THE IMAGE OF THE CITY AT NIGHT:

THE EFFECTS OF ARTIFICIAL LIGHTING ON URBAN LEGIBILITY AND WAYFINDING

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by

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I, Diana Del-Negro confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

ABSTRACT

The studies that concern the legibility of a city and navigation and wayfinding tasks usually only address the day-time dimension. Additionally, the implementation of lighting in the urban environments are often focussed mainly on functional aspects which rarely include improving the image of the entire urban scene, enhancing the legibility or facilitating the wayfinding process in a city at night.

A small number of studies suggest that the movement of people may be affected by lighting, and that people select different landmarks at night on wayfinding tasks. Thus, it can be hypothesized that the legibility of a city and that wayfinding may be affected at night by artificial lighting. However, no systematic study has been made on this matter.

This study took place in the cities of London and Lisbon and it aims to evaluate how the legibility and wayfinding may be affected by artificial lighting in an urban environment. It partially replicates a modified version of the methodology developed by Kevin Lynch in “The image of the city”, by adding to it a night-time dimension. It hypothesizes that the perception of the main elements of a city, and its image can differ at night, resulting in a modification of wayfinding behaviour.

The results suggest that the recognition and the visual hierarchies of the most distinct elements of the cities can be modified at night. This seems related to luminance and colour contrast and also to the expectations of the observers. Wayfinding also seems to be affected by lighting, since the results suggest that people tend to select different routes at night. This seems to be mostly due to changes in the perception of space and of known landmarks, and to the fear of crime, all of which result mainly from the lighting conditions.

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Chapter 1 INTRODUCTION

Overview of the main concepts by Kevin Lynch

Spatial orientation and wayfinding

The main components of cognitive maps

The influence of lighting in wayfinding

INTRODUCTION

Electric lighting has radically transformed the way that we live and also the way that we perceive our cities. In, not such a distant past, the ability to socialize or work after the sun-set or to travel safely through the streets of a city at night was a difficult task, possible to only to a few. The first attempts to implement public lighting systems were motivated by safety reasons and depended mainly on, usually failed, efforts to keep a number of streets lit at night[1]. A few buildings and temporary structures could also be lit in special occasions, as it was the case of Saint Peter's Basilica in Rome[2].

Thus, for centuries the urban environments and its architecture were planned exclusively according to the day lighting conditions. Today, however, with the availability of ever more efficient new technologies and the extensive use of electric lighting in the urban environments, cities could also be planned according to the particularities of artificial lighting. Or, probably more plainly, there should exist an urban plan for artificially lighting our cities. On this subject, a growing number of cities throughout the world, but particularly in Europe, have been creating and implementing lighting masterplans, in the past recent decades. An urban lighting master plan is a strategy document that organizes and defines criteria for urban lighting.

[1] There were laws drawn to enforce the illumination of streets and crossroads in many European cities such as in London (1405), in Paris, (1318 and 1461), and in Lisbon (1383 and 1689). These were all mostly unsuccessful, probably due to the high cost of the fuel needed to keep a flame burning, the risk of fire hazards and the fact that such costs were to be supported by its citizens, who were also responsible to keep watch and maintaining the lighting equipment. Street lighting would only be successful after the invention of gas lighting, but mainly after the implementation of electric lighting (O'Dea, 1958), (Neuman, 2002), (Mariano, 1993).

[2] The Basilica was lit regularly between the fifteen and the nineteen centuries by candles placed on its domes and façades. (Pergolizzi & Sandri, 2000)

However, these are very recent instruments[3], which rarely follow common guidelines and are often designed disregarding any serious urbanistic concerns. Many are often focussed on aesthetics and crime prevention alone, and constricted by subjective concepts and political goals. These aspects will be further discussed ahead on chapter two which describes the current state of urban lighting.

The problem with an absent or incomplete lighting strategy is that the appearance of a city can become distorted, leading to potential visually chaotic environments and eventually hampering wayfinding at night. The recent quick development of new technologies, such as the LED and OLED[4], which enable an easier use of colour and media content on façades and other surfaces has the potential to aggravate the situation. The visual quality of the urban environments and its perception by its inhabitants may be compromised at night, eventually affecting its use.

The concepts of the image of a city and its legibility regard the ease with which its parts can be recognized and organized by its inhabitants (Lynch, 1960). A legible city allows for an easy identification of its main elements and for efficient navigation and wayfinding. Thus, it can be inferred that a good urban lighting masterplan would be one that, among other things, enhanced the legibility of a city and facilitated wayfinding.

The work and concepts developed by Lynch were subjected to various criticisms but were eventually widely accepted and influencing the work of researchers, architects and planners many years after they were first introduced.[5] However, his ideas were developed considering the day-time dimension alone and were not tested in urban environments after dark, lit by artificial means. Similarly, most studies related to wayfinding and the detection of landmarks in an urban environment were developed

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[3] The first lighting Masterplans were developed in the late 1980s in The United Kingdom, France and in the United States, respectively in the cities of Edinburgh (1989), Lyon (1989) and Milwaukee (Gardner, 2001).

[4] Light emitting diodes and Organic light emitting diodes.

[5] (MIT libraries, n.d.)

considering day lighting conditions only (Ittelson, 1973), (Golledge, 1999), (Sorrows & Hirtle, 1999), (Winter, 2003), (Allen, 2004). Hence, it is not clear if the legibility of a city and the ability of its inhabitants to orientate and travel is unaltered between the day and the night-time.

However, as other studies have concluded, the visibility of the elements that allow wayfinding and that are part of the image of a city during the day may be modified at night. For example, the research of (Winter, et al., 2004) and (Yuktadatta, 2002) have concluded that people refer to different landmarks in a city at night. Additionally, there are studies that suggest that variations in the quantity of light may influence the movement of people when confronted with a similar choice of direction (Kang, 2004). Yet, there has not been much research on the effects of artificial lighting on wayfinding in a city.

The objective of the present study is to examine the effects of artificial lighting on the urban legibility and wayfinding. It will partly replicate the methodology described in “The image of the city”[6] but adding to it a night-time dimension, with the aim of evaluating if the recognition of the main elements of a city and the wayfinding behaviour of its inhabitants are modified at night. The results of this work aim at providing future references for the development of lighting masterplans.

The thesis is structured in five main chapters: Introduction, Urban Lighting, Methodology and analysis, Results, and Conclusions.

The introduction includes a review of related work which was divided in three main issues: an analysis of the main concepts developed by Kevin Lynch, a review of the work related to the particular issues of wayfinding and legibility of the urban environment and a survey of the current state of urban lighting.

The overview of the main concepts by Kevin Lynch intends to introduce the central ideas resulting from his seminal work, such as those of legibility, imageability and cognitive maps. It also analyses the strengths and weaknesses and demonstrate its

[6] (Lynch, 1960)

importance to other fields of research, including wayfinding and that of the present study. It explores research by others on spatial orientation and wayfinding and the importance of the perception of the main components of the image of a city. It will also briefly speculate the potential effect of lighting on wayfinding, based in previous research.

Urban lighting is a chapter dedicated to examining the role of urban lighting, and it includes a survey of existing lighting master plans in different cities of the world and particularly to the effort that these dedicate to the issue of legibility at night. At the end of this chapter, a more detailed description of the objectives and expectations of contribution to related scientific fields and practice will be further discussed.

The methodology and analysis will describe in detail the method followed in the thesis and analyse the similarities and discrepancies with the method produced by Kevin Lynch. It will also explain that the work was divided in three sets of interviews undertaken in the cities of London and Lisbon, and it will describe the different approaches taken for analysing the results of these interviews.

The results chapter is divided in three main sections: One describes the results of the three sets of interviews in London and the second the results of the interviews in Lisbon. The third section compares the results of the photographic and the walking interviews between the two cities.

Finally, the conclusion will synthesize the main findings of the study, discuss its possible implications and point the direction of future lines of further research on the topic.

OVERVIEW OF THE MAIN CONCEPTS (DUE TO LYNCH)

The objective of the work published in “The image of the city” [7] by Kevin Lynch, was to “consider the visual quality of the American city by studying the mental image of that city which is held by its citizens.” He was looking to test the concepts of legibility and imageability, to develop suggestions for urban design and to create a short-cut method to elicit the public image in any given city.

The concepts of legibility and imageability were developed to try to describe a visual quality of the city. Legibility is defined as “the ease with which its parts can be recognized”[8] and imageability as “that quality in a physical object which gives it a high probability of evoking a strong image in any given observer”[9]. However, sometimes they were also treated as synonyms[10] since a high imageability presumes that an environment is also highly legible and vice-versa.

These aspects are considered by the author as being important for the well-being and emotional security of the inhabitants of a city and also to allow for practical tasks such as wayfinding. He concluded that the inhabitants of a city constructed an image of the urban environment which was composed of five distinct elements: paths, edges, districts, nodes and landmarks. These were essential references to organize the image of a place and for spatial orientation. Thus these elements were determinant to create a memorable image and for wayfinding. Later studies related to cognitive maps and wayfinding[11], confirmed the importance of cognitive maps and consistently

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[7] (Lynch, 1960)

[8] *Ibid.* p.2

[9] *Ibid*. p.9

[10] Imageability “is the shape, color, or arrangement which facilitates the making of vividly identified, powerfully structured, highly useful mental images of the environment. It might also be called legibility…” (Lynch, 1960) p.9.

[11] For example (Golledge, 1999)

confirmed the existence of the five elements distilled by Lynch, as it will be discussed further ahead.

The study which lead to the previously described conclusions consisted in the interview of fifteen to thirty participants about their mental picture of the inner city of Boston, Jersey City and Los Angeles. This included the sketching of a map and taking imaginary trips through them. They were also asked to describe the distinctive elements of the city, to recognize and place various photographs and to go on actual walks (in Boston only). A few persons were also stopped in the streets and asked for directions to places. At the same time a team of trained observers who were uncontaminated by the information provided by the interviews, surveyed the cities and created a map of guessing what the typical image of the city would be to its inhabitants, given its physical form. A more detailed description of this methodology can be found in the chapter regarding the methodology of the present study, where a comparison is established to better clarify its differences and similarities.

Lynch was the first to recognize, in retrospect, that this study was "too simple to be quite respectable"[12], and in fact, in the first pages of his work[13] he had warned the readers that he was presenting a "preliminary exploration (...) an attempt to capture ideas and to suggest how they might be developed and tested"[14], and even anticipates possible criticisms to his work.

Criticisms

One of the main criticisms to the method described in "The image of the city" relates to the sample of participants in the study. In that same book, Lynch himself recognizes that he uses a small sample, unbalanced in nature regarding class and occupation: they were all middle class, professional and managerial. He also states as unfortunate the fact that there was a lack of a random distribution of residence and work place of

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[12] (Lynch, 1985) p. 248

[13] (Lynch, 1960)

[14] *Ibid*. p.3

the participants. Thus, he points as a direction for future research the testing of the method with a more adequate sample of the population, less biased and of larger size. After, he would also add the fact that the sample was only constituted of young people. [15]

Another criticism to his method was that the techniques of office and field interviews, photo recognition and map drawing were not adequate to extract the true mental image. Furthermore, the drawing of maps was too difficult for most people. Lynch, countered[16] that each method elicited a piece of the internal picture, which could be partial and distorted, but if a sufficient array of probes were employed, then the composite image that would develop would not be very far from the truth. As for the possible drawing difficulties, he still advocated its use as a means of expression especially of spatial ideas because it conveyed important information in supplement to the verbal comments.

Years later, when revisiting his earlier work[17], he explains how the replication of the method in different cities around the world showed that the basic ideas held, and that the fundamental elements of the image of a city were very similar in different cultures and places. Yet, the images were also much modified by differences in culture and familiarity. For example, (De Jonge, 1962), found that Amsterdam was more legible than Rotterdam and Hague to its inhabitants. Appleyard[18], showed how social class and habitual use resulted in different images of the city. Similar studies to that of Lynch but using larger samples confirmed his basic concepts. For example, (Skorpanich, 1983), and (Francescato & Mebane, 1973), had respectively one hundred and twenty-eight participants and two to four times the size of the sample obtained by Lynch. The study by Skorpanich tested the hypothesis laid by Lynch

[15] (Lynch, 1985) p.152-157

[16] *Ibid.*

[17] *Ibid.*

[18] Cited in (Lynch, 1985) p.251. This study replicated the work by Lynch with a larger sample in *Ciudad Guayana* and was published in 1976.

using a simulation of an urban scale model, and the research by Francescato and Mebane compared the image of the cities of Milan and Rome. The studies confirmed the main concepts of Lynch, and that there were differences in the perception of the image of a city of according to the familiarity with the environment[19], age and social class[20]. Overall, twenty four years[21] after the publication of his seminal work, Lynch concluded that the existence of the image of a place, its basic elements, and the techniques for eliciting and analysing it appeared as very similar in very diverse cultures and places.[22] This suggests that the hypothesis of imageability and legibility was verified and validated by successive subsequent studies.

The development of suggestions for urban design seems to have raised fears among some designers who were concerned that the method could usurp their creative skills. They thought that the analysis of the image of a city could lead to form decisions unrelated to creativity. However, these fears proved to be unfounded because, according to Lynch, the analysis could describe a situation or predict consequences, but it could not generate (creative) new possibilities. In fact, the work of Lynch was described[23] as being difficult to apply to actual public policy. However, it led to a wealth of research in other fields such as sociology, anthropology and in geography and environmental psychology. Even today a large volume of research is produced based on the concepts created by Kevin Lynch, as for example work on wayfinding (Tomko & Winter, 2013), and digital information (Offenhuber & Ratti, 2012). Furthermore, an internet search reveals that the “Image of the city” has had tens of thousands of citations since it was first published in 1960, an indication of its continuing importance.

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[19] In both studies.

[20] In the study by (Francescato & Mebane, 1973)

[21] (Lynch, 1985)

[22] (Lynch, 1985) p.249

[23] *Ibid.*

Probably the most significant criticism to the work developed by Lynch was that regarding the importance of wayfinding and legibility itself[24]. This remark was pointed at the core of the object of his research and on a certain level it could partly question the basis of the present thesis as well. The study by Lynch assumes that wayfinding and legibility are essential but never demonstrates it, except indirectly, by the emotional remarks of the participants, such as "the satisfaction of identification with a distinctive home place and the displeasure of feeling lost…"[25] However, even if Lynch recognizes that he worked with assumptions, he claims that succeeding studies continued gathering indirect evidences of the importance of legibility and wayfinding, and that the self-identity of an individual is reinforced by a strong identity of place and time.

Questioning the importance of wayfinding is a pertinent issue, especially at a time when maps are so widely and promptly available on smartphones. To the comment intended to question the importance of wayfinding: "if lost in a city one can always ask the way or consult a map"[26] it could be added "…or one can consult his smartphone". The best answer to the importance of wayfinding and legible places is probably not best found on the emotional responses of individuals, as Lynch did, but rather on the numerous studies dedicated to processes of navigation and wayfinding. Many of these were developed after the death of Kevin Lynch.[27] But additionally, there was also later research that suggested that disorientation is indeed related to distress and anxiety, which supported the emotional responses that had been observed by Lynch[28].

The process of wayfinding or navigating in an urban environment is a complex task which entails a constant comparison between mental information (or that provided by

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[24] *Ibid.*

[25] (Lynch, 1985) p.250

[26] *Ibid.*

[27] Kevin Lynch died in April, 1984.

[28] For example (Lawton, 1994), (Lawton, 1996).

a map) and the environment where the task takes place[29]. This suggests that if an environment is not sufficiently legible, it will probably be less easy to find the way or follow directions in it. In this regard, a line of research was found on the subject of incorporating salient landmarks in routing instructions. For example, the work of, (Sorrows & Hirtle, 1999), (Raubal & Winter, 2002), (Notthegger, et al. 2004), (Sadeghian & Kantardzic, 2008), (Winter, et al., 2010). These demonstrate the importance of associating navigation instructions with the visibility or legibility of the features that exist in the real environments, particularly landmarks.

The basic concepts on spatial orientation and on the wayfinding process will be briefly reviewed in the next pages.

SPATIAL ORIENTATION AND WAYFINDING

Spatial memory, and particularly the mental representation of an environment, has been established by several authors[30] from different fields of study[31] to be essential for orientation purposes. It results from a combination of information from multiple sensory systems, chiefly the vestibular and visual systems.[32] It relies on information on balance, movement and direction, and also on visual cues and on the functioning of the hippocampus.

The term cognitive mapping was first introduced in 1948 by Tolman[33], who presented convincing results that even rats acquired an internal representation of place. In 1978[34] the discovery of place cells in the rodent hippocampus, followed by several

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[29] Its essence is to match internal with external information (Stern & Portugali, 1999)

[30] For example Baker in (NATO Advanced Study Institute, 1987) p.217, (Downs & Stea, 1977), (Golledge, 1999), (Lynch, 1960).

[31] For example: Psychology, neuroscience, geography and urban design.

[32] (Wolfe, et al., 2009)

[33] (Tolman, 1948)

[34] (O'Keefe & Nadel, 1978)

other related studies[35] supported the neurophysiological existence of cognitive maps.[36] They are a mental representation of an environment, consisting basically of the elements identified by Kevin Lynch: Landmarks and nodes, paths and edges, and districts; or (using a different terminology) points, lines, areas and surfaces[37]. The information in a mental map is hierarchically organized.

A cognitive map allows for one to recognize his own location, and to predict the outcome of taking a certain path, to make a decision and taking action to arrive at a destination.[38]Its purpose is to facilitate wayfinding[39], the recognition of a place, and to organize spatial experiences[40], thus, it also allows for navigation in the urban environment. Urban navigation consists in travelling from an origin to a destination through a "sequential process of decision making concerning route choice, whose essence is to match internal with external information"[41] while moving between the two points.

Golledge and Garling[42] differentiate wayfinding from navigation, defining that the first regards finding a path in an environment which is not necessarily known, whereas the second implies a pre-planned route. Therefore wayfinding can be identified with exploration and is purpose oriented, and navigation can be dominated by criteria such as the shortest time, path or minimum cost. Other authors, however, attribute different definitions to these concepts, and in some cases, do not establish a clear distinction

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[35] For example, (Burgess, et al., 1999), (O'Keefe & Burguess, 1996)

[36] (Allen, 2004)

[37] (Golledge, 1999) This study explains that there is a different terminology for elements with roughly coincident meaning.

[38] (Devlin, 2001)

[39] *Ibid.* p.20

[40] (Lynch, 1960)

[41] (Stern & Portugali, 1999)

[42] (Golledge & Garling, 2003)

between them.[43]In order to keep a certain coherence it was decided to follow the definitions described in the study by Golledge and Garling, 2004.

There are five main factors that seem to influence the behaviour and the decisions of a traveller, these are: The purpose of the trip, the role of the traveller, his particular knowledge or experience, the means of travel, and the specific situation in which the navigation is practiced.[44] Thus, people may choose different routes and features as references when in different situations.

Other studies also suggest that spatial configuration, that is, the way in which spaces are related with respect to each other and the overall pattern that they constitute also influences the wayfinding behaviour (Peponis, et al., 1990) (Barton, et al., 2012). For example, research in the field of Space Syntax (Hillier, 1996) suggests that the layout of a city shows a probabilistic relationship with human movement (Hillier, et al., 1993). Hence, those paths with higher connectivity and integration are usually more populated and may thus appear more attractive, especially for novice searchers, because there is an enhanced opportunity to ask for directions and the feeling of safety may be increased (Peponis, et al., 1990). The results of other studies also suggest that people tend to choose the most populated paths in buildings (Beaumont et al.) and also in the urban context (Appleyard, 1970 and Evans et al., 1982).[45]

However, none of these studies inform if, at night, the decisions of the traveller may be influenced by the particularities of the lighting conditions. That is, if artificial lighting can influence the perception of the visual references and of space, eventually modifying the choice of path and the wayfinding behaviour.

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[43] Some of these definitions are described in (Sadeghian & Kantardzic, 2008). It was found that in other literature there is not a very clear boundary between the two concepts.

