EXPLORING THE DYNAMIC READING OF ENVIRONMENT TOWARDS A MULTIDIMENSIONAL LEGIBILITY

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Abstract

This study investigates the understanding of legibility, defined as the coherency of built environment features. Legibility enables production of mental image that helps individuals with their spatial navigation. The current discussion positions legibility as an objective aspect in the process of making sense of the environment. The study argues that such a process has dynamics that reflect individuals' subjectivity, therefore further study is important to reconcile the objective and subjective reading of legibility.

This research qualitatively investigates legibility using a case study of an indoor environment of a shopping mall in East Jakarta. The analysis was conducted based on the objective and subjective aspects which construct individuals' cognitive map. The objective-based analysis examines the complex topological interconnection and good form principles, as well as the landmark potential based on visual, semantic, and structural saliency. Meanwhile, the subjective-based analysis focuses on examining the spatial knowledge represented through the cognitive map produced based on the respondents' experiences. The analysis shows the multidimensional nature of legibility derived from a dynamic process during the encounter between individuals and the environment. The reconciliation of the objective and subjective aspects of legibility integrates two- and three-dimensional spatial knowledge. The multidimensions of legibility demonstrate ways of revealing the complexity of the built environment, triggering various design approaches.

Keywords: legibility, cognitive map, objective and subjective aspects, spatial knowledge

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Environmental legibility

This paper investigates the process of reading the environment to acquire spatial knowledge and how such a process contributes to environmental legibility. Environmental legibility helps us to navigate and find a way in unfamiliar environmental conditions, as individuals continuously move between and in different environments. Legibility is related to the pattern of objects, places, or features contained in an environment, providing spatial knowledge for individuals that is projected through the individual cognitive map. However, legibility tends to be seen mainly as an objective aspect of the environment, neglecting the process of reading the environment which requires a subjective process of an individual. Environmental legibility cannot be only described based on a 'good form' of plan configuration. It also needs to consider the potential of the objects, places, or features that act as a landmark that adds complexity to the process.

It is believed that reading the environment exhibits a particular dynamic and legibility becomes multidimensional rather than only depending on a rigid and coherent quality of an environment. Therefore, this study aims to investigate further the role of a set of environmental properties and features in the acquisition of spatial knowledge through the utilisation of the cognitive mapping process. Multidimensional legibility arguably reveals how the complexity of the environment could increase or decrease depending on the interrelations of various aspects involved in the encounter between human and their environment.

Reading environmental legibility through the cognitive map

Environmental legibility is a concept commonly used to evaluate the level of complexity and coherence of an environment—which involves both two- and three-dimensional aspects—and how individuals read and make sense of it. The idea of legibility is related to the easiness for humans to identify parts of an environment and arrange them in a coherent pattern (Lynch, 1960). In other words, legibility can be seen as a characteristic of space that provides some level of environmental understanding for humans (Herzog & Leverich, 2003), an important factor related to the individuals' constructed mental image or a cognitive map.

In this paper, a mental image or cognitive map is considered an important means to unfold the process of reading the environment and constructing legibility. The term cognitive map describes an internal image of the environment, an internal structure that represents information about the everyday environment (Gärling et al., 1984). Kaplan (1973) describes a cognitive map as a mental construction used by an individual to identify and understand their environment. Meanwhile, Lynch (1960) uses the term environmental image to describe a result of two-way interaction processes between individuals and their environment, in which this process is used to interpret the information and guide their actions in the environment. It can be understood that a cognitive map is a collection of environmental information constructed internally

in the form of an image that influences how an individual acts in the environment.

The cognitive map acknowledges the role of both environmental aspects and the individual experience or perspective (Baskaya et al., 2004; Kaplan, 1973; Koseoglu & Onder, 2011). The actual condition and characteristics of the physical environment influence the formation of a cognitive map. However, there is a tendency to put only emphasis on the objective aspects of legibility during the reading of the environment, focusing more on the role of layout configurations or two-dimensional spatial knowledge, including the two-dimensional complexity of the environment. For example, Kaplan (1973) discusses the idea of environmental complexity and how it is simplified in the human cognitive map. The simplicity or complexity of a two-dimensional layout can affect the wayfinding behaviour in unfamiliar environments (Baskaya et al., 2004). Simplicity or coherence becomes essential in forming spatial knowledge because a coherent environment is easier to read and understand (Askarizad et al., 2022). It shows how coherence is more valued rather than some level of complexity that potentially encourages exploration.

Siegel and White (1975) argue that a cognitive map is constructed gradually based on an individual's spatial knowledge of a certain environment. Specifically, cognitive maps are developed through three phases of spatial knowledge, namely landmark, route, and survey (Figure 1). The first phase is related to landmark, which is a knowledge of objects, places, or features based on visual saliency and importance in an environment, but without understanding their relative relationship (Iachini et al., 2009). The second phase is knowledge of the route, which is understanding the connection between landmarks (Siegel & White, 1975). The last phase is knowledge of survey, which is a comprehensive understanding of spatial layout as a whole, including the relation of objects and places inside it (Jamshidi et al., 2020). In this phase, the route is integrated into a network or configuration that contains landmarks (Viaene, 2018). This integration of landmark and route in a particular configuration becomes the basis for the cognitive map (Youngson et al., 2019).

