination).

4.1. AXIAL ANALYSIS OF THE NATIONAL HOSPITAL ABUJA (NHA)

Figure 8 shows the axial map of the National Hospital Abuja. The significant axial lines are the external lines represented in Red color, while the Blue color indicated the internal axial lines. The pattern of the external axial lines indicates the level of disconnected lines of sight and dispersed connectivity between each of the Blocks and Cluster units in the Hospital's Layout. The complexity of its connectivity further signifies the challenges of connecting from one destination (node) point to another (represented in Red circles).



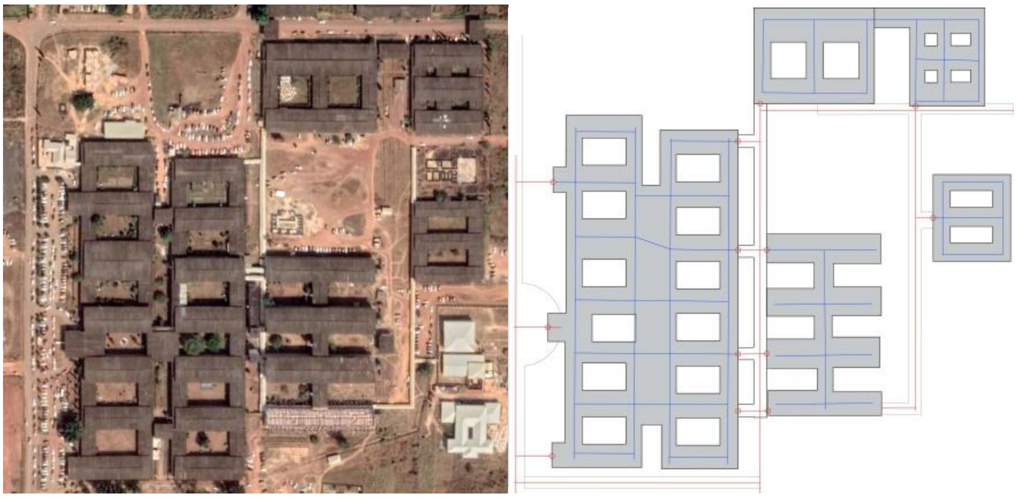
(a) Axial map of NHA layout showing the External Axial lines in Red and internal Axial lines in Blue

(b)Axial map of NHA showing the External Axial lines in Red and internal Axial lines in Blue

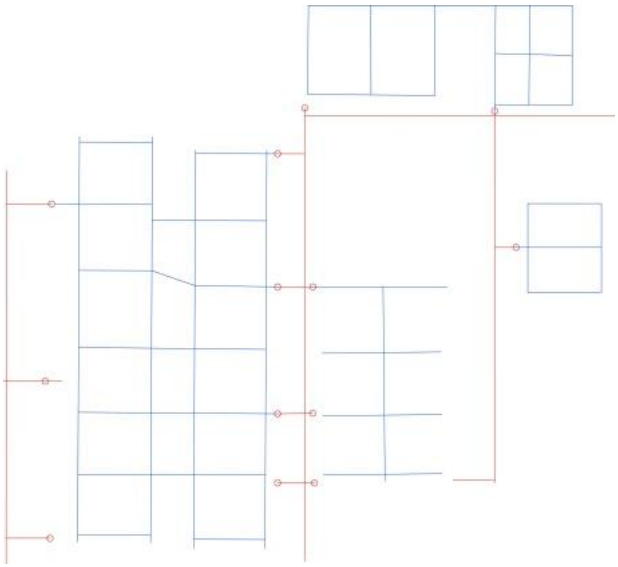
Figure 8. Axial analysis of the National Hospital Abuja. Source: Author's axial analysis diagram

4.2. AXIAL ANALYSIS OF THE UNIVERSITY OF NIGERIA TEACHING HOSPITAL (UNTH), ENUGU

To further observe the impacts of building layout configuration on spatial orientation and wayfinding, the axial map of the University of Nigeria Teaching Hospital (UNTH) was developed. Figure 9a shows the Google map/Layout of UNTH, while 9b and 9c presents the axial map and analysis of the layout. The significant axial lines are the external lines represented in Red color, while the Blue color indicates the internal axial lines. The pattern of the external axial lines indicates more linearly connected lines of sight and pathways between each of the hospital Blocks. The external axial lines indicates less unobstructed (clear) direct sight connections from one destination (node) point to another with less turns than that of the NHA.