[44](Golledge & Garling 2004), (Winter, et al., 2004)

[45] During the walking interviews there was an account of the number of people on the streets, given that this could have influenced the decisions of the participants.

According to several authors[46] the most critical points, in a navigation or wayfinding task, are decision points, such as intersections or nodes. These can be particularly critical in the absence of distinguishable landmarks that may provide guidance cues.

Landmarks are considered[47] to be a fundamental component of cognitive maps, thus of spatial orientation and wayfinding. Spatial knowledge and efficient navigation rely on detecting and recognizing landmarks, because these act as references that enable to travel from one point to another. A traveller can therefore follow a sequence of landmarks and be able to make choices at decision points. Landmarks can also help to organize large scale spaces, and may provide references with which to calibrate distances and directions.[48]

If sufficiently prominent and well-known, any of the elements which constitute cognitive maps can serve as references for orientation purposes[49], and effectively act as landmarks. These will be described in greater detail next.

[46] Such as (Lynch, 1960), (Sadeghian & Kantardzic, 2008), (Golledge, 1999) (Dalton & Bafna, 2003)

[47](Downs 1973), (Downs 1977), (Golledge, 1999), (Lynch, 1960)

[48](Sadeghian & Kantardzic 2008)

[49] (Winter, et al., 2010)

THE MAIN COMPONENTS OF MENTAL MAPS

The urban elements that were identified by Lynch seem to be roughly coincident to those found by studies related to navigation and wayfinding[50]. These allow the city to be legible, and help guidance through space.

According to Lynch[51] the most important elements to perception are paths, edges, landmarks, nodes and districts. This definition seems to correspond to later descriptions of the components of cognitive maps. For example, (Golledge, 1999) explains that despite the variety in terminology used to describe them, it is “commonly agreed that cognitive maps consist of points, lines, areas and surfaces” [52]. This definition seems to correspond to the terminology used by Lynch, where points could be landmarks and reference nodes, lines would correspond to paths and edges and areas could be correlated to districts. The concept of surface is considered to be a three dimensional characteristic of features or places, such as density or topographic elements. The table in the next page summarizes these concepts.

[50] Such as the studies described in (Golledge, 1999)

[51] (Lynch, 1960)

[52] In (Golledge, 1999) p.15

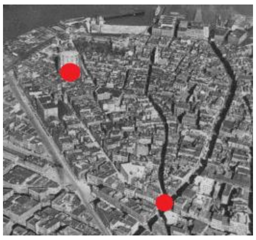
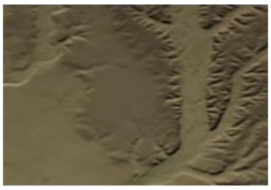
Designation		Examples:
Points		Landmarks, Nodes
Lines		Paths, routes, Edges
Areas		Districts, regions, neighbourhoods.
Surfaces		Physical Topography, slope or gradients, density

Table 1. Summary table of the urban elements that form a cognitive map.[53]

Figure 1. An illustration of the five elements defined by Lynch. From left to right: paths, edges, districts, nodes and landmarks[54]

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[53] (Golledge, 1999) p.16. Images of Boston, North America, 1923 retrieved from http://massengale.typepad.com/venustas/2004/11/index.html accessed in November 2010. The identification of a district is fictional.

[54] (Lynch, 1960)

The above described urban elements which compose the spatial mental representations are interconnected as part of a whole. Landmarks are usually the most important components which can be related to all elements. They can be references along a path, the element that organizes the image of a district, may define an edge, and are an important element when associated with nodes, or intersections, to aid in decision making. Nodes are usually the result of the intersection of two or more paths, and thus are closely related to these elements, and can also be the core of a district. Paths connect or cross the other elements. Districts are the containers of all the other elements.

> *"It is the total orchestration of these units [paths, districts, landmarks, edges and nodes] which will knit together a dense and vivid image, and sustain it over areas of metropolitan scale."*[55]

The five, above described, elements may be considered common anchors which help to organize cognitive maps, thus to understand complex environments[56]. Lynch underlines the importance of understanding these elements as part of a whole, rather than considering them separately. They will be analysed individually next in greater detail.

Landmarks

Landmarks are elements which are commonly recognized as such, by its particular visual characteristics, underlying meaning, or structural salience[57]. The main visual aspect that usually characterizes a landmark is its prominence due to, for example its dominant size, contrasting colour, shape or structure. It may also be memorable due to its sociocultural significance, or by its role or location in the structure of the space. A landmark which assembles all of this aspects will probably be stronger than one which gathers only one.

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[55]*Ibid.*p.108

[56] (Golledge & Garling, 2003)

[57] (Sorrows & Hirtle, 1999)

Landmarks are one of the most important components of a cognitive map[58] which act as anchor points to calibrate distances and directions[59] and to help to recall the procedures required to get to a destination. Thus, these elements can be strong aids to orientation and to the construction of cognitive maps. They may be globally significant or subjective landmarks, that is, known to all the inhabitants of a city (for example, as Saint Paul's Cathedral is known to Londoners), or only significant to one or a small group of individuals, such as the home or work place of a given person.

Landmarks may be visible from a long distance (Distant landmarks) or only from a short distance (local landmarks). Distant landmarks, such as mountains, are visible from a large area, and can be particularly helpful in wayfinding and navigation as a reference for directions. Its strength is reinforced "if visible over an extended range of time or distance"[60]. The strength of a local landmark depends on its visual characteristics and underlying meaning but also on its spatial location on a given route. For example, any building located at a place of reinforced attention, such as a decision point, or an intersection, will be more conspicuous than a distinctive landmark located along a continuous route.

When navigating or in a wayfinding task, the presence of a landmark at an intersection is particularly important to influence or confirm a decision in the choice of path. It is also useful when located along the path of travel (on-route landmarks), to confirm that one is taking the correct route. Landmarks which are not directly located on the path of travel, but are located off-route, such as distant landmarks can provide a sense of global orientation.

[58] (Lynch, 1960)

[59] (Darken & Sibert, 1996)

[60] *Ibid.*

Visual Salience:	**Contrasting, unusual, dominant:**	Size
		Shape
		Colour
		Structure
Underlying meaning:	**Sociocultural salience**	i.e. Monument
	Subjective relevance	i.e. Home or work place
Structural salience of:	**Distant landmark**	Visible from a long distance and for a long time
	Local landmark	Visible from a short distance Located at a place of reinforced attention

Table 2. Summary table of the main characteristics of landmarks.

A landmark can be any prominent object that acts as a reference point, which includes the other four elements defined by Lynch. If a node, a path, an edge or a district is sufficiently salient they could be recognized as landmarks[61]. For example, a very busy street or node can be a landmark known by all citizens of an area.

Table 3 summarizes the essential aspects that make a strong or weak landmark. The illustrations are an interpretation of some landmarks that could exemplify the definitions.

[61] (Winter, et al., 2010)

	Strong	Weak	
	Seen for a large period of time and from a great distance		
	Located at a decision point (node, break of transport)	Located along a continuous route	
	Great contrast with the background or context	Small contrast with background or context	
	Coincidence of association between meaning and image.		
	Clarity of general form with additional detail or texture		
	A spatial setting which allows it to be seen		
	A set of clustered landmarks, which separately would be too weak to be noticed		
	A set of landmarks in sequence		
	A set of landmarks grouped in a pattern (which may indicate direction)		

Table 3 Summary table of the essential characteristics of landmarks (according to Lynch).

Nodes

According to Golledge (and also Lynch) nodes are points, which "often act as primers for landmarks, so that once a specific node has been perceived the expectation that a given landmark will occur is heightened"[62]. Nodes are places where routes intersect or overlap, and thus are critical points to decision making and to wayfinding.

Lynch assigns nodes the same role that Golledge assigns landmarks, as foci to and from where one can travel. Nodes are described as points in which one can enter, unlike landmarks, and which have an important role in spatial organization. They can be classified as different urban situations, such as places of crossing or convergence of paths, shifts from one structure to another, or break in transportation. But, nodes can also simply be a place of concentration of a certain use or physical character, in a corner or a square. In these cases, they may acquire a symbolic status and become the core of a district.

Therefore, nodes have a close relation to districts, as they can become its core. They are also strongly connected with paths, since junctions are usually located in the intersection of these elements. Finally, nodes are also closely connected to landmarks. Where there is a node, it is expected to be found a landmark, and at nodes, the perception of landmarks is strengthened. Furthermore, it seems that, these two elements may both be foci, towards where one moves to or away from.

The concept of node in a travel network may change according with the means by which one is travelling. Therefore, for car drivers nodes may be street intersections, for pedestrians nodes may be places, and for business travellers it can be airports. [63]

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[62] (Golledge, 1999) p.17

[63] (Raubal & Winter, 2002)

Paths, districts and edges

Paths are defined by Golledge[64] as lines which connect places (eventually nodes or landmarks). They overlap and cross, and can be integrated into a network which embeds a hierarchy (freeways, highways, roads, streets, lanes and alleys). In subjective terms, known and frequently travelled paths, may also provide linear anchors for portions of a cognitive map, and contribute to its construction, thus to wayfinding.

From the point of view of legibility[65], paths are the elements through which the observer moves, and thus, it is along paths that other elements are perceived, arranged and related. It can probably be concluded that paths are the main connector and gathering element.

Lynch[66] defines districts as medium to large sections of the city which are recognizable by having a common and identifiable character. These elements are always identifiable from the inside, but may as well be used for exterior reference if visible from the outside.

Edges are considered to be linear elements, which constitute boundaries in an environment. They are breaks in continuity such as walls, shores or railroad cuts. Thus, they may be more or less penetrable barriers which separate one region from another, or seams along two regions. Although not seen as a dominant element such as paths, edges also have an important role in organizing and assembling large areas, as it happens in the outline of a city.

[64] (Golledge, 1999)

[65] (Lynch, 1960)

[66] *Ibid.*

THE INFLUENCE OF LIGHTING IN WAYFINDING

Given the importance of cognitive maps and their components it seems pertinent to question in which way lighting may affect them. That is, how do the differences between a day and a night-time lit environment affect the legibility of urban elements and the function of wayfinding? A few considerations can be discussed regarding this matter, by speculating on how artificial lighting may affect the perception of urban elements at night.

Examining the previously discussed issues it can be summarized that:

- Wayfinding and navigation are usually enabled by the existence of cognitive maps;
- In an urban environment cognitive maps are composed of five main elements: Landmarks, nodes, paths, edges and districts;
- For a city to convey a strong image and legibility its elements should have clear interconnections and be perceived as a whole ;
- These elements are organized in a hierarchy where landmarks are the prime objects;
- A landmark is recognized as such by its visual salience, its underlying meaning and, or its structural salience;
- The most critical points in a wayfinding task are the places where a decision is required, usually at an intersection or node.

During the day, all elements are fully visible in a city. However, at night, only a few elements can be lit and in a manner which provides a different appearance than that delivered by the sun. This can eventually have a positive or negative impact on the perceived quality of an environment. The potential positive impact of artificial lighting on an urban environment are well encapsulated in the words of the architect Gerhard Rosenberg who visited the city of Cologne in 1953, while it was being reconstructed:

> *"The use of direct lighting of buildings and streets at night has much greater possibilities. In Cologne, for instance, the reconstruction of lighting has outrun the reconstruction of the actual buildings so far that only at night does one become consciously and subconsciously aware of the plan underlying the reconstruction of the city. Lights outline the streets, replace the non-existent upper floors of buildings, create squares and define open spaces, outline and emphasize the buildings that are reconstructed and make one feel secure and at home in a town that, in daytime, still looks more like a shanty town or a huge bomb site than a thriving city."*[67]

Artificial lighting modifies the aspect of the elements of a city and its legibility in different ways. For example, it can be presumed that if the main components of a cognitive map become undetectable at night, then wayfinding could be hindered. Thus, in practical terms, for example, if the main landmarks of a given environment are unlit, then wayfinding may be affected.

Furthermore, lighting can have different impacts on the salience of landmarks, eventually affecting its effectiveness as references. For example, it can be speculated that a landmark may be detected but unrecognized if its main features are modified by lighting. It can also become less salient if there is not sufficient contrast of luminance, colour or texture against its background[68] or if it is set against a very complex background[69].

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[67] (Rosenberg, 1953) Note that these remarks refer to a city that had been almost completely destroyed after the Second World War.

[68] (Blake & Sekuler, 2006)

[69] (Davoudian, 2011)

A study[70]in the city of Vienna investigated whether the choices of landmarks varied during the day and night. The conclusions pointed that people chose different buildings as landmarks at night. The study also investigated the differences in the weight given to the visual features of the façades between the day and the night-time. The results suggested that at night the most important features for the selection of landmarks were the size of the facades and the marks on the buildings, while in the day the most valued feature was its shape.

Another study[71] investigated the day and night-time perception of urban elements located in central London. It also concluded that certain elements emerged as landmarks at night time only, while others, which were conspicuous during the day, were not regarded as such at night.

Thus, the three attributes that make an element a landmark, can be all annulled or, on the contrary, enhanced by lighting: its visual salience, its underlying meaning and its structural salience. The same is probably true for the other elements that compose cognitive maps, and for the hierarchies that exist among them under daylight.

Moreover, lighting may attract not only visual attention but also the movement of people,[72] and studies that related the choice of path with different illuminances, suggest that people tend to choose the brightest path[73]. Another study[74] suggested that people occupied differently the streets of China Town in London in the day and night-time relating it to the opening hours of the main local attractions. However it failed in making a correlation between the occupation and the lighting conditions in different streets.

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[70] (Winter, et al., 2004)

[71] (Yuktadatta, 2002)

[72], (Michel, 1996)

[73] (Kang, 2004), (Taylor & Socov, 1974)

[74] (Chung, 2008) p.57

It was found that the practical consequences of lighting on the legibility of a city and on wayfinding do not seem to have been sufficiently explored in previous works. Next, the current state of lighting in the urban environments and the strategies adopted in the real world for planning urban lighting and particularly for maintaining or enhancing the legibility and wayfinding in the cities will be briefly examined.

Chapter 2 URBAN LIGHTING

The lighting in the city centres

Light pollution

Urban lighting masterplans

The objectives of this study

URBAN LIGHTING

The first purpose of artificially lighting the cities was mainly functional, that of providing safety at night and extending the normal activities beyond the sun-set. Still today, this seems to be one the main objectives when implementing lighting. For example, The Royal Comission on Environmental Pollution[75] considers that “the purpose of most outdoor lighting is to enable people to go safely and securely about their business on the ground”(…) “There is a demand for outdoor lighting for road safety, personal security against crime, and evening social and commercial activities.”[76]

However, many cities have already acknowledged, that artificial lighting can have a wider role, involving the improvement of several other night-time urban aspects. The LUCI[77] charter on urban lighting[78], for example, states the importance that well designed lighting may have in the urban development and regeneration.

Lighting can be interpreted as an instrument of urban planning since ancient times. There are several examples of the role that the sun had in the urban design of numerous civilizations, from ancient Roman to pre-Columbian cities. However, for centuries, artificial lighting was mainly associated to practical needs, such as safety, or to royal and aristocratic festivities[79].The danger involved in the use of combustive materials and its maintenance cost prevented an effective lighting policy until the invention of gas and electricity lighting. Thus, until the end of the nineteen century lighting was very scarce and restricted to small areas. Today lighting is available to

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[75] (The Royal Comission on Environmental Pollution, 2009)

[76] *Ibid.* p.9

[77] Lighting Urban Community International

[78] (Lighting urban community International, 2010)

[79] (Neuman, 2002), (O'Dea, 1958), (Dillon, 2002)

everyone and implanted almost everywhere. This “lighting democratization” is positive, but it also has disadvantages.

For example, street lighting, in the UK alone, accounts for some 450MW of installed load, resulting in 1 million tons of CO_2 emissions per annum and is responsible for considerable light pollution[80]. Light pollution can take various forms, such as glare, light trespass and sky glow. Moreover, it may have pernicious effects on flora, fauna, and human health.[81] There are, however, regulations and equipment designed to control the projection of light into the atmosphere.

Lighting has also an impact on economy, through expensive energy consumption, leading some authorities to consider measures as strong as restricting its use during certain periods of the night[82]. Less drastic measures include adopting dimmable lighting, or restricting the time during which monuments are lit[83]. There are also authorities that are investing largely in new technologies, such as LED street lighting[84], and/or in alternative energy sources, such as solar, wind, or tides[85].

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[80] (Mansfield & Raynham, 2005)

[81] (The Royal Comission on Environmental Pollution, 2009)

[82] For example the county of Shropshire**,** in the West Midlands region of England, Swansea, Essex, Leicestershire, Devon and parts of Yorkshire in: http://www.bbc.co.uk/news/uk-england-shropshire-11210468, and http://www.bbc.co.uk/news/uk-11209143 accessed in September 2010.

[83] For example, in Lisbon, Barcelona, Geneva, Lion and Paris most Monuments are turned off around midnight, and have different schedules for summer and winter time. (information gathered in Lisbon light department, and http://www.ecodallecitta.it/notizie.php?id=417 last accessed in 2007.

[84]Such as several cities in the United States and in Europe.

[85]According to the European Union's official research and innovation information service, the use of photovoltaic panels have been growing rapidly in Europe, with Germany as the leading country in the application of this technology. http://cordis.europa.eu/fetch?caller=en_news_fp7&action=d&doc=1&cat=news&query=012aec4cfb15:b828:56533b09&rcn=32488 accessed in September 2010

The advantages of having a lit environment that enables a visible and safe environment during the night-time surpasses the disadvantages. Otherwise there would not be any artificially lit cities at all. But given the current concerns with reducing energy consumption, will the purpose and the way of artificially lighting the cities remain the same?

It can be speculated that the concern with energy savings will lead to the new and more efficient technologies and alternative energy sources having an increasingly important role in lighting. However, careful planning of urban lighting may also have a significant part in reducing energy costs while improving the quality of the night-time environments. In the last twenty years, a great number of lighting masterplans were developed and implemented, mostly in Europe, and also in other parts of the world. Some of these masterplans, and particularly those from recent years, include in its objectives environmental and economic goals. A survey on the role and objectives of lighting masterplans will be presented further ahead. Before, there will be a brief review of the problems related to lighting in historical city centres and on light pollution.

THE LIGHTING IN CITY CENTRES

Lighting heritage or historical centres can be a complex task and should probably entail a reflection on several questions. First, because most heritage precedes the invention of electricity, it is difficult to determine how to light such environments. Mainly, because any lighting intervention will result in an interpretation of a space or building whose image should be protected. There are those who advocate that the original image of such an environment, which is its day-time appearance, should be maintained at all cost[86]. Others[87] defend that, since it is almost impossible to reproduce daylight, a subjective interpretation should always take place. Secondly, historical urban areas and heritage buildings are especially important to the cultural identity of a city. Thus, many are protected by entities that issue recommendations and regulations to ensure its protection. Lighting should comply with specific heritage recommendations and regulations that may apply. The International Council on Monuments and Sites (ICOMOS) defends in its publications[88] the relationships between buildings:

> *"The qualities to be preserved include the historic character of the town or urban area and all of those material and spiritual elements that express this character, especially: Urban patterns as defined by lots and streets, relationships between buildings and green and open spaces, the formal appearance of buildings (…), the relationship between the urban area and its surrounding setting."*[89]

The relationship between monument and its context is one of the main principles of historical centres conservation, and lighting should be planned according to this

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[86] (Ginesi, 2000)

[87] For example, (Ravizza, 2006)

[88] (International Council on Monuments and Sites, 1965) (International Council on Monuments and Sites, 1987) (International Council on Monuments and Sites, 2000)

[89] (International Council on Monuments and Sites, 1987)p.11

premise. Terzi[90] describes light as a substantial component of requalification and restoration due to its capacity to enhance details, rebuild the relations between ensembles and allowing selecting what will be visible or invisible during the night time.