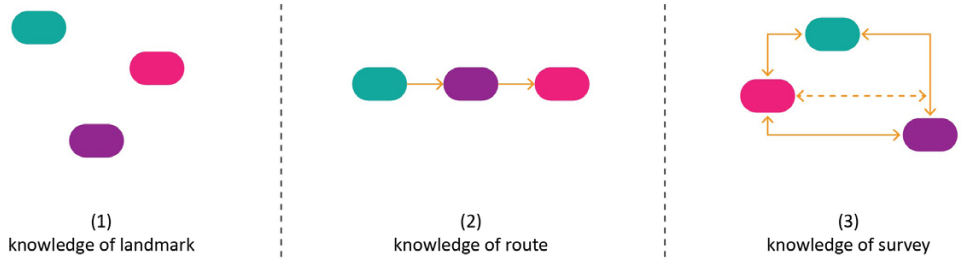


Figure 1. Three phases of spatial knowledge in the formation and development of cognitive map (Image by authors)

Koseoglu and Onder (2011) highlight the importance of the layout and saliency of landmarks within the process of acquiring spatial knowledge. Even though Koseoglu and Onder (2011) recognised that both spatial knowledge and individual perception play essential parts in the acquisition process of spatial information, the subjective aspect of legibility is hardly

taken into account. There is a lack of explanation of how the objective and subjective aspects relate to each other. Hence, this study adopts the framework proposed by Koseoglu and Onder (2011) and extends the idea by connecting it with the construction process of a cognitive map. By identifying both aspects of environmental legibility, it is expected that the dynamics of reading the environment can be further unfolded.

Aspects of cognitive map and the dynamic construction of environmental legibility

This study extends the legibility framework proposed by Koseoglu and Onder (2011), focusing on the objective and subjective aspects of a cognitive map which help to define further environmental legibility. The objective aspects of constructing a cognitive map cover two- and three-dimensional spatial knowledge that is related to the layout and saliency of landmarks within the built environment. On the other hand, the subjective aspects of a cognitive map rely on the degree of familiarity experienced and perceived by the individuals. In this study, both aspects will be compared to get a comprehensive and multidimensional understanding of the interrelation between various environmental features in reading and acquiring spatial information. This section will explore further and specify the aspects involved in these analyses, including how they interrelate as a theoretical framework for the study.

Two-dimensional spatial knowledge

Two-dimensional aspects of legibility consist of a good form of a floor plan and topological interconnection. The complexity of floor plan configuration becomes a crucial determinant and has an important influence on the legibility of the environment (Baskaya et al., 2004; Slone et al., 2015). The legibility of an environment is influenced by the good form of its floor plan. A good form of a floor plan is based on Gestalt principles of perceptual organisation (Yoo, 1992). It states that an individual tends to perceive an entity based on its simplest form or arrangement (Cherry, 2022). Hence, understanding spatial knowledge through a floor plan configuration will be easier if it has an overall pattern with a simple structure or arrangement that allows simple verbal labelling, such as a square or rectangle (Montello, 2007).

O'Neill (1991b) argues that a good form-based assessment related to floor plan configuration tends to be influenced by symmetry. Symmetry refers to the level of similarity between the opposite sides of an object or form (Yoo, 1992) and a symmetrical form is easier to conceive and use (O'Neill, 1991b). The symmetry characteristic reduces the complexity of the form, which would make it easier to read and perceive.

On the other hand, the complexity of the floor plan suggests not only a good form but also can be conceptualised as a 'topological interconnectivity.' It shows how units of floor plan are connected in a certain arrangement (Hölscher & Dalton, 2008). A topological arrangement shows the interconnection

between choice points contained in the whole form of the floor plan. Decision in navigating within an environment is often made in the choice points, the location of decision points is functionally crucial and increases its importance as a feature in an environment. The complexity of the interconnection between choice points influences the easiness of an individual to form the cognitive map (O'Neill, 1991a). The complexity of a floor plan can be measured using the Interconnection Density (ICD) which is calculated by dividing the total option in all choice points by the total number of choice points in a floor plan (O'Neill, 1991b). O'Neill (1991c) argues that an individual's accuracy of a cognitive map form will decrease when the ICD increases and vice versa.

Three-dimensional spatial knowledge

Three-dimensional aspects of legibility can be described through the saliency of landmarks and there are three kinds of saliencies: visual, structural, and semantic saliency (Sorrows & Hirtle, 1999). Saliency can be defined as the attractiveness or qualities of a landmark based on its important characteristics and differences relative to the surrounding environments (Caduff & Timpf, 2008). An individual tends to store salient physical characters as a part of the cognitive map (O'Neill, 1991c). Hence, it is crucial to analyse the saliency of landmarks and how they influence the formation of the cognitive map. Even though three categories of saliency are proposed as features contained in the outdoors, Viaene et al. (2014) argue that these saliency categories can also be used for indoor environments.

Visual saliency is related to the visual characteristic that makes a certain landmark easy to remember, considering how it stands out or contrasts with the surrounding environment and signifies the spatial location. Visual saliency is based on the visual properties of the landmark, such as shape, visibility, size, richness of colour, texture, quantities, and depth (Davis et al., 2008; Sorrow & Hirtle, 1999). Based on the amount of information, visual saliency can be categorised into three levels—complex, simple, and non-salient. A landmark with a complex salient means that the landmark provides a lot of information to produce an accurate cognitive map, despite more time needed to identify and remember it (Davis et al., 2008). A landmark with a simple salient provides adequate information for an individual to remember the general location of the landmark, which can be shown through the faster speed and lower accuracy in constructing the cognitive map. Meanwhile, non-salient landmarks provide minimal information for individuals to develop their cognitive map.