(a) (b)



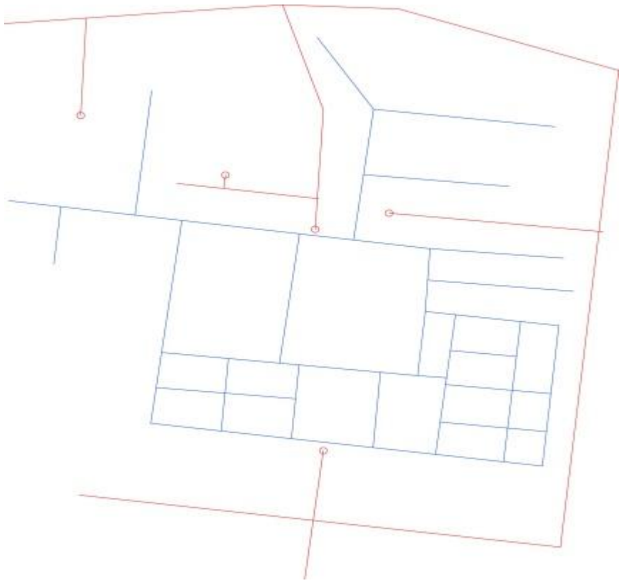
(c)

Figure 9. Axial analysis of the University of Nigeria Teaching Hospital
(a) Google map/layout of UNTH, (b) Axial map of UNTH layout, (c) Axial map of UNTH showing the external and internal Axial lines. Source: Author's axial analysis diagram

4.3. AXIAL ANALYSIS OF THE UNIVERSITY COLLEGE HOSPITAL (UCH), IBADAN

In the case of the analysis of the UCH layout configuration, spatial orientation and wayfinding, the axial map of the UCH was developed. Figure 10a shows the Google map/Layout of UCH, while 10b and 10c presents the Axial map and analysis of the layout. Likewise, the significant axial lines are the external lines represented in Red color, while the Blue color indicates the internal axial lines. The pattern of the external axial lines in this case indicates a rather scattered lines of sight and pathways between each of the hospital Blocks. The external axial lines indicates obstructed and indirect sight connections from one destination (node) point to another requiring more turns than that of the UNTH. Owing to these scattered lines, the spatial orientation course will likewise follow cumbersome process.

(a) (b)

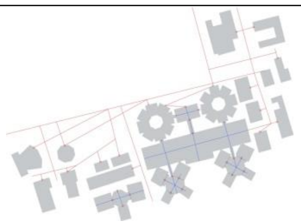
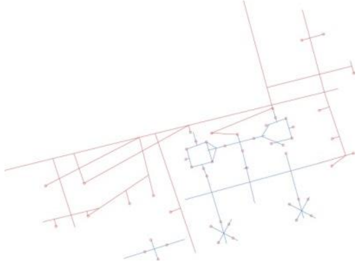
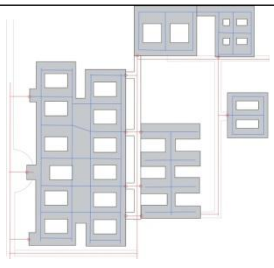
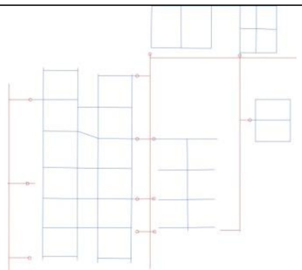
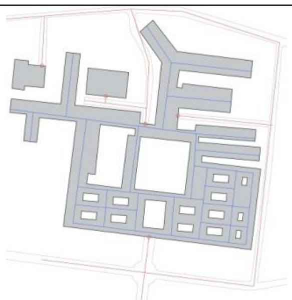
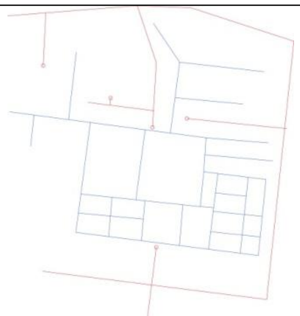


(c)

Figure 10. Axial analysis of the University College Hospital
(a) Google map/layout of UCH, (b) Axial map of UCH layout, (c) Axial map of UCH showing the external and internal Axial lines. Source: Author's axial analysis diagram

Comparative summary of the three hospitals in the study as presented in Table 3, a view of the three cases demonstrates that the less complex hospital layout presents lesser spatial disorientation outlook. While the NHA is made up of dispersed sightlines and connection to access points of the numerous blocks and clusters, thereby making wayfinding more challenging, the UNTH presents a less complex layout and more linear sightlines with less turns that enable visual connectivity to destination points thus indicating lesser challenges for wayfinding. The UCH layout on the other hand presents limited sightlines to the scattered access points to various blocks in the hospital. This presents a medium challenge to spatial orientation on the external axis, with even more challenges envisaged in the internal pathways as the building exists as a massive unit with integrated blocks. While the experience of spatial orientation may be minimal from the external axis, the internal wayfinding process in the UCH is expected to be highly disorienting.