LIGHT POLLUTION

There are several ways by which lighting can become a disturbing element in an environment. It can be responsible for creating light pollution, has an impact on the local fauna and flora and on the quality of life and health of the human beings. The Royal Commission on Environmental Pollution defines light pollution as "the experience of light in the wrong place at the wrong time"[91].There are three ways by which light pollution manifests: Sky glow, glare and light trespass.

Sky glow results from a combination of reflected and refracted light from the atmosphere, which consequently reduces contrast in the sky and prevents the observation of the stars. Glare is the excessive contrast between bright and dark areas in the field of view, which can produce discomfort and disability or dazzle glare in observers. Light trespass occurs when unwanted light is produced from adjacent properties, activities or street lighting installations. An example would be the sleep disturbance caused by the presence of unwanted light in bedrooms originating from outdoor light spill.

Concerns with the protection of the night sky, produced associations such as International Dark Sky Association[92], and national entities such as *Cielo Buio*[93] in

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[90] (Terzi, 2001)p.15

[91] (The Royal Comission on Environmental Pollution, 2009), p.1-2

[92] http://www.darksky.org last accessed in August 2015

[93] http://cielobuio.org/ last accessed in August 2015

Italy. They work towards creating laws and recommendations that may prevent light spillage towards the sky.

High luminance or colour contrast can also have a negative impact in an environment. The competition that often takes place between commercially lit structures with the objective of capturing attention, can often lead to a deformation of space. A study[94] which assessed the perceptual impact of commercial lighting in a square in Lisbon, suggested that commercial lighting could distort the day-time perceptual hierarchies, and hamper the salience of the façades of heritage buildings. The image below represents the result of luminance measurements in a façade in Lisbon, where commercial lighting had a predominant weight.

Figure 2. *Rossio* Square South façade luminance measurements. The building in the middle is classified as heritage.[95]

The Royal Commission[96] recognizes that, the floodlighting of certain buildings or even advertisements may contribute to the spirit of a particular environment when correctly placed. But although the exterior lighting by private owners is regarded as a cause of

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[94] (Del-Negro, 2012)

[95] In *Ibid.*

[96] (The Royal Comission on Environmental Pollution, 2009)

concern, the Comission only recommends that the sale of new lighting equipment and floodlights should be accompanied by “best practice advice”[97]

However, in the United Kingdom, illuminated advertisements are subjected to some restrictions in England[98] and other countries. In “areas of special control” which often regard an Area of Outstanding Natural Beauty or a National Park, illuminated advertisements cannot be installed without “express consent”[99].

In Italy, privately owned buildings also face restrictions concerning lighting. In Turin “Private entities and citizens who intend to light their buildings should request permission to do so, with the objective of not modifying the planned luminance for the context in which they are located”[100], and further South, in the Campania region[101], those buildings which are not listed as heritage should contain its luminous flux to the limits of the façade, and have an average luminance level of 1 candela per square metre.

[97] *Ibid.* p.10

[98] (Great Britain. Department for Communities and Local Government, 2007), schedule 3 4(1)

[99] (Institution of Lighting Professionals, 2014)

[100] (Città di Torino / AEM, 2000)

[101] Legge regionale n. 12 del 25 Luglio 2002 Regione Campania, art.6 1 f)

URBAN LIGHTING MASTERPLANS

The definition of what an urban lighting masterplan is, varies according to different countries and entities. It may be considered a simple instrument to survey the maintenance of the existing equipment and to discipline the installation of new ones[102], a project which regulates the exterior lighting produced by public and private entities[103], or a wider management tool, which sets design guidelines, towards a variety of objectives, aiming at improving the night-time urban environments.

> *"We are convinced that high quality and carefully designed urban lighting can influence the process of urban development and regeneration in a decisive and positive way. We believe that a fully integrated public lighting strategy supported by a master plan constitutes one of the keys to a balanced urban development."*[104]

There are numerous reasons, presented by different entities, cities and authors, why a masterplan should exist. The most general purpose is probably to simply organize urban lighting and bring coherence to the perception of the cities at night. Other reasons include social, cultural and economic aspects.[105]The Royal Commission[106] recommends that local authorities should develop a lighting masterplan, because it considers that "more explicit recognition needs to be given to the visual and wider societal impacts of artificial lighting, particularly in urban areas"[107]

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[102] As described in a regional law for the region of Lombardia, in Italy (Regione Lombardia, 2004).

[103]Linee Guida per la Realizzazione dei Piani dell'illuminazione, in (Cielo Buio; International Dark Sky Association Italia; Unione Astrofili Italiani, 2005)

[104] (Lighting urban community International, 2010)

[105] (Borden & Levy, 2009)

[106] (The Royal Comission on Environmental Pollution, 2009)

[107]*Ibid.* p.12

The quality of the night-time urban environments should, obviously, be of the interest of most citizens, but it can also benefit other entities. The Italian Guide for Urban Lighting Masterplans, PRIC[108], describes who it considers to be the main beneficiaries of a regulated urban lighting. These would be the citizens, the night-time businesses, the tourism related economy, the maintenance companies, the city which owns the lighting equipment, the designers, the manufacturers of the lighting equipment, the companies that implemented the equipment, insurance companies, the police (due to the potential reduction of crime) and the astronomers (due to the eventual mitigation of light pollution).

Survey of existing urban lighting masterplans

Europe seems to be the continent with the largest number of implemented lighting masterplans, mainly due to the efforts of France as a pioneer[109]. This country has also had an important role in promoting lighting master planning in other countries through the creation of LUCI (Lighting Urban Community International) which connects several cities around the world with the purpose of promoting the best practices in urban lighting. In fact, it seems that most of the functioning lighting masterplans are in France, covering more than 250 communities[110]. Additionally, French cities have recently started producing a second generation of lighting masterplans, with the objective of correcting past errors and initiate new approaches to urban lighting[111].

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[108] (Associazione Italiana di illuminazione, 1998)

[109] (Narboni, 2006)

[110] (Ritter, 2006)

[111] (Narboni, 2006)

However, there are also numerous plans implemented in other European countries such as in Germany and in the United Kingdom. Urban lighting master plans do not seem to be so well implement in the rest of the world as in Europe.

For example, in Italy, the first studies towards an urban lighting master plan began in the early 1980's, culminating with the first lighting master plan for the city of Turin in in the late 1990's[112]. In 1998, the Italian Lighting Association (AIDI) produced a document which provided a general methodology for urban lighting (PRIC[113]). Additionally, several regions[114] of Italy also have developed their own laws regarding public lighting interventions, which are mainly focused on controlling and reducing light pollution and promoting energy savings. On this context the association Cielo Buio[115] also published guidelines to the development of lighting masterplans.

In practical terms, however, despite the considerable amount of studies and regulations, it seems that urban lighting masterplans are not very well implemented in Italy. [116] Most of the recent lighting interventions are described[117] as being mainly directed at lighting the main squares and monuments with the objective of attracting tourism.

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[112] (Terzi, 2001)

[113] Piano Regolatore dell'Illuminazione Comunale (Associazione Italiana di illuminazione, 1998)

[114]Veneto, Umbria, Trentino, Valle D'Aosta, Toscania, Sardegna, Puglia, Piemonte, Molise, Marche, Lombardia, Liguri, Lazio, Friuli, Emilia Romagna, Campania, Basilicata and Abruzzo.(From http://www.pianidellaluce.it/leggi-e-norme.html accessed in July 2010.

[115]An Italian association which follows similar principles to those of the International Dark Sky Association

[116] (Terzi, 2001) (Ritter, 2006)

[117] This information was obtained through a conversation with Corrado Terzi in circa 2010.

In the United Kingdom, according to the Royal Commission[118] there are lighting masterplans implemented in the cities of Leeds, Edinburgh, Coventry, Liverpool and Belfast. A study by Carl Gardner[119] informs that more than twenty five such plans have been commissioned for cities, and small urban areas, of which only nine could be considered a success. Most of the lighting masterplans were developed by private lighting design consultants and in a minority of cases by lighting manufacturing companies. Some of the possible reasons to the failure of the implementation of some of the lighting strategies were lack of involvement of the local authorities, a poor inter-departmental cooperation and an unrealistic geographical scope for the plans.[120]

In the United States of America, despite the creation of a lighting masterplan for Milwaukee, there does not seem to exist a true culture of planning urban lighting, and in the words of Ritter[121] its definition “is incredibly superficial”. Many projects are limited to the design of street lighting equipment, lighting small urban areas, a few streets or buildings.

In Asia, lighting seems to be used in a different scale than in the rest of the world. Perhaps because there are many new cities under development, and possibly due to cultural and historical reasons, Chinese urban areas are described[122] as being “overloaded with light”. They also comprise large scale lighting schemes, such as in the City of Shenzhen, where the lighting of a thousand roofs at night are controlled to form choreographies. Shanghai, has had over one thousand buildings lit since 1989.[123] Guangzhou, a fast developing Chinese city, has concluded some three

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[118] (The Royal Comission on Environmental Pollution, 2009)

[119] (Gardner, 2001)

[120] (Gardner, 2001)

[121] (Ritter, 2006)

[122] *Ibid.*

[123] (Lighting urban community International, 2006)

hundred lighting projects. These include bridges interactive lighting, skyscrapers lit with LEDs and TV screen walls used for festivities and publicity.

Probably the most distinctive and interesting aspect of Asian Masterplans, is that some are developed before a new city is built, in opposition to what happens in Europe.

The objectives of urban Lighting Masterplans

> *"The purpose of a strategic lighting master plan is to design, in a coordinated manner, all lighting within a delineated urban area, as so to avoid arbitrary and uncoordinated lighting initiatives which waste considerable sums of money and have little net visual effect on the night-time appearance of the relevant area"*[124]

An analysis of the existing lighting strategies was undertaken by examining twelve lighting masterplans in Europe, North America, Australasia and Asia. It revealed that different cities follow a number of different objectives for the development and implementation of their lighting strategies. These objectives can be summarized in seven main aspects, which relate to improving the aesthetical, cultural, functional, economic, environmental, urbanistic and social qualities of the cities at night.

The improvement of the aesthetics of a city was found to be the most popular objective, and common to all of the masterplans which were analysed. This objective refers generally to all intentions of enhancing the visual quality of the city nightscape. It may include the broad objectives of beautification, improving the attractiveness of a city, of its image, and promoting coherence in lighting. Many cities regard the improvement of aesthetics as a means to attract tourism, hence to provide economic growth.

Cultural objectives are closely related to aesthetics, as they are usually a means to enhance the main cultural assets of the city or to expose the cultural differences within distinct areas of the urban environment. It was also found that some cities sought to create a strong cultural identity through lighting that could bring it national and international visibility (for example, as stated in the objectives of the city of Sydney).

The economic factor is mostly indirectly stated in the objectives set by the cities as a consequence of other goals such as increasing tourism or reducing energy costs. Improving the functional aspects of lighting also has an impact on economy, as it aims at optimizing the efficiency of lighting and of maintenance costs. The direct references

[124] (The Royal Comission on Environmental Pollution, 2009) p. 12

to economic aspects regard the improvement of the night-time economy, by motivating an increase in the number of visitors, and the increase of the volume of business eventually resulting in higher employment.

The objectives that were classified as functional are those which regard improving the functional aspects of lighting. The objectives which were found to belong to this category were: Implementation with the latest technologies, providing efficient lighting, avoiding glare, improving functional lighting, and maintenance.

The environmental objectives refer to the intentions which regard lowering the impact that lighting has in the environment. This usually means to reduce the consumption of energy and to reduce light pollution.

The objectives classified as social aspects were those that intended to have an impact on the improvement of the quality of life of the inhabitants of the city. The most popular goals under this classification are the reduction of crime and providing a safe environment at night. There are also masterplans which have a more ambitious view on social aspects, by trying to involve the communities and personalise districts. These last features are more commonly found in the French lighting masterplans, where there is also a particular concern with the peripheral areas of the city.

Some masterplans also describe goals that could be classified as an urban design concern such as accentuate main gateways and entry points (The Pool of London), integrating architectural and functional lighting (Rome), creating hierarchies, assuring an harmonious transition between two distinct urban spaces, or even provide good orientation at night (Vienna).

A summary of the classification of objectives for several lightning masterplans can be found in the table on the next page.

Aesthetics	▪ Beautification. ▪ The improvement of the image of the city. ▪ Improving nightscape. ▪ Attractiveness. ▪ Promote a good integration between the design of the lighting equipment and the particular characteristics of the place of implementation.
Economy	▪ Improvement of night-time commerce and economy. ▪ Improve the attractiveness of the city for tourism. ▪ Reduce the consumption of energy.
Functionality	▪ Implementation of the latest technologies. ▪ Providing efficient lighting. ▪ Glare control. ▪ Improving functional lighting. ▪ Improving maintenance. ▪ Define parameters to coordinate the implementation of lighting within the lifetime of the plan.
Environment	▪ Reducing energy consumption. ▪ Reducing or controlling light pollution.
Culture	▪ Enhancing the elements of the city which express its culture (such as heritage). ▪ Creating a cultural identity. ▪ Differentiating cultural differences between districts. ▪ Creating a sense of patriotism.
Social	▪ Improving safety. ▪ Preventing or reducing crime. ▪ Raise community involvement. ▪ Promote the improvement of the quality of life of the inhabitants of the city. ▪ Promote the personalization of neighbourhoods.
Lighting urbanism	▪ Promoting the use of lighting to accentuate urban features. ▪ Create hierarchies. ▪ Create a sense of orientation. ▪ Assure harmonious transitions between two distinct urban features.

Table 4. Classification of the main objectives extracted from the examined lighting Masterplans.

The examined lighting strategies were, in Europe: the Masterplans of the cities of Rome and Turin in Italy; the Pool of London[125], Gloucester and Coventry in the United Kingdom; the two masterplans for the city of Lyon in France and Vienna in Austria. In North-America: Toronto, in Canada. In Asia: Putrajaya, in Malaysia; and Gwangju, in South Korea. In Australasia, the masterplan for the city of Sydney in Australia.

As it can be observed in the next two charts, only half of the surveyed strategies include in its objectives parameters related to improving the urbanism through lighting. It was also evident that the objectives are not coincident among the cities. For example, Turin had no objectives related to urbanism, economic or social aspects, and Putrajaya had no urban or functional aspects. Vienna has a balanced number of objectives regarding all aspects but gives particular emphasis to social and environmental goals. The urbanism concerns and particularly the environmental objectives seem to be more frequent in the most recent plans. This can be observed by analysing the evolution between the two lighting masterplans for the city of Lyon in France.

[125] The Pool of London lighting masterplan refers to an area of London comprising a part of the boroughs of Southwark and Tower Hamlets.

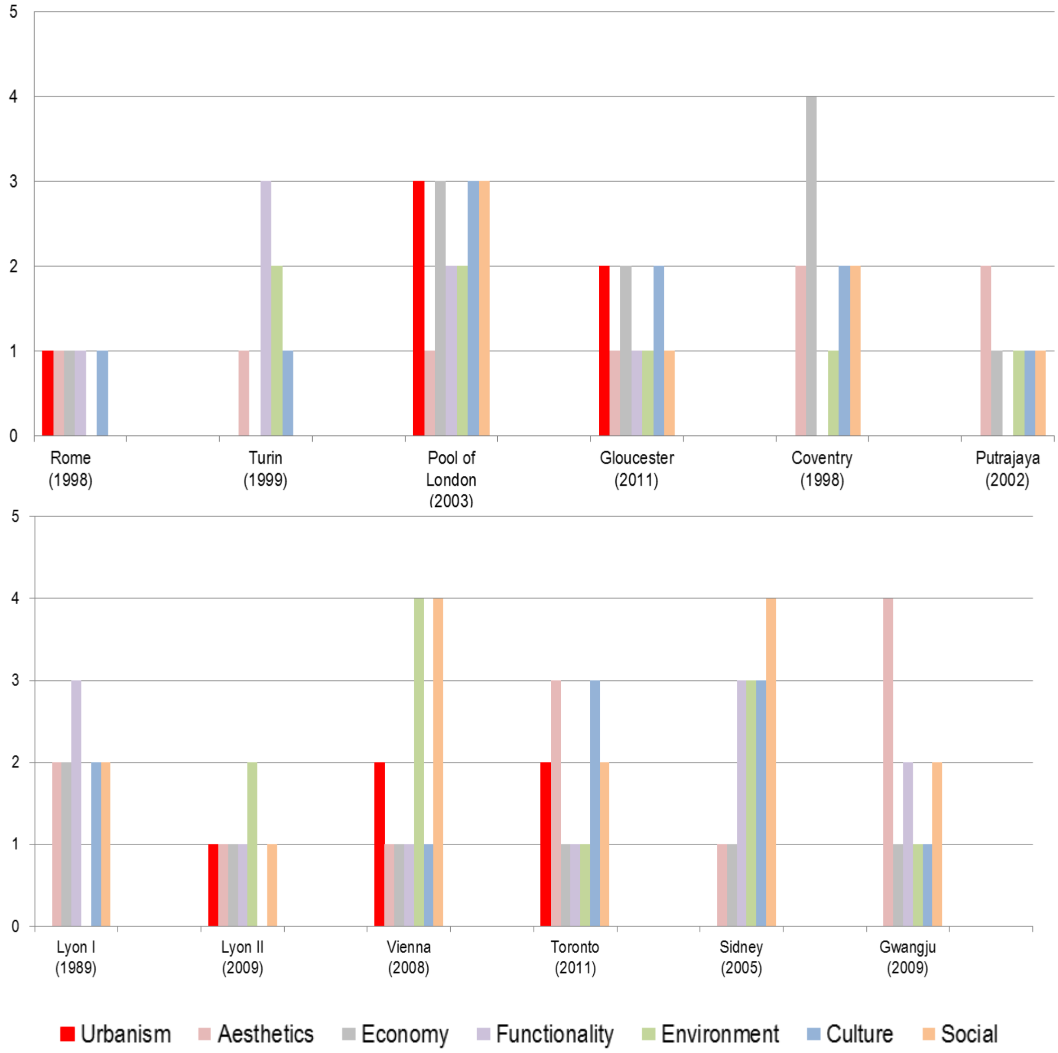

Figure 3. The number and types of objectives stated by the lighting masterplans of different cities.

Lyon has recently produced a second lighting masterplan, over fifteen years after the first one. Comparing the objectives set in the first version[126] with the second, there seems to exist an evolution of concepts and objectives. The first plan gave more relevance to functional and economical aspects, translating concerns with its implementation. The cultural and aesthetic concerns were also stronger, which was

126 In (International Lighting Review, 1993)

probably related to the need of attracting attention to the city at that time. The second plan, added environmental and urban objectives which were absent in the previous version of the strategy. Both versions describe social concerns, but the first plan aims at a stronger community involvement. It goes as far as setting as an objective the financial support of the plan by population, and it proposes to personalize each neighbourhood through lighting. In the second lighting plan, the only social aspect refers to the use of lighting for social development.

The six lighting masterplans which mentioned objectives related to urbanism were those of Rome, Lyon II, The Pool of London, Gloucester, Toronto and Vienna. Of these only three (The Pool of London, Toronto and Vienna) have direct descriptions on having lighting as a means to improve orientation in the city. For example, Toronto suggests the illumination of landmarks to enhance wayfinding and Vienna proposes improving the night-time orientation by enhancing lines of motion, the topography, landmarks, squares city gates, urban hubs and having all urban structural elements perceived as a whole.

The analysis of the masterplans shows that there is not a common strategy to use lighting as a means to improve the legibility and wayfinding. In fact, the objectives concerning aspects that could relate to urbanism vary and are not present in all masterplans. From lighting landmarks alone (as Toronto proposes), or lighting all “urban structural elements” (as proposed by Vienna), the concepts of the impact of lighting in the legibility of the city vary.

The nonexistence of a consensus on the objectives for the lighting of different cities could be a reflection of cultural differences or the existence of distinct problems concerning each city at night. However, it also reflects how there may exist a lack of theoretical support for the development of urban lighting masterplans and particularly for the issues related to the urban legibility and wayfinding at night.