Structural saliency is the saliency of an object that acts as a landmark due to its significant function, role, or position within the structure of an environment (Sorrows & Hirtle, 1999). Landmarks located in a choice point tend to be perceived better than landmarks in other positions (Aginsky et al., 1997). Structural saliency is also often related to places with high levels of connectivity (Viaene et al., 2014), such as open spaces, intersection areas, long corridors, and stairs.

Semantic saliency or cognitive saliency is an idea about how the saliency of an object or landmark in an environment can be identified from its meaning (Sorrows & Hirtle, 199). Semantic saliency is necessary to explain the role of some objects or landmarks in forming cognitive maps, which cannot be depicted only by visual or structural saliency. Semantic saliency can be acquired by revealing the meaning of some objects described by the individuals (Viaene et al., 2014). This meaning can be a historical meaning commonly known by the public or a unique connotation only known by a specific group of people, even though visually and structurally they look identical or common with other environmental features.

A landmark becomes very salient if it can fulfil all the requirements in all saliency categories (Viaene et al., 2014). However, identifying and selecting the landmark in the formation of the cognitive map can be personal, depending on individual preferences influenced by sex, age, familiarity with the environment, and other aspects. Therefore, the degree of saliency resulting from environmental features can be different for each person (Millonig & Schechtner, 2007; Raubal, 2001).

Degree of familiarity

The above discussion explains the objective aspects of a cognitive map used for assessing environmental legibility. To extend the idea, subjective aspects of a cognitive map should take the internal and subjective process of individuals in reading the environment into account. The internal process of such subjectivity is influenced by the external condition and pretty much related to individual preferences, which should be acknowledged in the construction of the cognitive map.

In this study, individual preference refers to the degree of familiarity that can affect their level of dependability on the environmental configuration and features (Baskaya et al., 2004; Viaene, 2018), aside from their sex and age profiles (Millonig & Schechtner, 2007; Raubal, 2001). When familiarity is involved, sex is not a strong determinant regarding an individual's ability to navigate the environment (Iachini et al., 2009; Piccardi et al., 2011). However, some study argues that female is weaker or less capable of navigating themselves in a setting than male (Kato & Takeuchi, 2003), hence some studies regarding the saliency of landmark focus on the female participant (Davis et al., 2008). Their findings also show that younger females (18–35 years old) are more accurate in remembering and understanding a place visually than older females or females between 20–40 years old for the possibility of getting better accuracy in understanding the environment and better skill of drawing a map (Shokouhi, 2017).

Related to the external condition, the environmental configuration and features become critical when an unfamiliar experience or a low degree of familiarity with the environment occurs. The individuals tend to orient themselves to the surrounding environment and tend to depend on the configuration of the space and the presence of surrounding features or objects that can act as a landmark. However,

when the individuals are familiar with the environment, they are less dependent on the surrounding arrangements and the configuration becomes less critical (Baskaya et al., 2004). Furthermore, Stankiewicz and Kalia (2007) argue that familiarity with the environment can also influence the tendency of an individual to select a landmark to depend on. Individuals unfamiliar with the environment will tend to choose a structural landmark (e.g., stairs) rather than objects, places, or features that are detachable or independent from the main structure of the environment.

Such landmarks can be used to identify the possibility of objects, places, or features becoming a landmark in one's cognitive map. However, there is no guarantee that a place or feature of an environment that is 'objectively salient' will be chosen by an individual as a part of their cognitive map (Viaene, 2018). A further investigation involving individual preferences may be required to understand the reasoning behind the selection and inclusion of landmarks in the cognitive map (Richter & Winter, 2014).

As mentioned before, this study seeks a set of environmental configurations and features that are crucial for environmental legibility informed by the cognitive map. Legibility is a concept related to the easiness of an observer to identify the parts of the environment and arrange them in a coherent pattern (Lynch, 1960). By adopting the conceptual framework by Koseoglu and Onders (2011), the environmental legibility of an indoor setting can be assessed based on objective and subjective aspects, as well as two- and three-dimensional spatial knowledge (Figure 2).