Table 3. Analysis of disorientation levels in the three selected hospitals

Hospital	Axial map	External Axial connection to Pathways and Access points (nodes)	Connectivity level	Disorientation level
National hospital Abuja (NHA)			Dispersed connection to numerous access points (nodes) owing to multiple building units	High
University of Nigeria teaching hospital (UNTH)			Lineal sightlines as indicated by external axial lines, ensuring ease of connection from locations	Low
University college hospital (UCH)			Scattered connection to controlled access points (nodes), limited sightlines from external axial lines	Medium

From the analysis of the three hospital buildings in Table 2 above, it could be asserted that simplified architectural morphology (building forms) and layout/arrangement of building units if adopted in the organization and composition of the hospital building layout would improve the connectivity of axial lines (sight lines), which in turn will increase the potential of spatial orientation and wayfinding process for visitors and users. Architectural designs that consider the problems of spatial disorientation often adopt simplified patterns of hospital building layouts for the benefit of patients and users. Previous study confirms that the quality of patients care and wellbeing are linked with the physical attributes of the healthcare environment (Gesler et. al, 2004). Also spatial configuration has been identified as significant in influencing human movements and this impact on the performances of the users within the space and the quality of decisions they make. For hospital buildings, spatial configuration and easy of wayfinding plays major roles in determining the efficiency of hospital services and thus, in order to understand the concept of wayfinding in hospital buildings, the process of spatial orientation, flow and visual connectivity must be comprehended (Edgett & William, 2004).

5. CONCLUSION

Studies in the past identified significant relationship between architectural design parameters, circulation designs, spatial and layout configurations, circulation efficiency, and wayfinding. Since building and urban environment designers are often challenged with the tasks of producing functional spaces, the success of which depends largely on the design implications, this study is thus tailored towards showcasing the values and importance of adopting fundamental concepts/principles of circulation design for generating appropriate building layouts focused towards on optimizing wayfinding and spatial orientation right from the conceptualization stages of design. The impacts of spatial orientation in buildings and ease of wayfinding can be attributed to general building safety and-post occupancy experiences of users. The values of wayfinding play key roles in problem-solving practices mostly associated with emergency evacuations, or with simple spatial cognitive attitudes that impact on user orientation. Professionals, especially Architects and Urban Planners, rely on several fundamental concepts of wayfinding to make buildings and urban environments legible to common users. In this paper, the principal findings are hugely relevant in the following areas:

a. Identification of effective patterns of circulations in buildings,
b. Strategies for wayfinding improvements in large buildings like hospitals,
c. Axial analysis methodology application system for assessing wayfinding performance in buildings and large spaces,
d. Effective building forms for improving wayfinding,
e. Identification of less complex user-cognitive representations of spatial information in buildings with components intended to improve indoor spatial cognition process

While the analyses of patterns of circulation presented in this paper portray that each type has its potentials and limitations in terms of circulation flow, visibility and wayfinding, the results from this discussion can be useful in the design process and consideration for effective circulation systems to be adopted by designers in critical buildings like hospitals.

Consequently, since spatial disorientation in built environments is attributed mostly to layout configurations which originate from the building conceptualization and design stages, architects and designers of spaces like large hospitals may reduce these negative impacts by adopting measures like:

i. Establishing spatial configuration as the dominant element in the design for eliminating spatial disorientation and improving wayfinding process.
ii. Application of pre-design axial analysis of conceptual building layouts prior to design development.
iii. Adoption of more linear building forms (configurations) that provides visitors and users with extended lines of sight and networks for ease of visual connectivity to destination points in large buildings, especially large hospitals where the effects of spatial disorientation may impact on the mental well-being of users.
iv. Employment of the additional principles for effective wayfinding, such as location distinctiveness, visual characterization, adaptive sightlines, and signage with decision points.
v. Adoption of spatial configurations that provides easy user-cognitive representation of spatial information, with components intended to improve indoor spatial cognition process, such as colors and textures.