THE OBJECTIVES OF THIS STUDY

The present study will explore the image of the city at night, by questioning if the mental representations that its inhabitants have are as functional at night as they are in the day. It will be hypothesized that at night, the perception of some of the most recognizable elements of a city may be modified, eventually compromising the legibility of a city and modifying wayfinding behaviour.

The methodology of the study was based on the method described in “The image of the city” by Kevin Lynch. However, it has some differences, based on trying to reconcile some of the critiques addressed to Lynch and on the fact that the objective of this study is not to merely replicate the method in different cities. Whereas Lynch was testing the hypothesis of legibility and imageability, this study will depart from the assumption that these concepts exist. He was also looking to extract the rough public image of three American cities and to compare this public image to a field reconnaissance so as to develop some suggestions for urban design. This study seeks to extract the image of two European cities and understand if artificial lighting modifies them, in order to develop some suggestions for urban lighting design.

The main contributions that this thesis intends to make are:

To provide an extension of the work by Kevin Lynch through the addition of a night-time-dimension, which has not been yet fully addressed in previous research.

To introduce a first exploration to the possible effects of artificial lighting on human wayfinding behaviour in a real urban environment. It can be of interest to the fields of geography, psychology and urban planning which usually ignores the night-time dimension when evaluating wayfinding.

It contributes towards the field of lighting by evaluating how lighting can influence the perception and legibility of a city and condition route choice in complex outdoor environments. It compares subjective assessments with objective field measurements assessing the quantity and quality of lighting, correlated to the choices of the participants.

It aspires to contribute towards the field of urban lighting design by introducing possible suggestions that can improve urban legibility at night.

The main research questions that will thus be addressed are:

Firstly, if the general method devised by Kevin Lynch works when adapted for the purposes of this study, that is, for the analysis of the image of cities at night, and specifically those of Lisbon and London.

Secondly if the perception of the most distinct urban elements of a city are modified at night and if the wayfinding behaviour of the inhabitants of a city changes between the day and night-time. Specifically, can the way by which a landmark is lit at night modify how accurately it can be identified?

Presuming that lighting affects the identifiability of landmarks by night, what is the effect on the ability of people to find their way to a specified destination?

Do people use the same routes when finding their way to a specified destination by day and by night?

Are there other factors related to lighting influencing wayfinding, or route choice decisions at night?

The methodology and techniques of analysis employed to address these questions will be described in detail in the pages of the next chapter.

Chapter 3 METHODOLOGY AND ANALYSIS

The comparison of the methodologies

The description of the method

- For the verbal interviews
- For the photographic interviews
- For the walking interviews

Analysis of the results

- For the verbal interviews
- For the photographic interviews
- For the walking interviews
- Additional methods of analysis

METHODOLOGY AND ANALYSIS

The methodology of the study was based on partially replicating the scheme described by Lynch in *The image of the city*. This had been devised to test the hypothesis of legibility and imageability, and to develop suggestions for urban design. It also meant to create a short-cut method for eliciting the public image in any given city. Although it was criticized in the past[127], as previously described, in time it has proven to be a robust technique, replicated in numerous studies[128] throughout the years and often cited in others[129]. It also influenced the work at MIT and that of architects and planners around the world, many years after it was originally published.[130]

The method of the present study, was designed to test if the image and the legibility of a city and its elements were modified at night and to evaluate its practical consequences, chiefly if the ability of wayfinding in the urban environment would be affected under artificial lighting. Thus, it was constructed to elicit the public image of two cities from its inhabitants and to analyse its day and night-time legibility. It entailed following the section of the method that had been applied in the city of Boston by Lynch, and adding to it tasks related to the evaluation of the night-time environment.

THE COMPARISON OF THE METHODOLOGIES

The original study by Kevin Lynch was undertaken in three different North-American cities, using a small sample of the population. These were Boston, New Jersey and Los Angeles. It entailed a lengthy office interview which included requests to describe the distinctive elements of the city and sketch a map. A systematic field reconnaissance of the central area of each city was undertaken by a trained observer who mapped the area for its main characteristics. In the city of Boston, the method

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[127] In (Lynch, 1985) the author describes the criticism done to his work by others.

[128] For example the work of Nasar, 1997 and Skorpanich, 1983.

[129] Google scholar research engine informs that there are at least 9191 citations of “The image of the city” online. Information retrieved in September 2014.

[130] (MIT libraries, n.d.)

also involved asking a smaller number of the participants to recognize and place various photographs, and to take these volunteers for actual trips in the field. Additionally it involved requesting directions to passers-by in the streets.

City	Sample size	Method	Type
Boston	30	Questionnaire	Office interview
	16	Photographic recognition tests	Office interview
	16	Walking task	Field interviews
	160	Request of directions to passers-by	Field interviews
New Jersey	15	Questionnaire	Office interviews
Los Angeles	15	Questionnaire	Office interviews
All		Field reconnaissance and mapping by a trained observer.	

Table 5. Summary of the methodology adopted by Kevin Lynch (Lynch, 1960).

City	Sample size			Method	Type
	Total	Detailed			
London	30	-		Questionnaire	Office interview
	30	15	Day	Photographic recognition tests	Office interview
		15	**Night**		
	30	15	Day	Walking task	Field interviews
		15	**Night**		
Lisbon	30	-		Questionnaire	Office interview
	30	15	Day	Photographic recognition tests	Office interview
		15	**Night**		
	30	15	Day	Walking task	Field interviews
		15	**Night**		

Table 6. Summary of the methodology of the present study.

In the present study two European cities were selected in place of the three North-American examples from the original method. However, the extended version of the exercise was undertaken in both cities, instead of in just one. The characteristics and size of the samples were consistent in both cities. Additionally, two of the sections of the technique were supplemented by a night-time version. However, there were no field reconnaissance mapping by a trained observer in this study for any of the cities, and the request for directions from passers-by was also ignored.

In summary the differences between the two methods regard:

- The cities selected for the study
- The size, distribution and characteristics of the samples
- The consistency of the use of the method in all cities
- The addition of night-time sections to the present method
- The removal of the field reconnaissance by a trained observer and the request for directions from passers-by in the present method

The cities selected for the study

The selection of the city centres in the original method seem to have been related to obtaining a diverse sample. Thus, Boston was selected for its unique character, vivid form and local difficulties; New Jersey for its apparent lack of form and Los Angeles for its scale and gridiron plan[131]. The two European cities selected for the present study were London and Lisbon. Located respectively in the north and south of Europe, these also provide distinct urban environments, with different cultures, light, morphology, urban shape and architecture. Thus, it was expected that they would offer interesting clues about the effect of artificial and natural light in the perception of similar urban elements, located in different contexts.

The characteristics of the sample

The present scheme used the same number of participants in all sections and in both cities. Additionally, it tried to be balanced regarding their age, gender, occupation, class and the location of their residence and work place. The selection of a more balanced and well distributed number of participants tried to address the criticisms[132] made to the original method regarding the general characteristics of the sample. It was not possible however to use a larger number of individuals due to time constraints.

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[131] (Lynch, 1960) p.14-15

[132] As described for example in (Lynch, 1985)

Sample	The original method	The method of this study
Size	Small: size of 30 to 15 people	Small: size of 30 and 15 people
Age	Young (above adolescence)	20 to 65 years old
Gender	Balanced	Balanced
Occupation	Professionals, managerial	Varied: Professionals, students, house wives, pensioners, managerial, entrepeneurs.
Class	Middle-class	Middle-class
Nationality	Possibly all North American	Represents roughly the percentage of nationals and foreigners in the cities
Distribution of residence and work	Lack of random distribution	Randomly distributed

Table 7. The summary of the characteristics of the samples in the original method and in the method applied in the present study.

The consistency of the use of the method

The method was replicated in London and in Lisbon with the most similar conditions as possible. The same number of stages were replicated and the same number of participants were interviewed in both places and at all sections of the method.

In the original version, all the stages of the method were only applied to one of the three cities. At the remaining examples the questionnaire was the only portion of the method used, along with the field reconnaissance technique, which was common to all cities. Additionally, the sample size was considerably smaller in these two cities.

The addition of a night-time version

The main original feature of the method used in the present study is the addition of night-time based interviews for the photographic recognitions and walking tasks. These interviews aim at searching for potential discrepancies between the day and night-time image and legibility of the main urban elements and of the cities and its influence on orientation tasks.

The exclusion of parts of the original methodology

Lynch argues that the best comparison to the interviews was the record of another subjective response, through the use of a few field observers trained to look carefully for the kind of urban elements that seemed to be significant in the pilot interviews. He states that using air photos, maps, diagrams may seem to be the proper objective description of the image of the city, but that these are inadequate for the purpose, given that the variety of factors that could be evaluated are infinite. He also suggests that, in the future, the replication of his method should begin with a generalized field reconnaissance, systematically covering the city both on foot and by vehicle, by night and day.[133]

A comparison of the verbal interviews with a field reconnaissance would be useful for the purposes of this study if this survey was conducted both in day and night-time. Ideally by different groups of people, familiar with Lynch’s concepts so as to understand if there were any differences in the perception of the main urban elements. However, ideally, the group of surveyors that would conduct the night field recognisance should not be too familiar with the image of that city in the day-time, to prevent distortions due to expectation of seeing certain known elements. However it was not possible to find people to make these assessments especially in such large areas as Lisbon and London city centres.

In face of the size of the city centres of London and Lisbon and the wealth of information available online, it was considered impractical to have a few trained observers mapping the cities as Lynch did.

The part of the method which entailed asking people for directions was also ignored in this study. Not only were there time constraints, but the data produced by the other experiments seemed to be sufficient for the objectives of this work.

[133] (Lynch, 1960) p.155

OVERALL DESCRIPTION OF THE METHOD

Lynch classifies the tasks that are part of his method as office interviews, which refer to those tasks that took place indoors such as the interview that was based on a questionnaire and involved sketching, and the photo recognition tests. The interviews that took place in the city centres are described as field interviews and encompass the trips in the field and the request for directions. In the present study, the stages of the method will be referred to, in the following chapters, as *verbal*, *photographic* and *walking interviews*.

	Interviews		Type
-	Verbal		Office interview
	Photographic		Office interview
	Walking		Field interviews

Table 8. Summary table of the methodology of the present study

The verbal interview encompasses the responses to a set of questions and the sketching exercise. The photographic interview includes all responses prompted by the manipulation of photographs of the cities, and the walking interview relates to the task of walking from an origin to a destination point in the city centre, while participants were encouraged to describe their thoughts and explain their decisions. All except the verbal interviews had a day and a night-time version. This means that for the photographic and walking interviews, half of the participants performed tasks related to day-time, and the other half related to the night-time urban environment.

As previously described, one of the main criticisms to Lynch's method was the size of the sample used. In the years following the publication of the study, however, other researchers replicated it in different cities, and with larger sample sizes, as for example (De Jonge, 1962) and (Francescato & Mebane, 1973) with success and overall confirming Lynch's findings. Further to this, because the method is replicated in two cities and uses a number of different tasks, a hypothesis generated by one group of participants can eventually be verified in other stages of the method or in the other city.

The next pages will describe in detail the method used in the verbal, photographic and walking interviews.

Challenges in the use of the method

The completion of the interviews took around two and a half years. It entailed travelling between two countries, gathering a large amount of volunteers and preparing the different stages of the method, during the day and night, many times under unfavourable weather.

While the verbal interviews were fairly easy to be completed, the preparation and execution of the other two stages took a greater effort. A total of 100 urban places were carefully photographed both in day and night-time, in Lisbon and London, from the exact same position, in a total of 200 photographs, which had to be printed, cut and placed on a card board. After that another set of sixty office interviews were executed, half in Lisbon and another half in London. Finally the last set of sixty interviews took place, again half in each city, by walking with each individual, while they tried to find their way from one point of the city to another, part during day and another part during the night. Some of these last interviews extended beyond the estimated time (as some participants hesitated, got momentarily lost, or chose longer paths), and they often had to be postponed due to poor weather conditions, thus prolonging its completion time.

VERBAL INTERVIEWS

The sample

For the first stage of the method, sixty volunteers were questioned individually, in a closed room. Half of the partcipants were residents in Lisbon and the other half in London. They were aged between 20 and 65 years old, with an average age of 35 years old for London and 40 years old for Lisbon. An equal number of males and females were interviewed in both cities. All individuals had a good knowledge of the city centre on which they were being interviewed and had been living there for an average of 14 years, in the case of London (between 2 years for the newest inhabitants interviewed and 65 years for the oldest). In the case of Lisbon the average time individuals had lived in this city for was 29 years (between 2 years for the newest inhabitants interviewed and 65 years for the oldest).

The main occupation of the persons interviewed in London were researchers and students (17 persons in total), and the remaining participants had a variety of professions ranging from the finance, software, diplomacy, public sector, among other industries, and including persons with no professional occupation (house wives and pensioners). Most individuals had a university degree: 76% in London and 60% in Lisbon. The occupation of the persons interviewed in Lisbon was more varied, where 6 participants were retired and the remaining came from a variety of professions, from public sector workers to the construction and health sectors, and including entrepreneurs and students. In Lisbon all participants were Portuguese and in London only half of the participants were British.

Although unintentionally, the sample of people replicates in some aspects the general characteristics of the population of London and Lisbon. This is roughly true for the numbers regarding the nationality and the age of the participants. According to the Office for National Statistics, in 2011[134], 62.2% of the population of London was born in England or Scotland, and the average age of the population was 33 years old[135].

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[134] Data from Census 2011, the same year when the verbal interviews took place.

[135]Information retrieved in the Office for National statistics website at http://www.ons.gov.uk/ons/rel/mro/news-release/census-2-1----london/census-gives-insights-into-characteristics-of-

In Lisbon only around 7% of the population were foreigners, and the average age of the population was 41.2 years old in 2011[136].

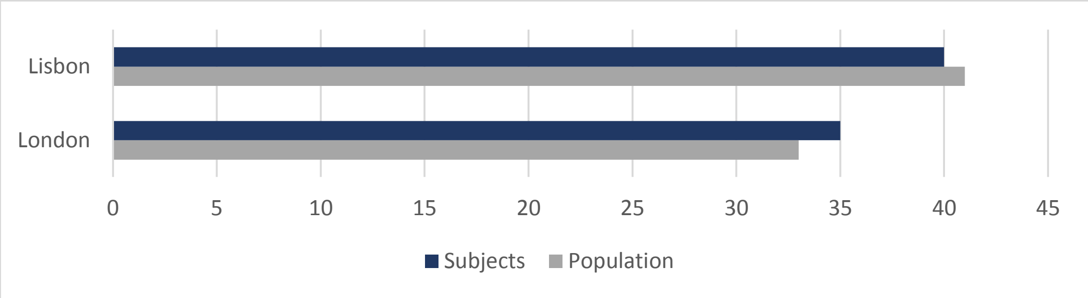


Table 9. The average age of the persons interviewed compared to the average age of the population in the cities of London and Lisbon.

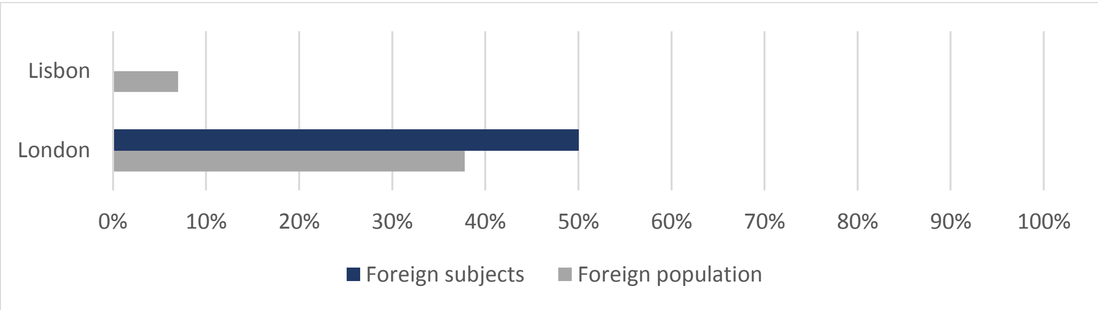


Table 10. The percentage of foreign residents who participated in the interviews and the percentage of the total number of foreigners in the population of the cities of London and Lisbon.

Lynch described that, the participants of his study were young, middle class people and that most of them were professionals. He also points that there was a lack of a random distribution of their residence and work place[137]. For this study a more diverse sample was used, partly to address the problem of bias pointed in the sample used by Lynch. The sample used in this study was also more or less randomly distributed in terms of residence and work areas, with the exception of working area for London, where half of the participants worked in the UCL campus. This slight bias appeared

london-s-population.html and at http://www.ons.gov.uk/ons/rel/mro/news-release/census-2-1----london/census-gives-insights-into-characteristics-of-london-s-population.html accessed in June 2014.

[136] Information from Census 2011 in (Instituto Nacional de Estatistica, 2011)

[137] (Lynch, 1985)

on the verbal interviews, although apparently not affecting the main image of the city extraction, as it will be discussed ahead.

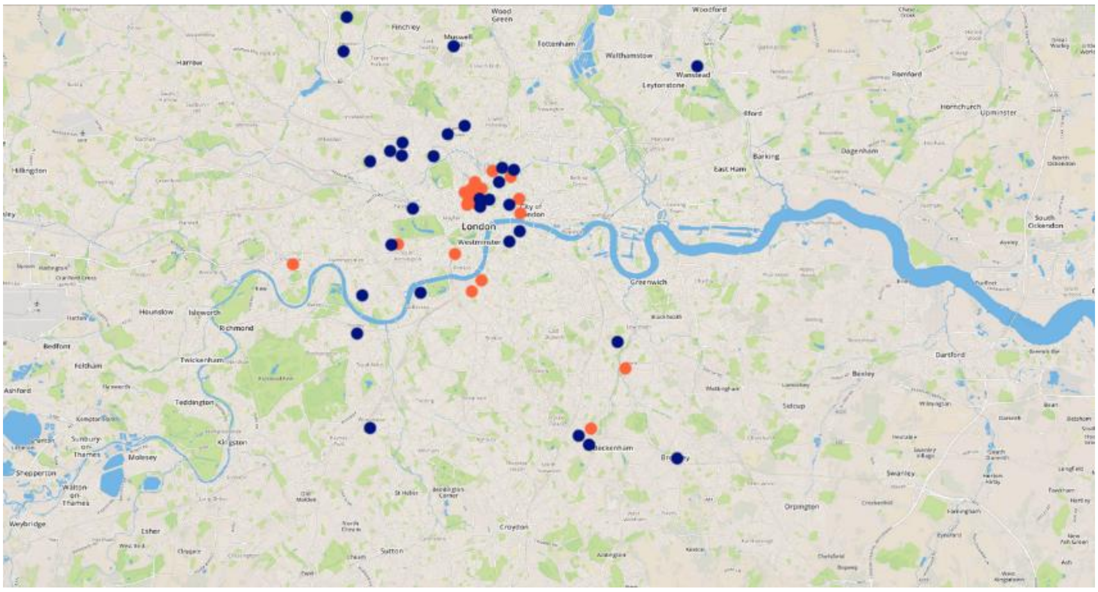


Figure 4. London: The place of work (orange circle) and the residence (blue circle) of each participant.