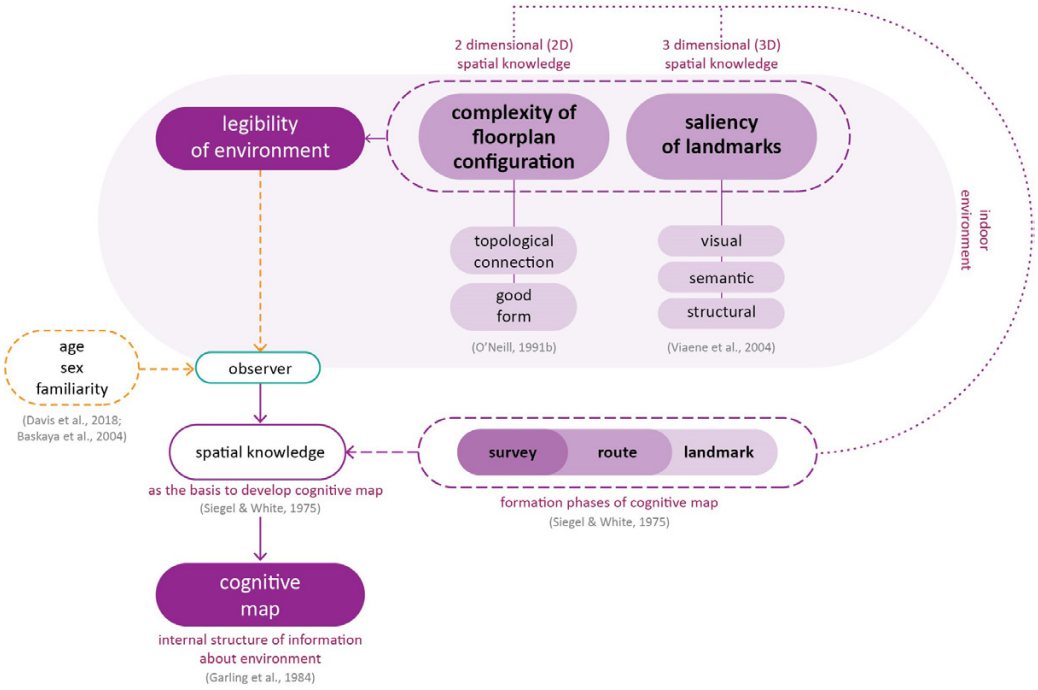


Figure 2. The multidimension of environmental legibility (Image by authors)

The complexity of floor plan configuration can be referred to as three-dimensional spatial knowledge and the saliency of landmarks is two-dimensional spatial knowledge. Two-

dimensional knowledge can be seen through the concept of topological interconnection and principles of good form, while the potential of objects, places, or features of the environment to become landmarks can be assessed through its visual, semantic, and structural saliency.

The concept of cognitive maps becomes a crucial part of this study as a means to understand and guide for navigating within the environment (Kaplan, 1973; Lynch, 1960). Cognitive maps are internal structures an individual uses to represent information about an environment (Gärling et al., 1984). An individual gradually forms the cognitive map through environmental encounters and interactions. In this case, the subjective-based analysis was conducted through the construction of a cognitive map that utilises three phases of spatial knowledge related to landmark, route, and survey (Siegel & White, 1975). The role and interrelation of both knowledge will be analysed based on the landmark, route, and survey phase projected in the cognitive map. The cognitive map becomes crucial to see whether two- and three-dimensional aspects of reading the environment could be of help to develop legibility.

Method of study

This study employs a qualitative approach to further elaborate the theoretical framework. The ground floor of a shopping mall in Cibubur, Jakarta, Indonesia, is used as a case study to illustrate the idea of environmental legibility, both from two- and three-dimensional aspects. From the two-dimensional aspect, the floor plan had a geometrical form that is quite simple, but it also had a lot of choice points. The simple geometrical form, the possibility of having complex choice points, and various environmental indoor features become the basis in choosing this case to see how different environmental complexity or simplicity levels affect visitors' acquisition of spatial knowledge.

The analysis consists of two parts, which are objective and subjective analysis. Objective analysis was conducted to investigate the legibility of the environment based on the complexity of the floor plan and the saliency of the landmark. The complexity of the floor plan is evaluated using the topological Interconnection Density (ICD) of the choice points and the good form characteristics (O'Neill, 1991b). The saliency of landmarks was assessed by analysing the potential of objects, places, or features of the building to act as landmarks based on three categories: visual, semantic, and structural.

The second part is subjective analysis through an interview with visitors, which is done to analyse the making of the cognitive map. The interviewees are chosen based on the degree of familiarity which leads to their dependability on the environment (Baskaya et al., 2004) and their understanding of environmental complexity. A low degree of familiarity becomes crucial for this study to retain the significance of the objective complexity of the environment. Based on the respondents' criteria discussed above related to the low degree of familiarity, criteria for the respondents such as sex and age are added. Thus,

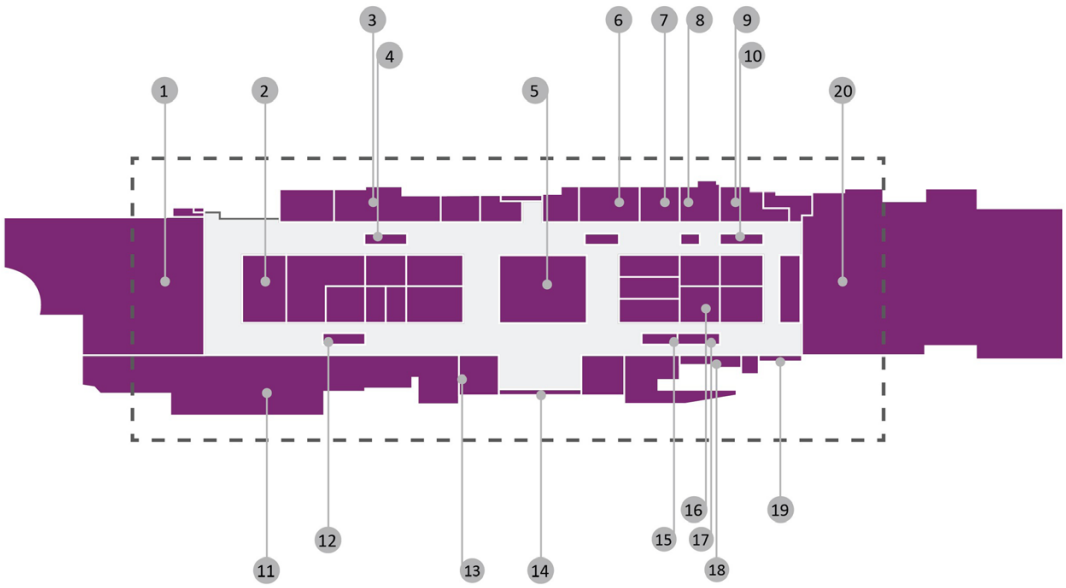
this study invited female respondents between 20–35 years old (Davis et al., 2008; Piccardi et al., 2011) for better accuracy in understanding the environment and better skill in drawing a map (Shokouhi, 2017).