REFERENCES

Abdo, S. N., Hsu, J. L., Kapetanakis, C., Newman, D. L., Wright, L. K., & Bailey, J. (2024). An Exploration of Spatial Visualization Skills: Investigating Students' Use of 3D Models in Science Problems during Think-Aloud Interviews. *Journal of chemical education*, 101(9), 3624–3634. https://doi.org/10.1021/acs.jchemed.3c01355

Al-Alwan, H. & Al-Azzawi, A. 2014. Wayfinding Performance in *The Built Environment*. 1-17.

Arisaka, Y. (1996). On Heidegger's Theory of Space: A Critique of Dreyfus. *Inquiry* 38, 455-467.

Arthur P., Passini R., 1992. Wayfinding: People, Signs, and Architecture. McGraw-Hill Book Co. New York.

Bernardo, G. (2023). The new building components of the Modern Architecture. VITRUVIO - International Journal of Architectural Technology and Sustainability. 8. 4-17.

Brunye, T. T., Gardony, A. L., Holmes, A., & Taylor, H. A. (2018). Spatial decision dynamics during wayfinding: Intersections prompt the decision-making process. *Cognitive Research: Principles and Implications*, 3, 13.

Burak, E., & Şermin, T. (2020). Chapter 27 - The effects of weightlessness on human body: spatial orientation, sensory-integration and sensory-compensation, Editor(s): Salih Angin, Ibrahim Engin Şimşek, *Comparative Kinesiology of the Human Body*, Academic Press, Pages 477-486,

Campbell, C, (2016). Space, Place and Scale: Human Geography and Spatial History in Past and Present. *Past & Present.* 239, 23-45.

Chamizo, V. & Rodrigo, T. (2022). Spatial Orientation. 10.1007/978-3-319-55065-7_1416.

Ching, F. D. K. (2007). Architecture: Form, space, & order. Hoboken, N. J: John Wiley & Sons.

Carlson, L., Hölscher, C., Shipley, T, & Dalton, R, (2014). Getting Lost in Buildings. *Current Directions in Psychological Science*, 19, 284-289.

Delmore, T. (2025). Re-Charting Tolman's Cognitive Maps. *Dialogue*. 63. 447-466. 10.1017/S0012217324000271.

Edgett, S.D., William, A.M., (2004). Vertical Circulation. *Building Design and Construction Handbook*. New York : MacGraw Hill Companies

Gesler, W., Bell, M., Curtis, S., Hubbard, P., Francis, S., (2004). "Therapy by design: Evaluating the UK hospital building program", *Health and Place*, 10 (2): 117-128.

Göksun, T., Goldin-Meadow, S., Newcombe N., Shipley, T. (2013). Individual differences in mental rotation: what does gesture tell us? *Cognitive Process*. 14(2):153-62. doi: 10.1007/s10339-013-0549-1. Epub 2013 Feb 20. PMID: 23423638; PMCID: PMC3648804.

Golledge, R. G., & Stimson, R. (1997). Spatial Behavior: A Geographic Perspective. New York: Guilford.

Gifford, R., 1997. Environmental Psychology: principles and practice. 2 Ed: Allyn and Bacon, Boston, USA.

Halawani, R. (2024). The Effects of Public Spaces on People's Experiences and Satisfaction in Taif City: A Cross-Sectional Study. *Land,* 13(9), 1529. https://doi.org/10.3390/land13091529

Hessari, P. & Chegeni, F. (2022). Measuring the Relationship between Spatial Configuration Concept Variables and Flexibility Components. *Journal of Architecture and Urbanism*. 46. 89-99. 10.3846/jau.2022.16437.

Hillier, B. (1996) Space Is the Machine: A Configurational Theory of Architecture. Cambridge University Press, Cambridge.

Hölscher, C., & Brösamle, M., (2007). Capturing indoor wayfinding strategies and differences in spatial knowledge with Space Syntax. Proceedings, *6th International Space Syntax Symposium, İstanbul*: ITU Faculty of Architecture

Inman, H. 2022. "Navigating blind without a map: models of active wayfinding." Proceedings of the ALIFE 2022: The 2022 Conference on Artificial Life. ASME,: 69-77.

Jamshidi, S. & Pati, D. (2025). The Role of Maps and Signage in Interior Wayfinding: An Exploratory Qualitative Study. *Interdisciplinary Journal of Signage and Wayfinding*. 8. 23-34. 10.15763/issn.2470-9670.2024.v8.i1.a144.

Jiang, S., Verderber, S., 2016. On the Planning and Design of Hospital Circulation Zones: A Review of the Evidence-Based Literature. *Health Environments Research & Design Journal*, 10, 1-23.