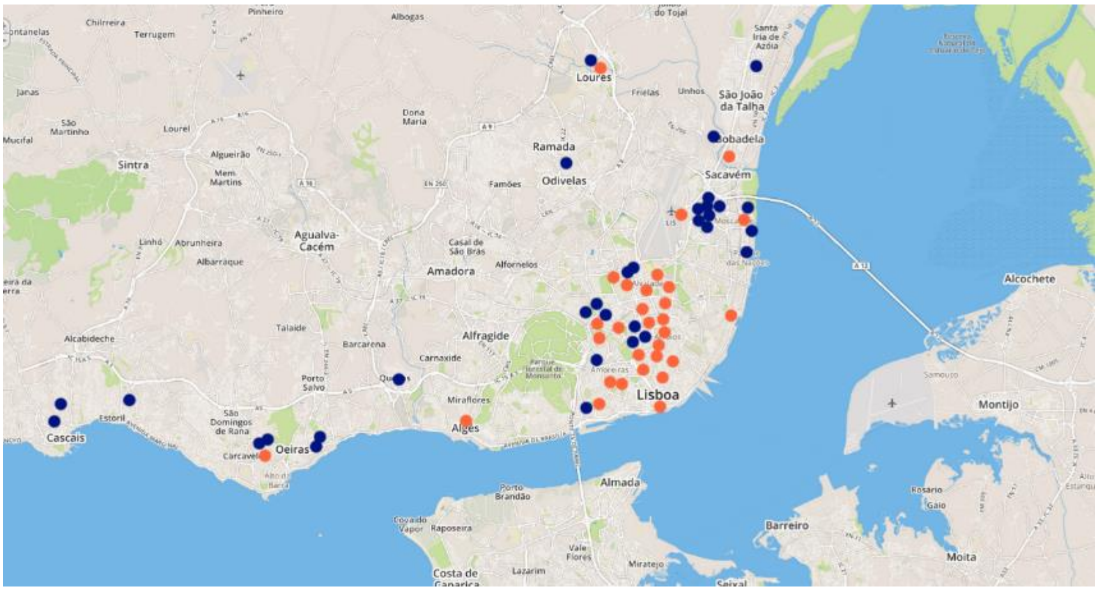


Figure 5. Lisbon: The place of work (orange circle) and the residence (blue circle) of each participant.

In the case of the Lisbon sample, as it can be observed in the image above, most participants worked in the city centre and a great part commuted, generally, by car, to the outskirts of the city. The importance of determining the work and residence location of the participants was that of understanding which areas of the city they were most familiar with. In the case of those who were retired, their last working place was considered, to have a sense of the areas they would travel to frequently.

Even though an effort was made in trying to get a varied sample of people, the selection was restricted to the difficulty in finding a great number of volunteers to participate, in sometimes, such lengthy interviews. The research had to rely on the kindness of strangers who responded to a call for volunteers but also on the help of acquaintances, friends, neighbours and colleagues. Thus, the characteristics of the sample is partly due to choice but also to a certain degree of chance.

Description of the method

The interview was based upon the questionnaire described by Lynch. This interview consisted in a number of questions designed to try to extract the mental image of the inhabitants of the cities of London and Lisbon.

Among other questions, people were asked to draw a map of what they considered to be London's centre and its main elements. They were also asked to name and describe what they thought were the most distinctive and recognizable elements of the city centre, and point them on the map. The participants drew these elements over their original map in a different colour. The drawings and the descriptions conjugate as a double check method to extract the most important urban elements. If an individual failed to draw a certain urban element, he might still have mentioned it when describing what he thought the most distinctive elements of the city were.

Afterwards, they tried to explain which characteristics made these elements distinctive. They were also asked to describe a mental trip between two points of the city and a route they would frequently take and were very familiar with. The full questionnaire for London can be read next[138]:

[138] The questionnaire for Lisbon was very similar to this one. The only difference was the places where the mental trip was required to take place: From Largo de Camões to Praça do Comércio, instead of from Covent Garden Market to The Houses of Parliament.

1. What first comes to mind, that symbolizes the word "London" to you? How would you broadly describe London in a physical sense?

*2**. We would like you to make <u>a quick map of greater London and then another of what you consider to be the historic centre of London</u>. Make it just as if you were making a rapid description of the city to a stranger, covering all the main features. We don't expect an accurate drawing-just a rough sketch.***

3. a. Please give me complete and explicit directions of <u>a typical trip that you take when going to London's historic centre</u>. Picture yourself actually making the trip, and describe the sequence of things you would see, hear or smell along the way, including the path markers that have become important to you, and the clues that a stranger would need to make the same decisions that you have to make. We are interested in the physical appearance of things. It is not important if you cannot remember the names of streets and places.

3. b. Do you have any particular emotional feelings about various parts of your trip? How long did it take you? Are there parts of the trip where you feel uncertain of your location?

3. c. Please give me complete and explicit directions of <u>a typical trip that you take when from Covent Garden to the Houses of Parliament</u>. Picture yourself actually making the trip, and describe the sequence of things you would see, hear or smell along the way, including the path markers that have become important to you, and the clues that a stranger would need to make the same decisions that you have to make. We are interested in the physical appearance of things. It is not important if you cannot remember the names of streets and places.

3. d. Do you have any particular emotional feelings about various parts of your trip? How long did it take you? Are there parts of the trip where you feel uncertain of your location?

*4**. Now we would like to know what elements of central London you think most distinctive. They may be large, small, but tell us those that for you are the easiest to identify and remember.(for each 2 or 3 elements ask question 5)***

5. Would you describe……….to me?

5.a. If you were taken there blindfolded, when the blindfold was taken off what clues would you use to positively identify where you were?

5.b. Are there any particular emotional feelings that you have in regard to……..

5.c. Would you show me on the map where ……is? And if appropriate where its boundaries are?

6 Could you show me on your map the direction of North? *7. The interview is now over. However it would help me to have just a few more minutes of discussion* *What do you think we are trying to find out?* *What importance have orientation and the recognition of city elements to people?* *Do you find London an easy city to find your way around and identify its parts?* *What cities of your acquaintance have good orientation? Why?*

Figure 6. The questionnaire presented to the participants in London.

This is a very lengthy interview which replicates the original work by Lynch. However, in the last section of “The image of the city”, the author indicates another way, a shortcut, for using his method, in which this interview would be reduced to:

a) *Sketching the map of the area in question, showing the most important features, and giving a stranger enough knowledge to move about.*
b) *Make a similar sketch of the route and events along one or two imaginary trips.*
c) *Make a written list of the parts of the city felt to be most distinctive*
d) *Put down brief written answers to a few questions of the type: “where…is located?”*

Even if there was a simpler way of conducting the exercise, it seemed relevant to have the entire original interview completed, as to gather the greatest amount of information as possible to prepare the next phases of this study. However, for the purposes of this research it will only be described the answers to the questions that were relevant for the next phases of this work. These are marked in bold on Figure 6 and will be reviewed in the results section.

The results of this phase of the study were used to set the foundations for the following stages. It allowed to extract the most distinctive elements of the cities, which were afterwards photographed and presented to the participants of the photographic interviews. Additionally, the descriptions of mental travels made by the participants of the verbal interviews, allowed to test if the use of a certain origin and destination was feasible to be applied in the field for the walking interviews. It could have also allowed for a comparison between this imaginary wayfinding task with the actual field exercise. However, this comparison was not pursued, as it was found to be slightly beyond the scope of the present study.

When presenting the results of his research, Lynch only considered those elements which were mentioned and sketched with a frequency superior to 12%. In this study, to be able to have an equal number of photographs for the photographic interviews for Lisbon and London, the first 50, most distinct urban elements were selected, corresponding roughly to those with a 20% frequency and above. These will be described in the results section.

PHOTOGRAPHIC INTERVIEWS

The sample

At each city, sixteen of the individuals who had been interviewed in the previous stage of the study agreed to participate in another set of tasks. The remaining 28 individuals who participated in this stage of the study were also all volunteers who said that they had a good knowledge of central London or central Lisbon. Half of these participants performed tasks related to manipulating day-time photographs, and the other half related to the night-time pictures of the city. The characteristics of this sample was very similar to the one from the previous phase of the study. However, here, and in the next phase of this research, there was the extra difficulty of trying to compose similar, balanced samples for both day and night tasks. Overall this is thought of having been fairly achieved in London.

In London there was a balanced number of gender for the tasks related to the night-time photographs (7 females and 8 males) but a higher number of females for the day-time based interviews (10 females against 5 males). The number of foreigners was balanced in both sets of interviews, with 46% of non-British for each set. Every participant had been living in London for over 3 years, an average of 21 years for the day-time volunteers and 17 years for the participants of the night-time based task. They were aged between 20 and 65 years old, with an average age of 36 years old for the day interviewees and 30 years old for those who participated in the night version of this section.

In Lisbon there was a slightly higher number of males in the night photographic interviews (6 females and 9 males) and a slightly higher number of females in the day interviews (9 females against 6 males). There were no foreigners interviewed. Every participant had been living in Lisbon for over 3 years, an average of 47 years for the day interviewees and 42 years for the night tasks participants. They were aged between 20 and 70 years old, with an average age of 55 years old for the day interviews and 45 years old for the night version.

Description of the method

In preparation of the second set of interviews, each element, previously extracted and registered, was photographed in agreement to what the participants described as being its most recognizable features. Consequently, for example, in London, Hyde Park was pictured from an angle which included the lake and the horse track.

Figure 7. On the left the day-time picture shown to the participants and on the right the position of the tripod from which the photograph was taken.

Two pictures were taken for each element: One during the day and another during the night. Both were taken exactly from the same position, using a tripod and an Olympus Stylus FE-230 7.1MP Digital Camera. The first photographs were taken during the day, and the position of the tripod was also photographed in order to replicate its location at night. The tripod was maintained in constant height. Additionally, several luminance measurements were made at several points in the environments using a Minolta luminance meter LS-100, placed on a tripod.

These pictures were colour printed in plain paper, and cut into rectangles with the dimensions of 13 by 9 centimetres. The images were then glued to black cardboard that had been cut into the same size. A number was attributed to each picture, according to the element it depicted and drawn on the back of the cardboard, so that it could be easily identified by the interviewer but not by the participant.

Figure 8. An example of the finished photograph over cardboard as presented to the participants.

Finally the interview was performed, by presenting the photographs to each participant, individually, in a closed room. For each city half of the participants were presented with the night-time versions of the photographs and the other half with its day-time appearance. The main differences to the methodology described in “The image of the city” is that the city was additionally portrayed at night, and that the photographs only represent fifty carefully selected places, instead of systematically covering the entire city.

The interview consisted of three tasks. First, the individuals were asked to classify the pictures in whatever groups seemed natural. Secondly they were required to identify as many images as they could and to describe which clues they used to do so. Next, they were asked to display the photographs in a large table as if they were placing them in the proper position in a large map of the city. Finally, they were presented with either the day or night-time photograph version of those elements that they were not able to recognize.

The tasks of ordering the photographs and displaying them in a map were found of little relevance for the purposes of this study. Thus, its results were omitted from the thesis.

WALKING INTERVIEWS

The sample

The sixty volunteers for the last set of interviews, were given the task of walking from one point in the city to another, Thirty walked in the city of London and the rest in Lisbon, half under day light and the other half under artificial lighting. Some of the participants had been part of the two previous stages of this study.

In London, eight of the persons who had been interviewed in the previous two stages of the study agreed to participate in the last interview. Half participated in the night-time interviews and the other half in the day time tasks. The remaining 22 participants were all volunteers. Contrary to the previous interviews, half of the individuals interviewed declared having a good knowledge of central London and the other half an average or poor knowledge. Because the objective was to find how lighting affected wayfinding, an earlier knowledge of the area was not assumed to be essential for the task. It was thought that people who did not have knowledge of the area would search for different clues from those who, knowing well the area could probably navigate almost automatically through the environment. The characteristics of the sample of individuals that took the interviews were similar for both cities.

In London there was a reasonable balance of gender, with a slightly higher number of males in both interviews: 7 females and 8 males in the night interviews and 6 females and 9 males for the day walks. Every participant had been living in London for over 6 months, with an average of 6 years for the day interviewees and 5 years for the night participants. They were aged between 27 and 65 years old, with an average age of 34 years old for the day interviewees and 33 years old for those who participated in the night version.

In Lisbon nine persons who had participated in one or both of the previous interviews, agreed to also join the last task of the study. Here there was also a generally balanced number of male and female participants: 7 females and 8 males in both the day-time and night-time interviews. Every participant had been living in Lisbon for over 5 years, with an average of 48 years for the day interviewees and 38 years for the night tasks participants. They were aged between 25 and 65 years old, with an average age of 57 years old for the day interviews and 39 years old for the night version.

Description of the method

In the verbal interview, the participants had been asked to describe a trip from one point to another, including all relevant elements in the space, for each city. In this last set of interviews, another 30 volunteers were evenly separated in two different groups, and were asked to perform that same trip by foot, while describing what markers along the way they found relevant. One group did the experience at night, the other during the day. All interviews were performed separately, the individuals could not look at maps, ask for directions or use any devices for orientation purposes, and were free to choose which path they wanted to follow. In London almost all participants met with the interviewer in front of the Covent Garden underground station, having arrived there by train that had stopped at that station. They were then led to the starting point, from which the interviewer followed each individual, one step behind them, so not to influence their movement and choice of path. While accompanying them, they were prompted to explain their route choices and the conversation was recorded using the voice recorder of the interviewer cellular phone. At the same time the route was automatically registered on a web map by using a *GPS* tracker phone application (*Jog Tracker*[139]).

Both routes are characterized by having multiple choices of paths to get to the final destination, and a length or around 1.5 Km. In London the participants were asked to walk from Covent Garden Market to the Houses of Parliament, in Lisbon from *Largo de Camões* to *Praça do Comércio*. The destination point was kept secret until the beginning of the experiment. The area of London where the experiment took place is characterized by an organic urban fabric constructed on a fairly flat ground. In Lisbon the area has an orthogonal urban fabric set on sloped ground. All streets in those areas, in both cities, are reasonably well and uniformly lit, at night, although main roads seem to have higher levels of light. There are several landmarks, which were part of the set of fifty elements, extracted and used in the previous interviews, visible in both areas where the walking experiment took place.

[139] *JogTracker* uses GPS to track the user's position and calculate distance in miles or kilometres, it also shows the route used on Google Maps. From http://www.jogtracker.com/

After the interviews, all paths were analysed and lighting measurements were taken at crucial points, that is, at the nodes where decisions diverged the most. The lighting measurements consisted of taking luminance and illuminance readings from all the travelled paths coming out of the intersections. These evaluations will be fully described ahead on page 95 where the analysis of the results for the walking interviews are described.

ANALYSIS OF THE RESULTS

This section will explain how the data resulting from the three interviews was treated and the underlying rational used in the process for each set of interviews.

For the verbal interviews

The analysis of the verbal interviews consisted in listening to the voice recordings of the responses to the questionnaire, transcribing them and examining the maps drawn by the participants.

The account of distinctive elements was made by adding the number of distinctive elements sketched in the maps with those prompted by question. Because the participants were asked to point and draw in their maps the additional distinctive elements which they described later in the interview (that is, after they drew the maps), the account of elements could have be done just by observing all maps. Yet, this account was double checked by listening to all voice recordings of the interview and comparing it to the annotations on maps.

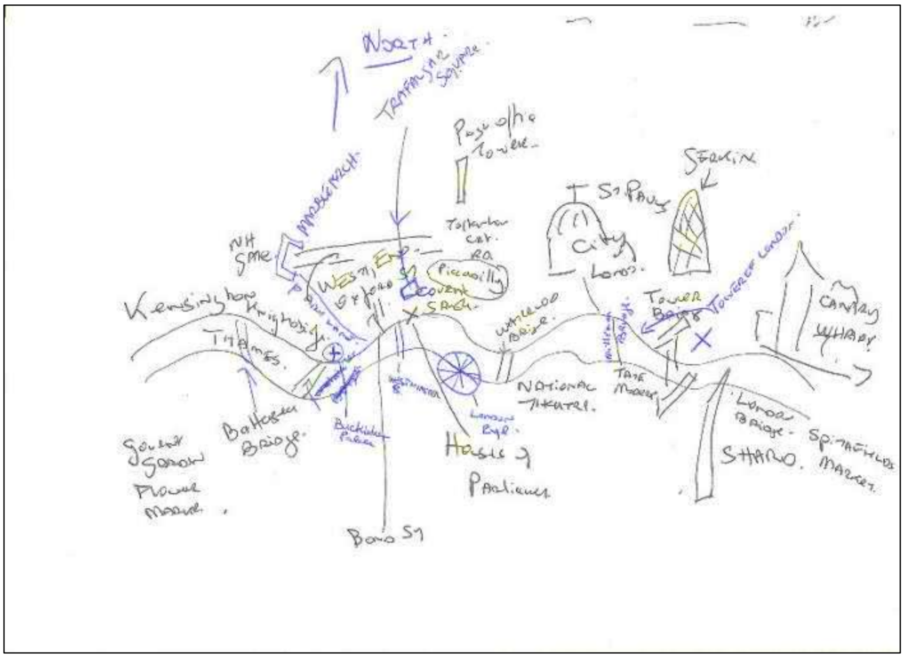


Figure 9. Example of a map drawn by one of the participants. In black the original map. In blue the location of elements which had been described as being the distinctive elements of London in the interview.

All elements were classified in different groups: paths, landmarks, edges, districts and nodes. There was however, some difficulty in the categorization process, since some elements have an ambiguous character. For example, Tower Bridge is both a landmark and a path, the same happening with the main bridge of Lisbon (*Ponte 25 de Abril*). Since all bridges in London were considered paths, London Bridge was also classified as such, for the sake of consistency. However, Lisbon's bridge was, in turn, considered a landmark, because it was for a long time the only bridge in the city, and the only one sufficiently distinct to emerge as a landmark of the city in most of the interviews. Those elements which could have been ambiguously classified will be pointed out as such in the results section.

For the photographic interviews

The analysis of this set of interviews consisted of listening to the voice records of the interviews, and looking at the pictures that registered the way that the individuals organized the photographs as a map. The main aspects of these recordings were transcribed into two spreadsheets for each city: One for the interviews based on the day-time images and another for the interviews based on the pictures captured at night. The tables were drawn by creating a set of columns for each participant. These columns were then intersected by rows corresponding to the 50 most recognizable elements of the city. The resulting cells were filled with the clues that allowed for each individual to recognize the corresponding element when observing its photograph, during the interview. Additionally, each set of cells was signalled as the element having been identified or not, through the use of colour.

Table 12 illustrates how this data was organized. It corresponds to a very small part of the spreadsheet for the results of the daytime photographic interviews for London. The original table comprises columns for all 15 participants and all mentioned clues, as well as rows for the 50 most recognizable elements of London. The whole table did not fit in these pages, but its contents will be discussed in detail, when relevant, in the following chapters. To maintain the anonymity of the participants, their names were replaced by initials.

Rank	Element	Distinctive features as described by participants							
		N.		L.			C.		
1	The river	Big Ben	London Eye	Big Ben	I see boats	The bridge	Big Ben	London Eye	
2	Oxford St.	Selfridge's and its columns	A busy street	It's Tottenham Court Road					
3	Hyde Park	The lake	The coffee shop	The lake	The coffee shop		water	The coffee shop	The horse track
4	St. Paul's	The dome		The dome	Its architecture		Its shape		

Table 11. A portion of the first version of the spreadsheet used to organize the large amount of information resulting from the day photographic interviews.

Soon it became clear, however, that, given the qualitative nature of the interviews, the answers could not simply be classified as the element being correctly or incorrectly identified. Thus, the answers prompted by the presentation of photographs to the participants, in both sets of interviews, were examined through six parameters. These were (i) Correctly identified, (ii) Not identified, (iii) Misidentified, (iv) Correctly identified, but the primary element recognized was not the target, (v) Not identified but recognizes the area, and (vi) Correctly identified but with doubts. These classifications are described in Table 12, below.

Classification	Colour code	Description
(i) Correctly identified		The participant was able to correctly recognize the element depicted in the image.
(ii) Not identified		The participant was unable to recognize the element depicted by the photograph
(iii) Misidentified		The participant mistook the element depicted by the photograph with another element not present in the image.
(iv) Correctly identified, but the primary element recognized was not the target		The participant pointed another object in the image as the primary element depicted by the photograph, instead of the intended target. The intended target is still mentioned, but as an aid to recognize the other object in the picture.
(v) Not identified but recognizes the area		The participant is unable to recognize the element but knows where it is located.
(vi) correctly identified but with doubts		The participant is able to correctly recognize the element depicted in the image, but is unsure of his answer. He hesitates, may change his mind many times before giving the correct answer and may also be undecided between that answer and a mistaken one.

Table 12. The classification attributed to the responses of the participants.