The interview consisted of three parts, which are based on the form and phases of spatial knowledge involved in the formation of cognitive maps, starting from landmark knowledge, route, and survey. The result from both objective and subjective analysis is then compared to see whether the environmental feature with a high level of legibility can be easily read by the visitors and stored as a part of their cognitive map.

Analysing the objective and subjective aspects of environmental legibility

The complexity of floor plan configuration

The complexity of floor plan configuration is the first variable used to analyse and assess the legibility of the environment (Koseoglu & Onder, 2011). This analysis consists of the topological interconnection of the choice points contained in the floor plan and the overall form of the floor plan. Both analyses were conducted based on the actual plan of the mall's ground floor (Figure 3).



01 | Dept. Store M
02 | Car exhibition
03 | Retail Store HP
04 | Escalator 2
05 | Main Atrium
06 | Retail Store CK
07 | Retail Store Ck
08 | Bank MS
09 | Marketing Office TP
10 | Escalator 4
11 | Retail Store HM
12 | Escalator 1
13 | Retail Store F
14 | Main Lobby
15 | Coffe Shop CB (sitting place)
16 | Retail Store M
17 | Escalator 3
18 | Coffe Shop CB (order area)
19 | Side Lobby
20 | Dept. Store TM

Figure 3. Actual ground floor plan of the case study (Image by authors)

Figure 4 represents the topological ICD of the mall's ground floor. The purple dots on the drawings represent the location of choice points in the environment, and the figure on each dot indicates the number of options available on the choice point related to the existing intersection or directional change on each choice point. Purple lines represent a path that connects the choice points. Overall, the case had 12 choice points connected to

28 options. Using the calculation model from O'Neill (1991c), the floor plan configuration resulted in an ICD score of 2.33. Based on O'Neill's study, a floor plan with a score of ICD within the range of 2.40–2.54 can be considered a complex environment. The ICD score of the case is slightly below 2.4, meaning that the mall can be considered a moderately complex environment.

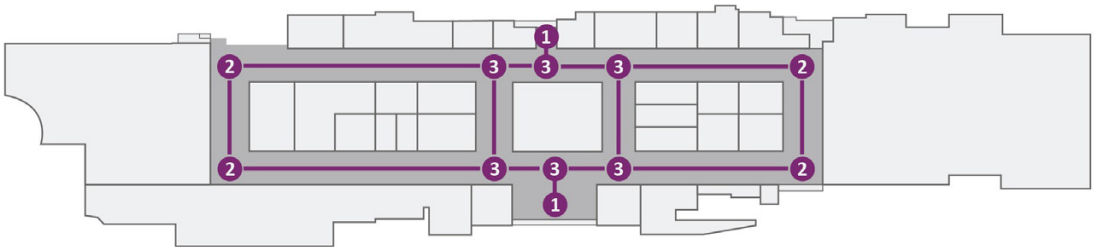


Figure 4. Topological interconnection between choice points (Image by authors)

Based on the principle of good form, the overall form of the floor plan configuration in the case can be seen as a simple form with 'easy-to-understand' verbal labelling, which is rectangular (Figure 5). In this case, the overall mainly refers to the mall corridor as a path where the visitors move, as mentioned by Montello (2007). This simplicity of the form is also supported by its symmetrical configuration. Therefore, despite its moderately high topological complexity, the whole floor plan configuration of the case study is arguably quite simple and legible, which can help the visitors to form their cognitive map.

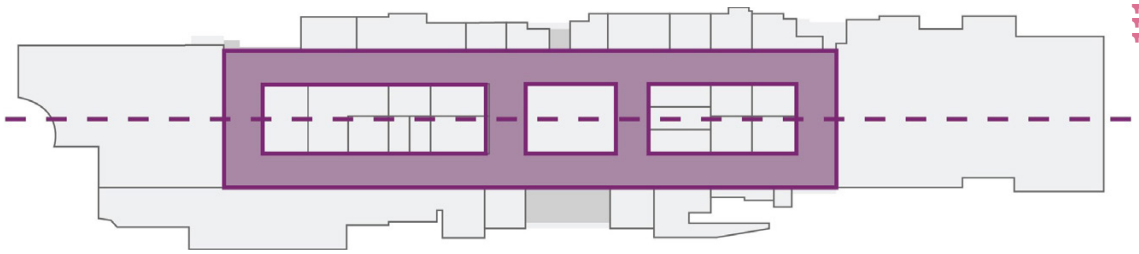


Figure 5. The simple rectangular form with a symmetrical configuration of floor plan (Image by authors)

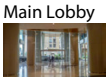
The saliency of the landmarks

The next variable to analyse and assess the legibility of the environment is the saliency of the landmark (Koseoglu & Onder, 2011). The analysis consists of three parts: visual, semantic, and structural. Visual saliency analysis is done based on visual aspects as follows: form, visibility, age, richness of colour, texture, and depth (Davis et al., 2008; Sorrows & Hirtle, 1999). However, the age aspect is excluded in this analysis since the case study environment is built around the same time, making the age aspect irrelevant. Semantic saliency analysis is done by considering things that are deemed familiar to the general visitors and signs that refer to a specific landmark (Viaene et al., 2014). Lastly, structural saliency analysis is done by investigating the role or location of structural features from their connectivity (Aginsky et al., 1997; Sorrows & Hirtle, 1999).