Khoshrooy, M., Safari, H. (2026). The contribution of spatial configuration analysis to the perception of safety in residential spaces. *Discover Cities,* 3, 12. https://doi.org/10.1007/s44327-026-00188-

Kuipers, B., 1982. The 'map in the head' metaphor. *Environment and Behaviour*, 14 (2), 202-220.

Kwon, J., Schmidt, A., Luo, C., Jun, E., & Martinez, K. (2025). Visualizing Spatial Cognition for Wayfinding Design: Examining Gaze Behaviors Using Mobile Eye Tracking in Counseling Service Settings. ISPRS *International*

Journal of Geo-Information, 14(10), 406. https://doi.org/10.3390/ijgi14100406
Lynch K, & Hack G. (1984). Site Planning. The MIT Press, Cambridge, Massachusetts and London, England.
Lynch, K. (1960). The Image of the City. The MIT Press
Martinez-Conde, S., Alexander, R., (2019). A gaze bias in the mind's eye. *Nature Human Behaviour*. 3(1), 10.1038/s41562-019-0546-1.
Mastrodonato, G., Camarda, D., Borri, D. (2016). Navigating in multi-level buildings: the effect of rotation. *City Territory Architecture*, 3(1); 1-9
McAfoose, J. & Baune, B.T. (2009). Exploring visual-spatial working memory: a critical review of concepts and models. *Neuropsychology Review*,19(1),:130-42.
Meeks, R.K, Anderson, J., Bell, P.M. (2023). Physiology of Spatial Orientation. [Updated 2023 Aug 14]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2026 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK518976/
Nes, A.. (2014). Space Syntax in Theory and Practice. 10.1007/978-3-319-08299-8_15.
Osman, K.M., Suliman, M., 1994. The Space Syntax Methodology: Fits and Misfit. *Architecture & Behaviour*, 10 (2), 189-204.
Passini, R. (1996). Wayfinding design: logic, application and some thoughts on universality. *Design Studies,* 17 (3), 319-331.
Ring, M., Gaigg, S.B., Altgassen, M. et al. Allocentric Versus Egocentric Spatial Memory in Adults with Autism Spectrum Disorder. *Journal of Autism Development Disorder* 48, 2101–2111 (2018). https://doi.org/10.1007/s10803-018-3465-5
Romedi, P., 1984. Spatial Representations: A Wayfinding Perspective, *Journal of Environmental Psychology*, 4 (2), 153-164.
Rooke, C.N., 2012. Improving Wayfinding in Old and Complex Hospital Environments. Thesis (PhD), University of Salford, UK, doi: 10.13140/RG.2.2.26694.27208.
Russell, A.E, Eva, Z.P., Joshua, B.J., Hugo, J S., 2017. Nature Neuroscience, 20, 1504–1513
Stott, J.R. 2013. Orientation and disorientation in aviation. *Extreme Physiology and Medicine*, 2(1):2-11.
Sworowski-Rondeau, I. (2026). Physiology in Aviation: Hearing, Vision, Spatial Disorientation, and Visual Illusions. 10.13140/RG.2.2.27928.05120.
Tragantzopoulou, P., & Giannouli, V. (2024). Spatial Orientation Assessment in the Elderly: A Comprehensive Review of Current Tests. *Brain sciences*, 14(9), 898. https://doi.org/10.3390/brainsci14090898
Turner, A., Penn, A., Hillier, B., 2005. An Algorithmic Definition of the Axial Map. Environment and Planning B: *Planning and Design*. 32. 425-444. doi: 10.1068/b31097.
Ullas, B, & Aju, R. (2014). Wayfinding in Theme Parks. *International Journal of Scientific and Engineering Research*, 5 (7), 139-145.
Vaez S., Burke M., Alizadeh T., 2016. Urban Form and Wayfinding: a Review of Cognitive and Spatial Knowledge for an Individual's Navigation. *ATRF 2016 Proceedings* 1-14
Werner, S., Krieg-Brueckner, B., Mallot, H., Schweizer, K., Freksa, C. (1997). Spatial Cognition: The Role of Landmark, Route, and Survey Knowledge in Human and Robot Navigation. *Informatik aktuell*, 41-50, Berlin: Springer-Verlag
Yamu, C., van Nes, A., & Garau, C. (2021). Bill Hillier's Legacy: Space Syntax—A Synopsis of Basic Concepts, Measures, and Empirical Application. *Sustainability*, 13(6), 3394. https://doi.org/10.3390/su13063394