A system of colours was used to classify answers according to these parameters. Thus, (i) Correctly identified, had no colour; (ii) not identified was coloured grey; (iii) Misidentified, red; (iv) Correctly identified, but the primary element recognized was not the target, green; (v) Not identified but recognizes the area, blue; and (vi) correctly identified but with doubts in yellow.

This general large working table was afterwards transformed into a summary table where the results prompted by the day and night-time photographs were compared, according to the different parameters (see Table 13). Afterwards, an analysis in greater detail was pursued for those elements with larger differences in results, as it will be explained further ahead.

	NUMBER OF CORRECT IDENTIFICATIONS		NOT IDENTIFIED		MISIDENTIFIED		CORRECTLY IDENTIFIED BUT THE PRIMARY ELEMENT IDENTIFIED WAS ANOTHER OBJECT IN THE PICTURE		NOT IDENTIFIED BUT RECOGNIZES THE AREA		CORRECTLY IDENTIFIED BUT WITH DOUBTS	
	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
1 The river Thames	15	15	0	0	0	0	14	8	0	0	0	0
2 Oxford Street	10	12	2	3	3	1	5	6	0	0	0	0
3 Hyde Park	14	0	0	6	1	9	0	0	0	0	0	0
4 Saint Paul's Cathedral	15	15	0	0	0	0	0	0	0	0	0	0
5 The London Eye	15	15	0	0	0	0	0	0	0	0	0	0
6 Oxford Circus	12	14	1	0	2	1	2	1	0	0	0	0
7 Big Ben	15	15	0	0	0	0	8	4	0	0	0	0
8 Trafalgar Square	15	15	0	0	0	0	0	0	0	0	0	0
9 Tower Bridge	15	15	0	0	0	0	0	0	0	0	0	0
10 The Houses of Parliament	15	15	0	0	0	0	1	3	0	0	0	0
11 Buckingham Palace	15	15	0	0	0	0	0	0	0	0	0	1
12 The Tate Modern	14	15	1	0	0	0	0	8	0	0	0	2
13 The Gherkin	15	6	0	6	0	3	0	0	0	0	0	6
14 Covent Garden	14	12	1	1	0	2	0	0	0	0	0	1
15 Regent's Street	14	13	1	1	0	1	0	0	0	0	0	0
16 Marble Arch	14	13	0	1	0	1	0	0	0	0	0	1
17 Regent's Park	9	11	1	1	5	3	0	0	0	0	0	1
18 Leicester Square	10	12	5	2	0	1	0	3	0	0	0	2
19 Piccadilly Circus	15	15	0	0	0	0	0	0	0	0	0	0
20 Soho	8	11	5	3	2	1	0	0	0	0	1	1
21 The City	15	15	0	0	0	0	1	4	0	0	0	0
22 The Millennium Bridge	15	15	0	0	0	0	0	5	0	0	0	0
23 Kensington	5	10	5	2	5	3	0	0	0	0	0	1
24 Southbank	15	15	0	0	0	0	0	1	0	0	0	0
25 Westminster Bridge	14	15	1	0	0	0	0	6	0	0	0	0
26 Waterloo Bridge	5	11	7	1	3	3	0	5	0	0	0	0
27 Kings Cross & St. Pancras Stations	10	14	2	1	2	0	1	0	0	0	0	0
28 The British Museum	11	5	3	2	1	8	0	0	0	0	0	3
29 St. James's Park	13	10	0	5	2	0	0	1	0	5	0	1
30 Harrods	15	12	0	2	0	1	0	0	0	0	0	0
31 Centre Point	9	13	3	1	3	1	3	0	0	0	0	0
32 The Natural History Museum	9	3	2	3	4	9	0	0	0	0	0	3
33 Green Park	3	0	6	11	6	4	0	0	0	0	0	0
34 The Strand	3	5	3	5	9	5	0	0	0	0	0	1
35 Picadilly	10	8	2	2	3	5	0	0	0	0	0	0
36 The Tower of London	13	14	2	1	0	0	0	0	0	0	1	2
37 Euston Station	15	15	0	0	0	0	0	0	0	0	0	0
38 The West End	15	15	0	0	0	0	0	0	0	0	0	0
39 Tottenham Court Road	12	11	2	2	1	2	0	1	0	0	0	0
40 The Mall	14	14	1	1	0	0	0	2	0	0	0	0
41 Globe Theater	11	11	3	4	1	0	0	0	0	0	0	0
42 Westminster Abbey	15	13	0	2	0	0	0	0	0	0	0	1
43 The National Gallery	15	15	0	0	0	0	0	0	0	0	0	0
44 Madame Tussauds	12	11	3	4	0	0	0	0	0	0	0	1
45 Victoria Station	6	6	4	5	5	4	0	0	0	0	0	4
46 Bond Street Station	15	15	0	0	0	0	0	0	0	0	0	0
47 China Town	15	15	0	0	0	0	0	0	0	0	0	0
48 Notting Hill	8	7	2	4	5	4	0	0	0	0	2	0
49 Westminster	14	14	0	1	1	0	0	0	0	0	0	0
50 The National Theatre	12	15	2	0	1	0	2	5	0	0	0	0

Table 13. The summary table for the photographic interview of London.

Analysing the meaning of results for the photographic interviews

The ability of the participants to correctly identify each urban element in the daytime and night-time photographs differed. Thus, it was found that some method was needed to evaluate if the differences in responses were statistically significant. According to (Robson, 2002) statistically significance testing is "both deeply entrenched in practice and highly controversial"[140], thus the strategy recommended[141] for analysing differences is to follow the pragmatic line of quoting significance supplemented with measurements of *effect size*. This was achieved by computing different *effect size* thresholds (h) for three combinations of statistical *significance*[142] and *power*[143] for each pair of responses to decide if their difference was meaningful.

a	significance level 5% power 80%	Coded orange
b	significance level 10% power 80%	Coded dark yellow
c	significance level 10% power 70%	Coded orange

Significance looks at the probability of the results not being due to chance[144], which is conventionally set at 5%, and *power* looks at the probability of the actual existence of an effect, which is conventionally set at 80%. This means that when the data meets the requirements there will be a 5% probability of finding an effect that is not there, and an 80% probability of finding an effect that is there. However, these values do not need to be fixed and can be adjusted according to circumstances[145].

The calculations were conveniently performed within the *R* software[146] environment using the package **pwr** (basic functions for power analysis). The code used was:

---

[140] p.401

[141] (Robson, 2002)

[142] (Fisher, 1925)

[143] (Cohen, 1988)

[144] Or, according to (Robson, 2002) p.400, more accurately, the likelihood of getting the same difference in results by chance alone.

[145] (Quinn & Keough, 2002)

[146] R is a free software programming language and software environment for statistical computing and graphics. The R language is widely used among statisticians and data miners

```
>library (pwr)
>a,-pwr.2p.test (h =NULL, n =15, sig. level =0.05, power =0.8)
>a
```

Difference of proportion power calculation for binominal distribution (arcsine transformation)

```
h=1.022993
n=15
sig.level=0.05
power=0.8
alternative=two.sided
```

Note: Same sample sizes

```
>b,-pwr.2p.test (h =NULL, n =15, sig. level =0.1, power =0.8)
>b
```

Difference of proportion power calculation for binominal distribution (arcsine transformation)

```
h=0.9079126
n=15
sig.level=0.1
power=0.8
alternative=two.sided
```

Note: Same sample sizes

---

for developing statistical software and data analysis." Definition from Wikipedia.com retrieved in September 2014.

>c,-pwr.2p.test (h =NULL, n =15, sig. level =0.1, power =0.7)

>c

Difference of proportion power calculation for binominal distribution (arcsine transformation)

h = 0.7920206

n = 15

sig.level = 0.1

power = 0.7

alternative = two.sided

Note: Same sample sizes

Thus, the effect size thresholds were **a**=1.02, **b**=0.91, **c**=0.79.

After, the actual *effect size* for each pair of responses was calculated from the following expression:

Actual effect size = 2 x asin(√ (A/S))-2 x asin(√ (B/S))

Where **A** equals the number of correctly identified pictures[147] for the day-time interviews, and **B** the number of correctly identified pictures for the night-time interview[148]. **S** is the sample size, which in this case is 15.

[147] Or the number of responses for any other defined parameter, such as the number of not identified or misidentified elements in the daytime version of the interviews.

[148] Or another parameter equal to the one used in A, but for responses prompted by the exam of the night-time version of the pictures.

As an example, in the photographic interviews that took place in London, the number of participants to “Correctly identify” the element Harrods in the daytime image was 15 and in the night-time image, 12. The code for calculating the actual effect size was therefore:

```
> 2*asin(sqrt(15/15))-2 x asin(sqrt(12/15))
[1] 0.9272952
```

The result, 0.93, is above the effect size threshold b=0.91 and this response was therefore coded light yellow in Table 16, in the results section. Similar calculations were undertaken for all the pairs of results both in London and in Lisbon.

The pairs of results that were calculated as equal or above the described actual effect size threshold were examined in further detail. This examination consisted of the observation of the luminance patterns and of the edges detected in each photograph.

For the walking interviews

The information gathered from the walking interviews consisted of voice recordings and *GPS* tracking data. The voice transcriptions were compared against the paths travelled by the participants in order to evaluate and compare the wayfinding behaviour of the individuals. It was found that there were discrepancies in the choices of paths, coming out of certain intersections, between the day and night-time interviews. Thus, after the completion of this first analysis, it was found necessary to examine the lighting conditions at these intersections in detail.

This examination consisted of taking lighting measurements at the intersections where a consistent difference was found between the selection of routes in the day and night-time. These were measurements for vertical illuminance (E_v), taken at the height of the observer[149], and luminance (L) measured from the beginning of each street coming out of the intersections. Additionally, measurements of horizontal illuminance (E_h) were taken from three different spots[150] of the streets, from a height of around 0.2 metres above the floor, and roughly from a distance of around three metres away from the intersection. The streets were also photographed from the intersection, at night-time, in order to apply, later, the technique of *approximate field measurements using a digital camera*[151]. This procedure, that will be explained further ahead, would allow to create a full luminance map of the scenes with which the participants were confronted with during the interviews.

The lighting measuring equipment used in all occasions were a Minolta luminance meter LS-100 and a Minolta T-10 illuminance meter. The photographic camera used in London was an Olympus Stylus FE-230 7.1MP Digital Camera, but in Lisbon another camera had to be used, as the former ceased to work. This was a Samsung WB800F digital Camera.

---

[149] Around 1.65 metres

[150] From each side and from the middle of the street.

[151] (Moore, et al., 2000)

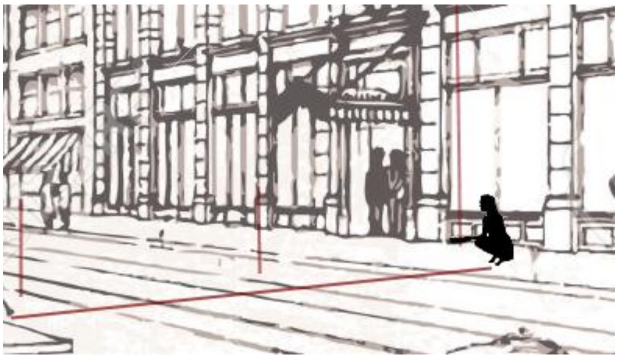


Figure 10. Illustration of the process of taking E_h measurements, using an illuminance meter at above 0.20 metres from the floor.

All measurements were performed at night only, because it would be very difficult to measure in a timely manner the same scenes under all possible daylight conditions. Thus, it is not possible to extract any conclusions regarding day lighting variations effect on decision making. Artificial lighting was regarded as constant (unchangeable during the hours it operates) and was compared against the dynamic daylighting. The interviews were held under various daylighting conditions (overcast and clear sky and at different times of the day, although mainly in the afternoon). The reason for this being the fact that the interviews took place according to the availability of the volunteers so that the study could be concluded in time.

Figure 11. Illustration of the spot luminance measurements using a luminance meter on a tripod[152].

[152] Adaption of an illustration by Martine Oger.

Additional methods of analysis

In all interviews the data which was produced by the participants was mostly of qualitative nature. They provided subjective opinions and descriptions of the city in the verbal interviews, they subjectively organized and tried to recognize and describe a number of images in the photographic interviews and they wandered freely trying to find the way towards the destination point in the walking interviews. However, as the resulting data was organized and analysed in order to understand if there were any common patterns in responses, it was found useful to introduce a numerical assessment, particularly in the case of the photographic and walking interviews analysis of results.

The main hypothesis of this study is that lighting can influence the perception and legibility of urban elements and affect orientation tasks. Thus, the images, with which the participants had been confronted with, in the two types of interviews that involved a day and a night-time version, had to be compared, to determine if the differences detected in the day and night perception of the same urban scenes were due to lighting. This implied examining the characteristics of lighting in the scenes that had shown divergent results, through the use of quantitative measurements. Additionally, the characteristics of the light sources of the public lighting where the walking interviews took place were also surveyed.

The quantity of light at each scene was compared by analysing the luminance patterns of some of the images shown to the participants of the photographic interviews, and of the images captured at critical intersections for the walking interviews. These measurements meant to provide information on the luminance contrast of objects in the scenes. Further to this, for the walking interviews alone, the colour rendering index and colour temperature of the public lighting were also registered, based on the information provided by the Council. However, no numerical analysis was performed for colour contrast of any environment or object.

For the photographic interviews alone, an additional method of analysis was introduced, with the objective of better examining the night-time potential distortions to the perception of the boundaries, thus the shape of the objects. The principle of the method is based on detecting areas of sharp luminance contrast in an image, thus detecting the main edges or boundaries present in an image. It was achieved through the use of a known software for the detection of edges.

The analysis of luminance patterns

There were two different types of images that were examined for luminance patterns. The first were a selection of the photographs that were shown to the participants in an office room (photographic interviews). The second were images taken from selected streets, which some participants had viewed or travelled through during the walking interviews. It is important to make this distinction because, in the first case the images under analysis were exactly the same as those observed by the participants, but the latter are a frozen moment of a dynamic scene that was viewed with slight differences by each participant. There were 24 scenes analysed for luminance patterns in the photographic interviews and 21 for the walking interviews.

<u>Overview</u>

The analysis of luminance patterns for all the relevant scenes with which participants were confronted with, was accomplished through the use of *approximate field measurements using a digital camera*[153]. This is a method that implies the use of software, a digital camera and a luminance meter. A digital photograph captures the target scene and at the same time a few luminance values are taken from the surfaces in this scene. The photograph is then analysed by software that deduces the missing luminance values of the scene by correlating the information contained in each pixel of the image with the luminance measurements taken in the field. The main principle of this method relies on that the luminosity value recorded by the camera will be strongly correlated with luminance.

There were different techniques that could have been used for measuring and recording luminance patterns in a scene. For example, using the luminance meter, to produce a grid of spot measurements. However, given the complexity of an urban scene, it would have been difficult to record the entire environment and to reproduce results. Besides, given the large number of scenes for analysis, the use of this method would have taken too much time. Apparently there are also specialist scanners developed for this task, which however are not widely available for field

[153] (Moore, et al., 2000)

measurement.[154] The method selected has the advantage of measuring and recording quickly while using a minimum of equipment.[155]

The method was applied by measuring a few spot luminance values in each scene, using a Konica Minolta L-100 luminance meter. Simultaneously three almost identical photographs were captured for each scene using different exposure times (low, medium and high) with a camera Olympus Stylus FE-230 7.1MP. The images were processed using the software *ImageLum* developed by Peter Raynham, 2000.

Imagelum is a software that is based in the combination of the manual introduction of values from field measurements in the program, with the information on individual pixels within an image taken by a digital camera. It relies on that the luminosity value recorded by the camera will be strongly correlated with luminance.

A minimum of 4 luminance measurements (previously collected in the field) were introduced in the three images of the same site. This allows the *ImageLum* software to compare the measured luminance values with the luminosity values in the image file, and thus map luminance to luminosity using a process of linear interpolation.

After the data input is complete, the program generates an *Excel* file for each image, in which each cell corresponds to a luminance value. The average of the three values for each cell, allows to obtain a complete luminance map. This can be visualized by translating the data into a surface chart, as the one on Figure 12.

[154] Rowlands, E.; Loe, D. L.; and Brickman N. T. " Instrumentation for measuring the luminance distribution within the visual field" Proceedings of the CIBSE National lighting Conference, Cambridge pp187-192 (1986) cited in Moore et al. 2000

[155] (Moore, et al., 2000)

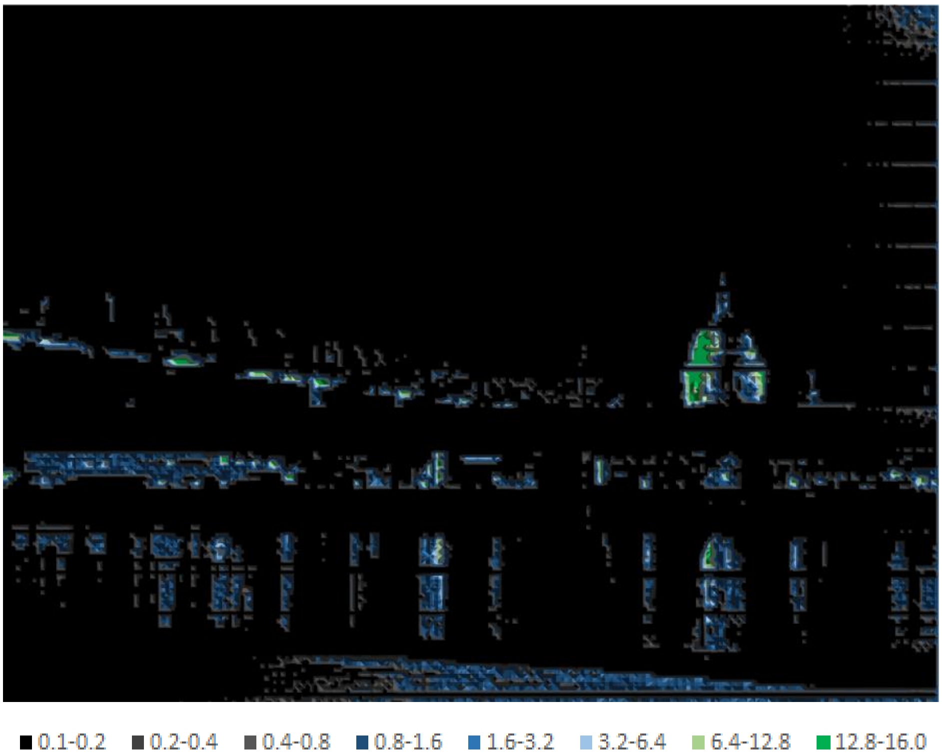


Figure 12. An example of a Luminance map generated through the use of Imagelum. (The Millennium Bridge luminance map- measurements in cd/m^2).

Further to this, a mask program was also used, in order to evaluate the luminance contrast of a target against its background. This program allows the isolation of areas within the *Excel* files which correspond to the intended target in the image.

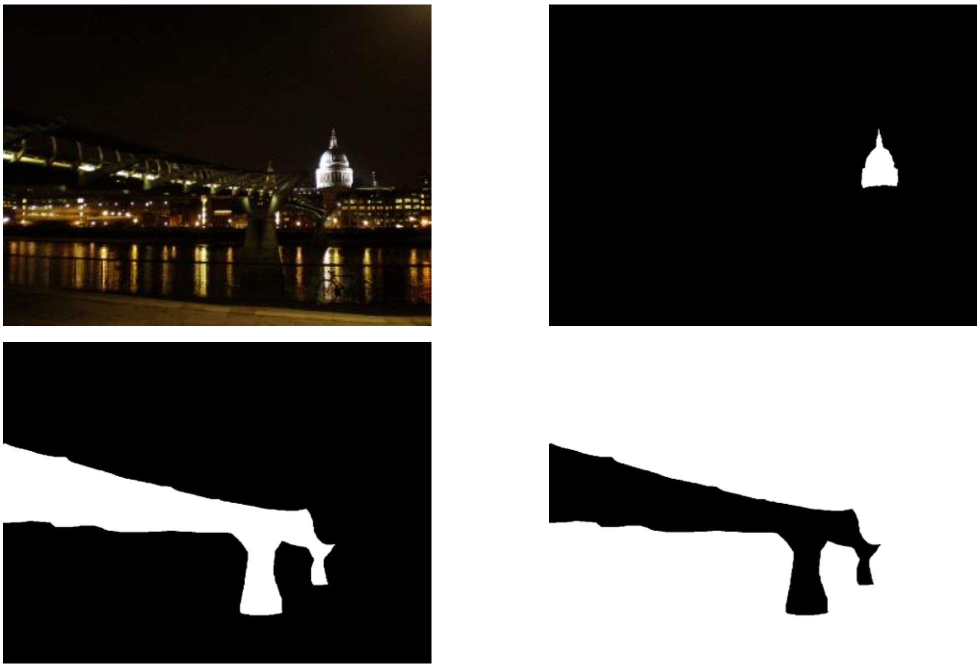


Figure 13. The Millennium Bridge night-time photograph and some of the masks used to calculate the average luminance of target areas in the picture.