Based on the information compiled in Table 1, it can be seen that visual landmarks with complex salient contain rich visual aspects with high differences (Davis et al., 2008). One of the landmarks with complex visual salient is the car exhibition. This

exhibition had a spacious area with products in the form of a car, making it stand out from shape and size perspectives. Five cars are on display, in which the car's texture (shiny red metal) contrasts with the ground (rug with rough and fibrous surface). In terms of visibility, this exhibition had a very high visibility since it was located in an open area.

Table 1. Analysing the potential landmark features based on saliency

No	Potential Landmark	Visual							Semantic		Structural		
	Photo Name	Form	Size	Colour	Texture	Visibility	Depth	Condition	Unique Meaning	Sign	Role	Location	Connectivity
1	Dept Store M 		Distinct		Complex	High	Complex	Complex	√	√		On two choice points	
2	Retail HP 	Distinct	Distinct	Contrast, Complex		High	Complex	Complex	√	√			
3	Car Exhibition 	Distinct	Distinct	Contrast, Simple	Complex	High		Complex	√			On two choice points	
4	Retail HM 		Distinct	Contrast, Complex		High	Complex	Complex	√	√		On choice points	
5	Retail F 			Contrast, Complex		High	Complex	Simple	√	√			
6	Coffee Shop CB (front) 	Distinct			Complex			Simple	√	√	The only F&B retail	On choice points	
7	Coffee Shop CB (sitting area) 	Distinct		Contrast, Simple	Complex	High		Complex	√	√	The only F&B retail	On choice points and in the middle of the corridor	
8	Retail M 			Contrast, Simple			Simple	Simple	√	√			
9	Retail CK 	Distinct	Distinct			High	Simple	Complex	√	√		On choice points	
10	Bank MS 	Distinct						Simple	√	√	The only ATM		
11	Marketing Office 	Distinct	Distinct			High	Complex	Complex	√	√		On choice points	
12	Dept Store TM 		Distinct	Contrast, Complex		High		Complex	√	√		On two choice points	
13	Main Lobby 	Distinct	Distinct			High		Simple	√	√	Main access	On choice points and across the atrium	The main entrance to the building
14	Main Atrium 	Distinct	Distinct			High		Simple	√		Intersection or choice points	Between choice points and in the middle area	Intersection with clear visibility
15	Side Lobby 	Distinct	Distinct					Non	√		Secondary access	On choice points	The secondary entrance to the building
16	Escalator 1 	Distinct	DIstinct			High	Complex	Complex			Access from above and below	In the middle of the corridor and near the main lobby	Vertical connection
17	Escalator 2 	Distinct	Distinct	Contrast, Simple		High	Complex	Complex	√		Access from above and below	In the middle of the corridor	Vertical connection
18	Escalator 3 	Distinct	Distinct	Contrast, Simple		High	Complex	Simple	√		Access to above	In the middle of the corridor and near the side lobby	Vertical connection
19	Escalator 4 	Distinct	Distinct	Contrast, Simple		High	Complex	Simple	√		Access from below	In the middle of the corridor	Vertical connection

Regarding semantic saliency, a smartphone or handphone outlet is one of the potential landmarks with high semantic saliency. This outlet is a brand's retail store that has been established and popular for over fifty years. This retail store also has a mascot in the form of a dog that is unique and famous and used as the brand identity. The store also had a logo and its name displayed on the front of its store, making it quite stand out and easy to identify relative to its surroundings. Based on these properties, there is a possibility that the visitors already have a high familiarity with retail outlets, even on their first visit to the mall.

An example of an environmental object that has the potential to become a structural landmark is the escalator. Of four available escalators on the ground floor, escalator 1 shows the possibility of the highest structural saliency. As a vertical transportation feature, escalator 1 connects more than two floors and shows higher vertical connectivity. Escalator 1 also is more strategically located, becoming the most visible, accessible, and nearest escalator from the choice points in the main lobby area.

The car exhibition, smartphone retail outlet, and escalator 1 area are just samples from various environmental features of the case that have been identified and analysed. Identification for other objects, places, or features in Table 1 is arranged based on through visual, semantic, and structural analysis. Meanwhile, the potential landmark of the environment in the case can be concluded on the diagram, as illustrated in Figure 6.

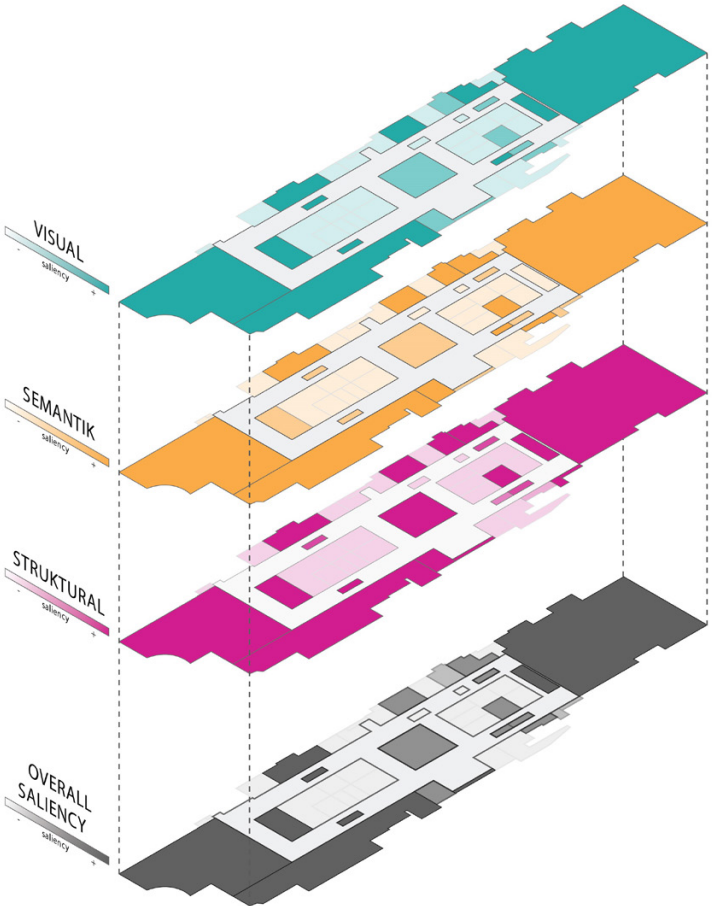


Figure 6. The saliencies of landmarks in the environment (Image by authors)

Objects, places, and features that fulfil the requirements of three saliency categories are the most salient (Viaene et al., 2014). In Figure 6, areas or regions with deep and saturated colour are the most salient and vice versa. In other words, those regions are highly likely to act as landmarks in the environment because the higher the saliency of objects, places, or features, the more legible to select as a landmark. However, other objects, places, or features that are less or even not salient can still act as a landmark since the selection will involve the individual preferences of each respondent.

The degree of familiarity and the constructed cognitive map

This section contains a subjective analysis conducted through interviews with four respondents. This interview consists of three parts based on spatial knowledge involved in the formation of cognitive maps, particularly related to route, landmark, and survey activity. However, the order of the analysis is a bit different compared to the objective analysis, starting from analysing the landmarks as a three-dimensional aspect of the spatial knowledge to the two-dimensional connectivity of the landmarks within the configuration.

In this part, the result of the interview shows that all respondents can identify objects, places, or features of the environment as landmarks. Here the respondents were asked to identify their knowledge about landmarks in various forms based only on their saliency, without involving their spatiality (Iachini et al., 2009). Such statements and explanations like "there are a lot of cars...," "...it looks like a stand instead of a store," or "the place has a lot of vegetation and a natural-looking bench...," suggest that the respondents include visual saliency in their landmark-related knowledge. A statement like "it looks like an ordinary marketing office..." shows that the respondents included semantic saliency. Despite the landmarks looking visually very common and ordinary, the respondents could identify them from their familiarity. Some statements from the respondents such as "...below the escalator" also indicate the role of structural saliency in their landmark knowledge.

The second part of the interview related to route knowledge, in which respondents were asked to explain the direction and connections between one landmark and another. From the interviews, it can be seen that all respondents tried to demonstrate their route knowledge as an association between landmark and direction, for instance, "...turn to the sitting area on the CB coffee shop, and then walk straight." Some of them also included brief descriptions related to the saliency of the landmark, such as visual saliency "to arrive at the M retail store... with its colourful cakes." However, despite the efforts of respondents to describe both the landmark and its spatial association, the route tends to be inaccurate. This inaccuracy is likely due to the unfamiliarity of participants with the environment (Viaene, 2018).

In the third part of the interview, respondents were asked to sketch a map of the environment as accurately as possible to

demonstrate their survey knowledge, a projected cognitive map of the respondents. The quick sketch map that the respondents created consists of the whole floor plan with its configuration with objects, places, and features that can be memorised (Figure 7). In this sketch map, the topological connection and relation between objects, places, or features are crucial points that became the focus of attention and discussion. To better understand the spatial knowledge of the respondents, their sketch map is recreated with consideration to detail knowledge, both landmark and route, that they have previously provided. The reconstructed sketches are then compared with the actual map of the floor plan, attempting to see the discrepancies between actual and perceived image.

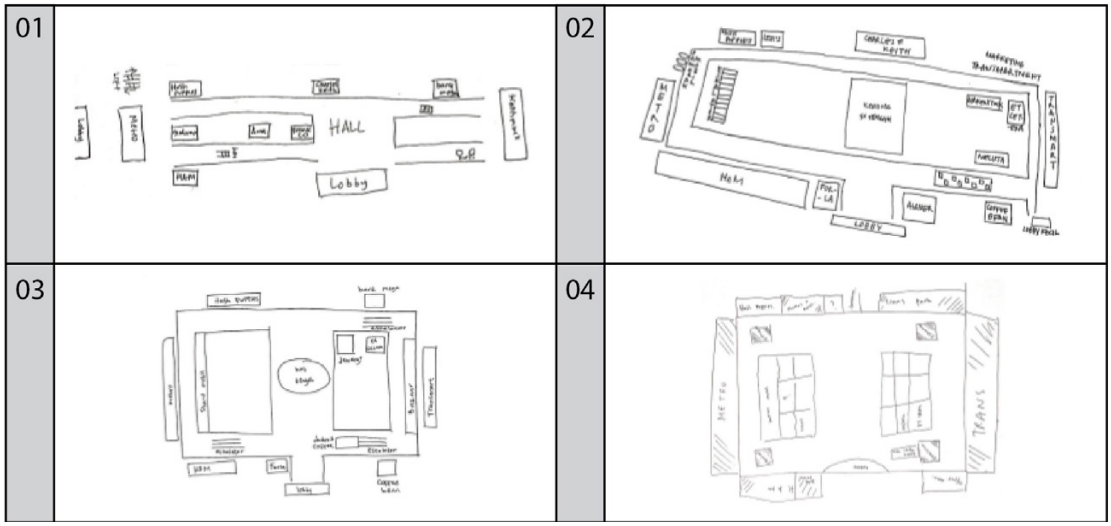


Figure 7. Sketch map drawn by the respondents (Image by authors)

Based on the floor plan configuration, the topological connection drawn by all respondents looks similar: two long horizontal paths with three shorter vertical paths in between them (Figure 8). The overall shape is also consistent with their statement in the verbal interview, which is a rectangle. Sketch maps also show the connections between objects, places, or features and their spatial relationship. In the sketch map, some landmarks appear more frequently than others (such as department store M). Some of the landmarks are also positioned in topological relation which is following their actual condition.