Luminance contrast, L_c, is given by the following equation (CIE: International Commission on Illumination, 1992):

$$L_c = \frac{|L_t - L_b|}{L_b}$$

Where:

L_b= Average background luminance (cd/m^2)
L_t= Average target luminance (cd/m^2)

Limitations of the method:

This method of analysis of surface luminance has however, a few restrictions or weaknesses. These are vignetting errors and restrictions on measuring and estimating luminance on areas of saturated colours, of very high luminance and on highly dynamic scenes.

The image captured by the lens system of the camera is subjected to vignetting errors. This means that, for a given scene luminance, the recorded value of luminosity is lower at the edge of the image than in the centre.

It is not possible to make measurements on surfaces lit with saturated colours, because the recorded value in one of the channels of colour RGB may have saturated, thus not recording its true luminosity.

The areas of very high luminance, especially of luminaires, cannot be estimated because most digital cameras have a limited capacity to extend their dynamic range before the higher-luminance areas of the scene “bleach out”.[156] Thus, to try to overcome this problem, in every scene, measurements were made by pointing the luminance meter to the light sources directly. This provided the highest value of the scene, enabling to complete those areas which could not be estimated. However, in some cases when too many different light sources with different luminance values were present at a scene, and not all were measured, there may have been a resulting margin of error.

It was also found that when capturing the three images with different exposure times in a dynamic scene, such as a very busy street, it was impossible to ensure that all would be similar, apart from the exposure time. For example, cars passing by with the lights on could be present in one image but absent in another. People walking in different patterns in front of the camera also made it impossible to have the three photographs exactly alike. This resulted in a few errors in the analysis of the image. Specifically the program recognized one pixel as having high luminance in one image and none in another. In practical terms it resulted in having a few blank cells, with no information, which corresponded to a percentage between 0 and roughly 2%. Table 14 shows the percentage of error for the images analysed from the walking interviews.

[156] (Moore, et al., 2000)

Nodes	Blank cells (%)	
	London	**Lisbon**
A		
R1	0.7	0.7
R2	1.5	1.8
R3	0.5	
R4	0.1	
B		
R1	0.3	2.2
R2	0.8	0.1
C		
R1	1.3	0.1
R2	0.1	0.1
D		
R1	0.0	2.0
R2	0.8	0.0
R3	0.7	
E		
R1	2.4	
R2	0.1	

Table 14. Percentage of cells presenting an error at each image that was analysed.

Edge detection

Edge detection refers to the process of identifying and locating sharp discontinuities in an image. The discontinuities are abrupt changes in the pixel intensity which characterize boundaries of objects in a scene[157].

The objective of using edge detection in the photographs shown to the participants is to determine how the perceived edges of the objects in these photographs, vary between day and night-time lighting conditions. The method was used both in the day and night-time pictures, contrary to the luminance pattern analysis which only analysed the night time images. Thus, it is looking at the possibility of artificial lighting reinforcing or modifying edges. Because the detection of boundaries determines the visibility and the way the shape of an object is understood, it conditions its identification. Therefore, the reason for the accurate or inaccurate identification of urban elements can be partly related to the ability of lighting conveying an adequate perception of edges.

There are many computational techniques to automatically detect edges in an image, such as, the *Canny*, *LoG*, Sobel and *Prewitt* operators. These use different algorithms and have different levels of complexity, performing differently regarding sensitivity to weaker edges, noise, and accuracy. It was assumed that, the requirements for the purposes of this study, would be a simple edge detector, with the ability to identify the most visible edges and disregarding those that may have been missed by the participants of the study.

The detection of edges was accomplished by using the *Sobel* operator in *Matlab R2013*, which is a widely used, simple operator that detects the strongest edges and their orientation. However, this operator only works with monochromatic images, meaning that it did not take into account possible colour contrast.

Most methods for edge detection work on the assumption that the edge occurs where there is a discontinuity in the intensity function or a very steep intensity gradient in the

[157] (Maini & Aggarwal, 2009)

image. The *Sobel* operator takes the derivative of the intensity value across the image and finds points where the derivative is maximum, so that the edge can be located. The gradient is a vector, whose components measure how rapid pixel value are changing with distance in the x and y direction[158].

The use of the edge detection technique allowed to observe the visible boundaries of the objects in the photographs and to examine if these were modified under different lighting conditions. Thus, it enabled a quick evaluation of the effects of artificial lighting on the perception of the shape of an object.

Figure 14. The edges detected in the day-time (on the left) and night-time (on the right) photographs of Hyde Park.

[158] (Vincent & Folorunso, 2009)

Chapter 4 RESULTS

IN LONDON

For the verbal interviews

For the photographic interviews

For the walking interviews

IN LISBON

For the verbal interviews

For the photographic interviews

For the walking interviews

THE RESULTS IN LONDON

For the verbal interviews

For the photographic interviews

For the walking interviews

THE RESULTS IN LONDON

For the Verbal interviews

The results of the verbal interviews were mainly important to extract the basic elements that compose the image that Londoners have of their city. In total, a number of one hundred and sixty eight distinct elements were extracted for London, which were classified under Lynch's nomenclature as *landmarks, nodes, paths, edges* and *districts* and ranked from high to low recognisability. The number resulted from the account of distinct elements that were drawn and described as distinctive. The element that was most frequently remarked upon and drawn was the river Thames at a total of 33 times. There were dozens of elements which were only mentioned or drawn once, making them the lower ranked elements.

The analysis of the maps that represented central London revealed that each participant had a different estimation of the size of the city centre. The map with the smallest size represented an area limited north by Oxford street, south by Piccadilly, east by Regent's street and west by Park Lane. The map that covered the larger area was roughly coincided with the boundaries of the zone 2 as defined in the maps produced by Transport for London (TFL).

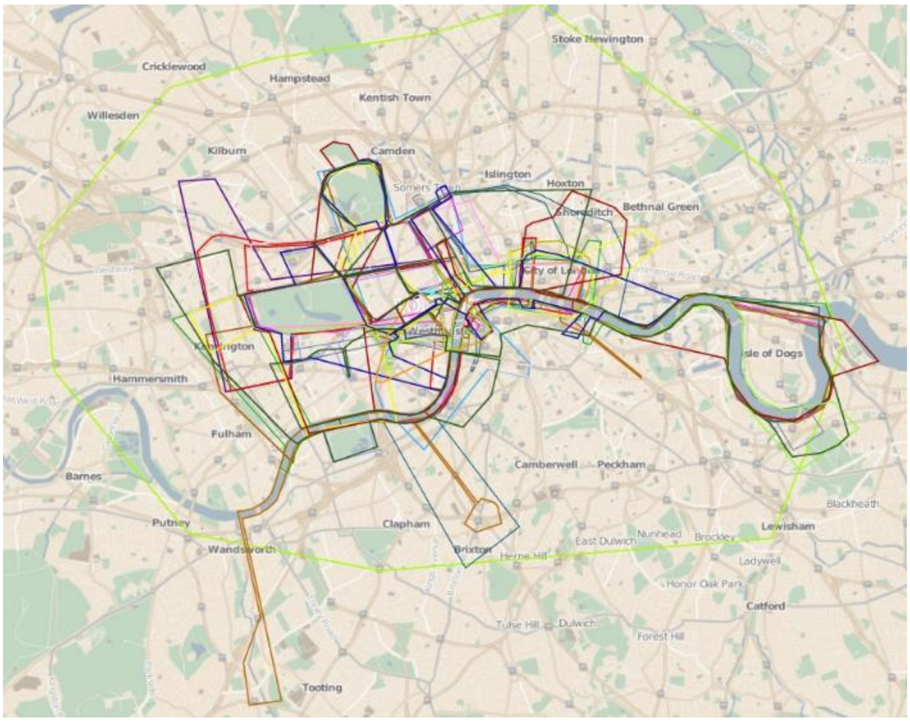


Figure 15. The different limits of the centre of London in the maps, retrieved from the drawing of the participants.

It was also noticed that a large number of participants visualized the city according to its system of public transports, specifically the map of the underground. This aspect also emerged in the walking interviews, when a few participants declared that their spatial references were the underground stations.

The account of elements which emerged from the verbal interview and the drawing of the maps with a frequency above 12%[159] are listed in the next table, by order of frequency, from high to low. The elements were classified according to Lynch's nomenclature as landmarks (L), Nodes (N), Paths (P), Edges (E), or districts (D). In this study, only the fifty first elements were used in the next phase of the study, roughly those with a frequency equal or above 20%.

159 The same threshold used by Lynch to represent the elements on maps.

#	Element	Total frequency	Classification
1	The river Thames	33	E
2	Oxford Street	31	P
3	Hyde Park	26	D
4	Saint Paul’s Cathedral	24	L
5	The London Eye	23	L
6	Oxford circus	23	N
7	Big Ben	22	L
8	Trafalgar Square	22	N
9	Tower Bridge	22	L/P
10	The Houses of Parliament	21	L
11	Buckingham Palace	21	L
12	Tate Modern	18	L
13	The Gherkin	16	L
14	Covent Garden	16	D
15	Regent Street	14	P
16	Marble arch	13	L
17	Regent's Park	12	D
18	Leicester Square	12	N
19	Piccadilly Circus	12	N
20	Soho	11	D
21	The City	11	D
22	The Millennium Bridge	11	P/L
23	Kensington	10	D
24	Southbank	10	D
25	Westminster Bridge	10	P
26	Waterloo Bridge	10	P
27	Kings Cross and Saint Pancras Stations	9	L/N
28	The British Museum	9	L
29	Saint James's Park	9	D
30	Harrods	8	L
31	Centre Point	8	L
32	The Natural History Museum	8	L
33	Green Park	8	D
34	The Strand	8	P
35	Piccadilly	8	P
36	The Tower of London	7	L
37	Euston Station	7	L/N
38	The West End	7	D
39	Tottenham Court Road	7	P
40	The Mall	7	P
41	Globe Theatre	6	L
42	Westminster Abbey	6	L
43	The National Gallery	6	L
44	Madame Tussauds Museum	6	L

45	Victoria Station	6	L/N
46	Bond Street underground station	6	N
47	China Town	6	D
48	Notting Hill	6	D
49	Westminster	6	D
50	The National Theatre	5	L
51	*Charing Cross Station*	*5*	*L/N*
52	*Museum V&A*	*5*	*L*
53	*The Barbican*	*5*	*L*
54	*Hyde Park Corner*	*5*	*N*
55	*Waterloo Station*	*5*	*N*
56	*Canary Wharf*	*5*	*D*
57	*Knightsbridge*	*5*	*D*
58	*UCL campus*	*5*	*D*
59	*Euston Road*	*5*	*P*
60	*Albert Bridge*	*5*	*P/L*
61	*Blackfriars Bridge*	*5*	*P*
62	*Royal Albert Hall*	*4*	*L*
63	*The Shard*	*4*	*L*
64	*Bank of England*	*4*	*L*
65	*The Science Museum*	*4*	*L*
66	*Royal Festival Hall*	*4*	*L*
67	*Saint Katharine Docks*	*4*	*D*
68	*Embankment*	*4*	*D*
69	*Shoreditch*	*4*	*D*
70	*Mayfair*	*4*	*D*
71	*Southwark*	*4*	*D*
73	*Holborn*	*4*	*D*
74	*Portobello Road*	*4*	*P*
75	*Whitehall*	*4*	*P*
76	*Baker Street*	*4*	*P*
77	*Fleet Street*	*4*	*P*
78	*Elephant and Castle*	*4*	*N*

Table 15. Table of those elements that emerged from the verbal interview of London with a frequency of 12% or above. The elements which are highlighted with a grey background are the 50 most distinct elements which were presented in the photographic interviews.

These elements can also be visualized on a map, according to the frequency in which they were mentioned:

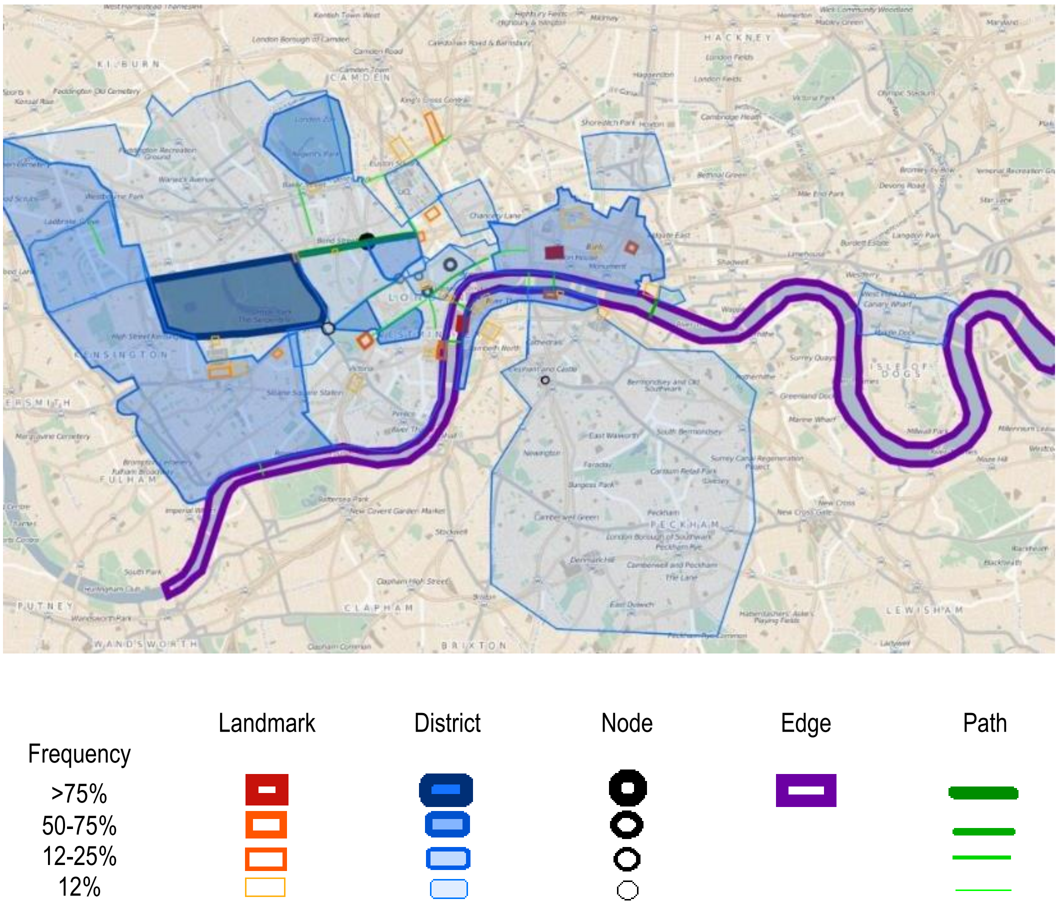


Figure 16. Mapping of all elements drawn and mentioned by the participants. Landmarks in red, edges in purple, districts blue, nodes in yellow and paths in green colour. The borders correspond to those elements described in the interview and the coloured areas to the elements that were drawn.

The only element classified as an edge in London was the River Thames, which was also the most frequently mentioned and sketched element of the city. The other most distinctive elements were: As a district Hyde Park; as a path, Oxford Street; as a landmark Saint Paul's Cathedral and as a node Oxford Circus. The type of elements which overall appeared in greater number were landmarks, followed by districts, paths, nodes and lastly edges.

The main five landmarks that were pointed by the participants were Saint Paul's Cathedral, The London Eye, Big Ben, Tower Bridge (which could also be classified as a path) and the Houses of Parliament. Figure 17 represents all landmarks that emerged from the verbal interview with a frequency above 12%.

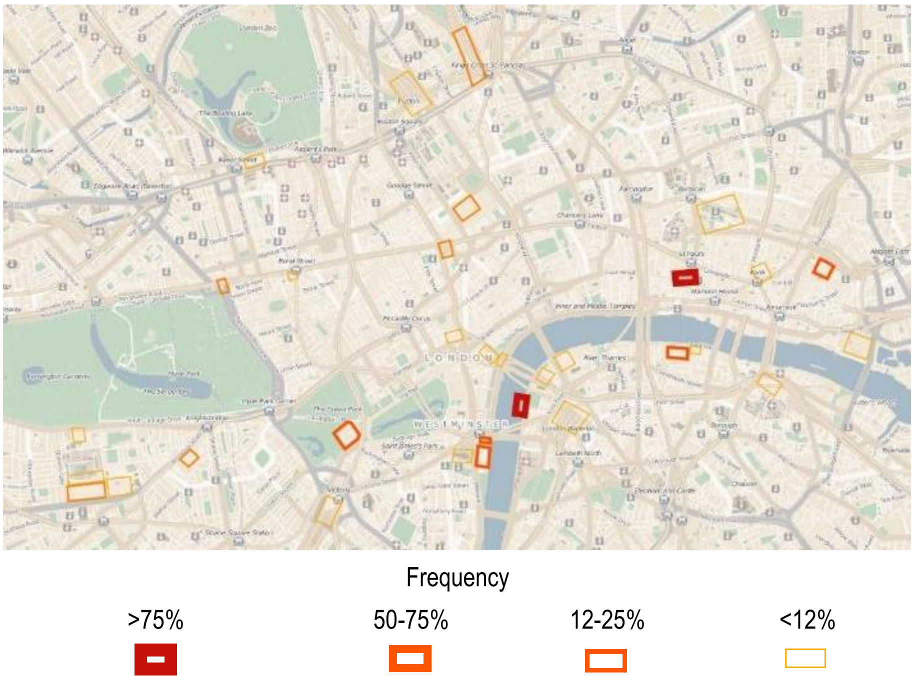


Figure 17. Location on map of the results of the verbal interviews for all *landmarks* with a frequency above 12% in London.

The most distinctive nodes were by order, Oxford Circus, Trafalgar Square, Leicester Square, Piccadilly Circus and Hyde Park Corner.

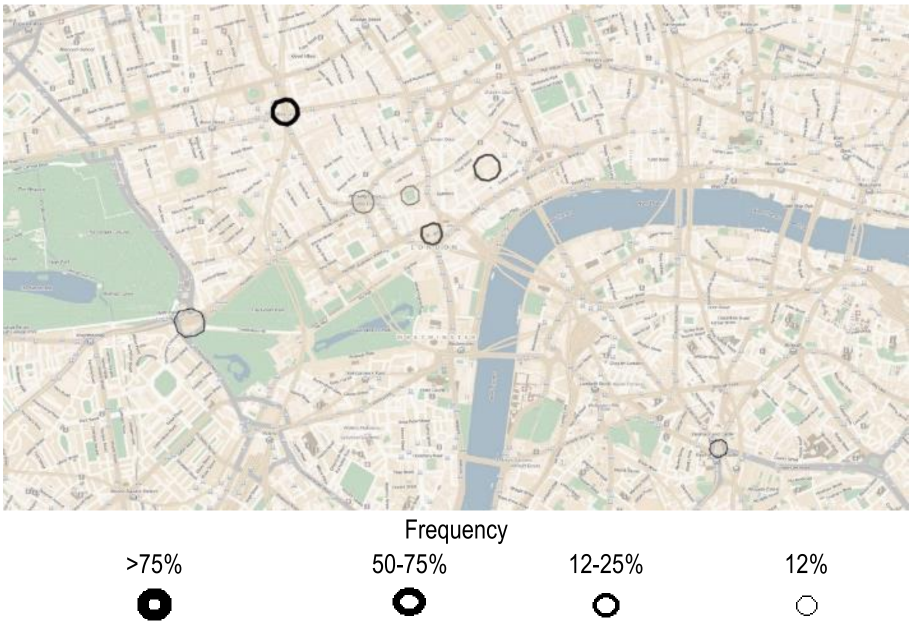


Figure 18. Location on map of the results of the verbal interviews for all *nodes* with a frequency above 12% in London.