An important takeaway from the comparison shows that there is some level of simplification regarding the topological connection on the sketch map, specifically on the middle part of the map (hall area), despite the similarity between the overall layout of the actual map and the sketch map. An interesting simplification happened on the part that is objectively quite complex. The middle part also contains a feature or area with high visual and structural saliency (indicating the main atrium). This simplification shows that legibility and complexity is not rigid and clear-cut variable. Instead, it is a flexible factor that needs to be evaluated from different perspectives. Parts of the environment deemed illegible or complex from one aspect can be overlapped by another perspective, simplifying its complexity.

Figure 8. Comparisons between floor plan configuration on the actual map and the reconstructed sketch map (Image by authors)

Figure 9. Comparisons between the saliency of landmarks from the actual map and the reconstructed sketch map (Image by authors)

Overall, comparing the actual floor plan of the environment with the sketch plan shows that the spatial knowledge regarding topological connections is enough to properly arrange the paths and choice points similar to their actual condition. The overall form of the floor plan configuration on the sketch map also follows the actual form, which has been analysed based on the good form principles. Therefore, it can be concluded that the floor plan configuration, which has been assessed as a simple and legible form in the objective analysis, can be adequately represented through the cognitive map.

From the comparison, it can be seen that objects, places, or features deemed salient by the participants also align with the potential landmarks identified in the objective analysis. Objects, places, or features identified as salient more frequently occur as landmarks in the participant's sketch map. Conversely, objects,

places, or features that are less or not salient are less frequently used as landmarks by respondents. However, these less or not salient objects are not completely irrelevant. For example, one of the respondents used retail store B on the sketch map due to personal preference (familiarity) with the brand. Despite some inaccuracies and differences, the spatial knowledge of the respondents is adequate to form the cognitive map of the environment. It can be concluded that the legibility of the environment can assist individuals in forming their cognitive map, even on their first visits to the environment.

However, what is more important is not simply the conformity between objective characteristics and the subjective process but the interplay between aspects or variables on the reciprocal relation between the environment and humans. Overall, two factors arguably increase the difficulty for visitors to read and form their cognitive map, namely the complexity of the topological configuration and the unfamiliarity of visitors with the environment. On the other side, two factors could assist visitors and make the process easier such as the symmetrical overall form and the presence of environmental objects, places, or features that potentially act as landmarks.

The results from the analysis show how the simplicity of the form and landmarks help visitors override the complexity of the environment and simplify it on their cognitive map, as shown how visitors simplify the most topologically complex area but still retain the overall form and landmark location. Another important note is how landmarks in the cognitive map are mostly objects, places, or features with high saliency with complex properties. In other words, in this case, the complexity of environmental features assists visitors in reading and making sense of the environment rather than confusing them. These results highlight the multidimensional nature of environmental legibility, and how the interrelation between various legibility aspects influences the process of spatial reading and knowledge acquisition by the observer.

Towards a multidimensional legibility

The findings of this study demonstrate that environmental legibility concerns the configuration and complexity of environmental features that help individuals to read and make sense of it. The exploration of reading the environment shows how legibility affects individuals in acquiring spatial knowledge, two- and three-dimensionally and using it to navigate the environment. By exploring the dynamic reading of the environment through employing a cognitive map, it can be shown that environmental legibility is a multidimensional character of environments, involving not only objective aspects but also subjective aspects. By considering the subjectivity, the environmental legibility can be more meaningful and well-improved, particularly to help individuals navigate and manoeuvre within an environment.

Environmental legibility goes beyond the principles of a good configuration, acknowledging the dynamic interrelation

between topological connection and the salient quality of landmarks. Instead of rigid categorisation of objective properties, environmental legibility needs to involve subjectivity to accommodate a higher degree of familiarity and stimulate individual preferences. The result shows the subjective process of reading the environment requires three phases for a better cognitive mapping process. Considering subjective aspects will make environmental legibility more flexible yet provide a more comprehensive picture of reciprocal relations between the environment and individuals. The multidimensional legibility shows how the complexity of the environment could be arranged depending on the interplay of the aspects and examined factors.

The multidimensional legibility insinuates a different degree of environmental complexity, triggering various design approaches as possibilities. This study shows the potential of employing a cognitive map as a basis to develop environmental legibility as a toolset that can help analyse and predict how humans read and navigate in space. The interrelation between the saliency of three-dimensional features of the environment with the complexity of two-dimensional configuration could be orchestrated to generate a better legibility. This study is limited to indoor environments with one level and relatively simple paths and areas. A study on multi-level environments and more complex configurations is required to further analyse and elaborate the relation between environmental objects, places, or features and their arrangements with the visitors' process in reading and acquiring spatial knowledge.

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