The five most frequently mentioned and drawn districts were Hyde Park, Covent Garden, Regent's Park, Soho and the City.

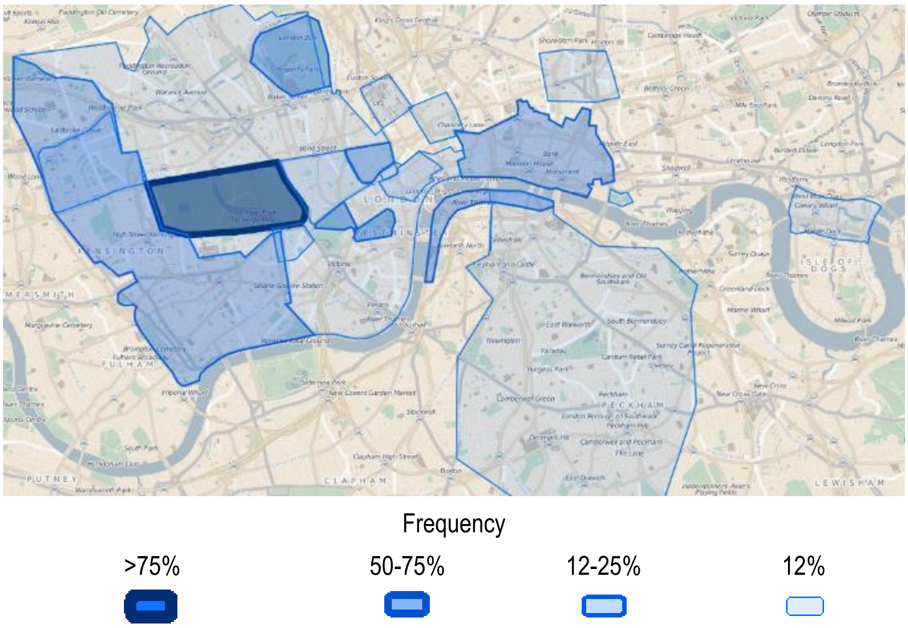


Figure 19. Location on map of the results of the verbal interviews for all *districts* with a frequency equal or above 12% in London.

The paths with a stronger image in London were, first Oxford Street, Tower Bridge (which was also considered a landmark), Regent Street, The Millennium Bridge, (also a landmark) and Westminster Bridge.

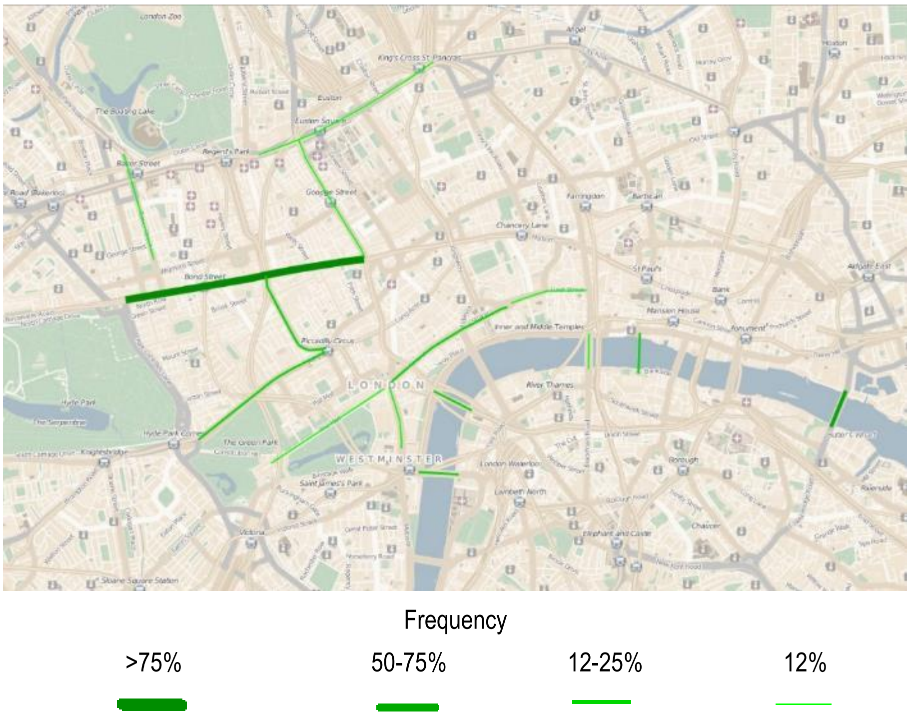


Figure 20. Location on map of the results of the verbal interviews for all *paths* with a frequency above 12% in London.

The most distinctive elements which were extracted from the combination of the questionnaires and the sketching exercises were afterwards photographed and presented in a second set of interviews: The photographic interviews.

THE RESULTS IN LONDON

For the photographic interviews

According with the statistical analysis, and as previously described, there were only a certain number of elements which revealed statistically relevant differences between the day and night time interviews. To understand the reasons for the discrepancies in responses, these were examined in greater detail. The results will be described through the previously established order[160] of the recognisability of the elements, from high to lower recognisability. The results of the interviews for these specific elements will be presented next. These are (in recognisability order): the river Thames, Hyde Park, Tate Modern, the Gherkin, the Millennium Bridge, the Westminster Bridge, Waterloo Bridge, the British Museum, St. James's Park, Harrods, Centre Point, the Natural History Museum, Green Park, Victoria Station, and the National Theatre.

The strength of the differences in results when comparing the responses to the day and night-time photographs varied. To express these differences a different colour was applied at each parameter as it can be observed in the table on the next page. Thus:

	Orange colour for when the pairs of results were tested for significance and power at the conventional values of respectively 5% and 80%
	Dark yellow for power set at the conventional value, but significance at 10%.
	The light yellow colour corresponds to significance set at 10% and power at 70%

This colour scheme was also applied when presenting the detailed results for each element.

---

160 The elements were ranked according to its recognition level, from 1 to 50, in the verbal interviews.

		NUMBER OF CORRECT IDENTIFICATIONS		NOT IDENTIFIED		MISIDENTIFIED		CORRECTLY IDENTIFIED BUT THE PRIMARY ELEMENT IDENTIFIED WAS ANOTHER OBJECT IN THE PICTURE		NOT IDENTIFIED BUT RECOGNIZES THE AREA		CORRECTLY IDENTIFIED BUT WITH DOUBTS	
#		DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
1	The river Thames	15	15	0	0	0	0	14	8	0	0	0	0
2	Oxford Street	10	12	2	3	3	1	5	6	0	0	0	0
3	Hyde Park	14	0	0	6	1	9	0	0	0	0	0	0
4	Saint Paul's Cathedral	15	15	0	0	0	0	0	0	0	0	0	0
5	The London Eye	15	15	0	0	0	0	0	0	0	0	0	0
6	Oxford Circus	12	14	1	0	2	1	2	1	0	0	0	0
7	Big Ben	15	15	0	0	0	0	8	4	0	0	0	0
8	Trafalgar Square	15	15	0	0	0	0	0	0	0	0	0	0
9	Tower Bridge	15	15	0	0	0	0	0	0	0	0	0	0
10	The Houses of Parliament	15	15	0	0	0	0	1	3	0	0	0	0
11	Buckingham Palace	15	15	0	0	0	0	0	0	0	0	0	1
12	The Tate Modern	14	15	1	0	0	0	0	8	0	0	0	2
13	The Gherkin	15	6	0	6	0	3	0	0	0	0	0	6
14	Covent Garden	14	12	1	1	0	2	0	0	0	0	0	1
15	Regent's Street	14	13	1	1	0	1	0	0	0	0	0	0
16	Marble Arch	14	13	0	1	0	1	0	0	0	0	0	1
17	Regent's Park	9	11	1	1	5	3	0	0	0	0	0	1
18	Leicester Square	10	12	5	2	0	1	0	3	0	0	0	2
19	Piccadilly Circus	15	15	0	0	0	0	0	0	0	0	0	0
20	Soho	8	11	5	3	2	1	0	0	0	0	1	1
21	The City	15	15	0	0	0	0	1	4	0	0	0	0
22	The Millennium Bridge	15	15	0	0	0	0	0	5	0	0	0	0
23	Kensington	5	10	5	2	5	3	0	0	0	0	0	1
24	Southbank	15	15	0	0	0	0	0	1	0	0	0	0
25	Westminster Bridge	14	15	1	0	0	0	0	6	0	0	0	0
26	Waterloo Bridge	5	11	7	1	3	3	0	5	0	0	0	0
27	Kings Cross & St. Pancras Stations	10	14	2	1	2	0	1	0	0	0	0	0
28	The British Museum	11	5	3	2	1	8	0	0	0	0	0	3
29	St. James's Park	13	10	0	5	2	0	0	1	0	5	0	1
30	Harrods	15	12	0	2	0	1	0	0	0	0	0	0
31	Centre Point	9	13	3	1	3	1	3	0	0	0	0	0
32	The Natural History Museum	9	3	2	3	4	9	0	0	0	0	0	3
33	Green Park	3	0	6	11	6	4	0	0	0	0	0	0
34	The Strand	3	5	3	5	9	5	0	0	0	0	0	1
35	Picadilly	10	8	2	2	3	5	0	0	0	0	0	0
36	The Tower of London	13	14	2	1	0	0	0	0	0	0	1	2
37	Euston Station	15	15	0	0	0	0	0	0	0	0	0	0
38	The West End	15	15	0	0	0	0	0	0	0	0	0	0
39	Tottenham Court Road	12	11	2	2	1	2	0	1	0	0	0	0
40	The Mall	14	14	1	1	0	0	0	2	0	0	0	0
41	Globe Theater	11	11	3	4	1	0	0	0	0	0	0	0
42	Westminster Abbey	15	13	0	2	0	0	0	0	0	0	0	1
43	The National Gallery	15	15	0	0	0	0	0	0	0	0	0	0
44	Madame Tussauds	12	11	3	4	0	0	0	0	0	0	0	1
45	Victoria Station	6	6	4	5	5	4	0	0	0	0	0	4
46	Bond Street Station	15	15	0	0	0	0	0	0	0	0	0	0
47	China Town	15	15	0	0	0	0	0	0	0	0	0	0
48	Notting Hill	8	7	2	4	5	4	0	0	0	0	2	0
49	Westminster	14	14	0	1	1	0	0	0	0	0	0	0
50	The National Theatre	12	15	2	0	1	0	2	5	0	0	0	0

Table 16. The summary table for the photographic interview of London with highlighted cells for those pairs of numbers which correspond to statistically important differences in responses between day and night-time interviews.

The detailed analysis of urban elements

The River Thames

The river Thames ranked as the most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for the river regard the number of correct identifications in which the primary element was not the target of the photograph.

The river was better recognized as the target of the photograph in its night-time version than in its day-time one. When looking at the day-time picture all participants, except one, asserted that the depicted objects were the Houses of Parliament and the London Eye, Big Ben or Westminster. But, when the other participants observed the night-time picture their responses were almost equally divided, between the river and the Houses of Parliament, London Eye and Big Ben as being the main targets of the picture.

A possible explanation for this result is the fact that the lights reflected on water at night, make the river more conspicuous than during the day, prompting individuals to notice it more. It was observed that the river was pointed more often in the nocturne images in eight out of eleven sets of pictures, in which the river was present. This hypothesis will be revisited further ahead in the conclusions of this chapter.

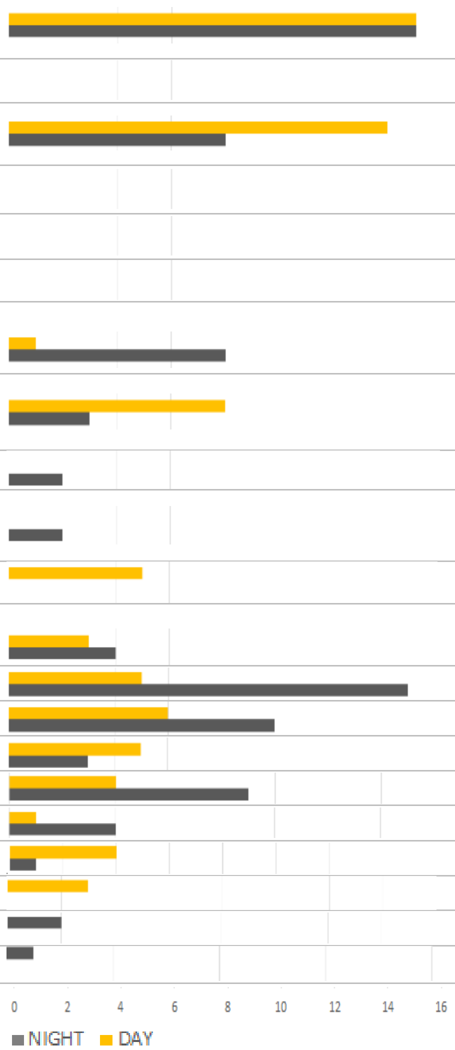
The reflections of the Houses of Parliament lighting on the river waters is visible when observing the luminance patterns map, and is even more apparent when looking at the comparison between the edge detection images generated from the daytime and the nigh-time images. It is also evident, both from the observation of the results of the interviews and from the analysis of the images, that Big Ben and the London Eye seem to have almost the same weight both in the day and night-time pictures, but the Houses of Parliament are much more salient in its night version than in the day one, where its main façade is in shadow.

LONDON

THE RIVER THAMES Rank # 1

The analysis of responses

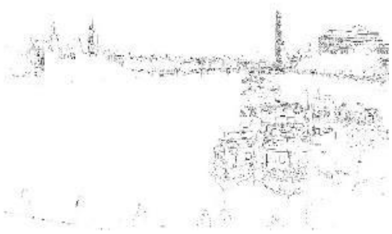
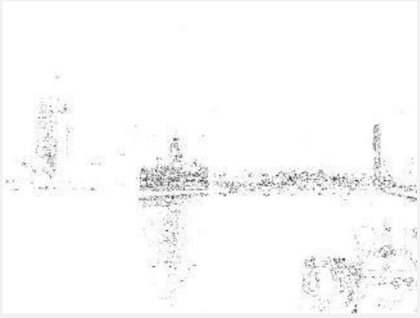
		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**15**
	But unsure	0	0
	But not as the primary object portrayed	**14**	8
	Not identified	**0**	**0**
	But recognizes the area	0	0
	Misidentified	0	0
Primary element recognized	**The river**	1	**8**
	The Houses of Parliament and the London eye	8	3
	The Parliament and Big Ben	0	2
	The Houses of Parliament London eye and Big Ben	0	2
	Big Ben	5	0
Recognizable features	Big Ben	3	4
	The Houses of Parliament	5	15
	The London Eye	6	10
	The river	5	3
	The Westminster Bridge	4	9
	Boats	1	4
	Unmistakable	4	1
	Westminster	3	0
	Blue lighting	0	2
	Yellow lighting	0	1



LONDON

THE RIVER THAMES Rank # **1**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns

(cd/m^2)

Hyde Park

Hyde Park ranked as the 3rd most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for Hyde Park regard the number of correct identifications, the number of no identifications, and the number of misidentifications.

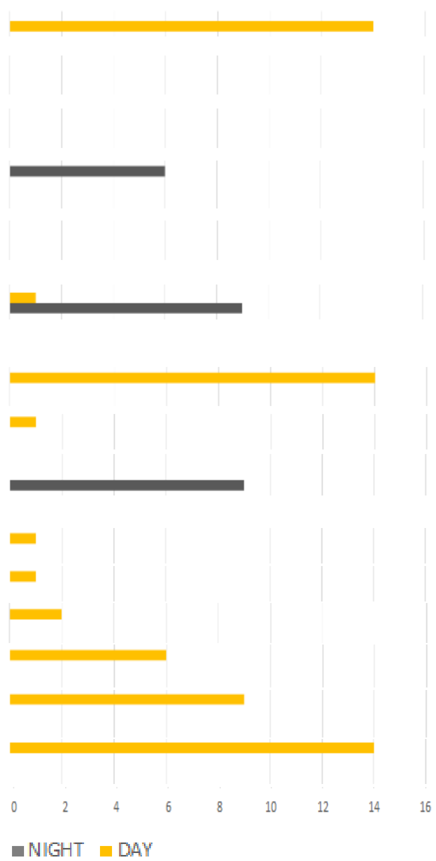
Hyde Park is highly recognizable (correctly identified by all participants except one) in its day depiction, but completely unrecognized in the night-time version. The day-time photograph captures the main features that had been stated by the participants, in the verbal interviews, as main clues for its recognition, but these are completely submerged in darkness at night. The luminance measurements at the site, were close to 0 cd/m^2, thus leaving no clues visible, and making the participants unable to identify the park at night. However, some decided to take a guess based on the perception of reflected lights on a body of water. These decided that they were probably observing a photograph depicting the river at night, where the poorly lit coffee shop on the left was a pier. Because there was almost no light, the field measurements in Hyde Park did not yield any useful results, and hence no luminance map was produced. However, observing the images resulting from the edge detection technique, it is visible how there are almost no edges, thus shapes, visible at night.

LONDON

HYDE PARK Rank # 3

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**14**	**0**
	But unsure	0	0
	But not as the primary object portrayed	0	0
	Not identified	**0**	**6**
	But recognizes the area	0	0
	Misidentified	**1**	**9**
Primary element recognized	**Hyde Park**	14	**0**
	St. James's Park	1	0
	Somewhere by the river	0	9
Recognizable features	People	1	0
	The footpath	1	0
	The green and open space	2	0
	The horse track	6	0
	The coffee shop	9	0
	The lake	14	0



LONDON

HYDE PARK Rank # **3**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Tate Modern

The Tate Modern Museum ranked as the 12th most recognizable element of London in the verbal interviews. The statistically relevant differences between day and night-time photographic interviews for the Tate Modern regard the number of correct identifications in which the primary element recognized was not the main target of the picture.

The set of participants who examined the day-time image declared that the depicted element was the Tate Modern, whereas the participants who observed its night-time version identified the Millennium Bridge instead, after which they would detect the museum.

Both the Tate Modern and the Millennium Bridge are only partially lit. The ratio between the average luminance of the bridge and the average luminance of the rest of the picture is lower than that between the Tate Modern and the rest of the picture. Respectively it is around 0.5/0.3 cd/m^2 and 1.3/0.2 cd/m^2, which corresponds to an almost absence or very low luminance contrast for a both the bridge and the building against its background. However, the bridge is lit in such a way that allows it to be recognizable, whereas the museum would be almost unrecognizable if the bridge was not in the picture (as stated by most of the interviewees who examined the night-time photograph).

The most recognizable feature of the Tate façade, is its chimney (as stated by 80% of the participants from the group who observed the day-time photographs). However, this element is almost invisible at night, and it was not mentioned by any of the participants who observed the night-time image. The contrast of the chimney against its background is almost non-existent, as the average luminance of the chimney is practically null, at around 0.07 cd/m^2, set against a context of around 0.4 cd/m^2 for the rest of the image. Even the only apparently visible region of the chimney (its lower area), presents a negligible contrast and a slightly lower average luminance than its immediate background at a ratio of 1.6/2.3 cd/ m^2.

The areas of higher luminance in the night-time picture are the horizontal lines of windows that flank the chimney of the building. However, these do not seem to be the best reference to allow a correct identification of the building.

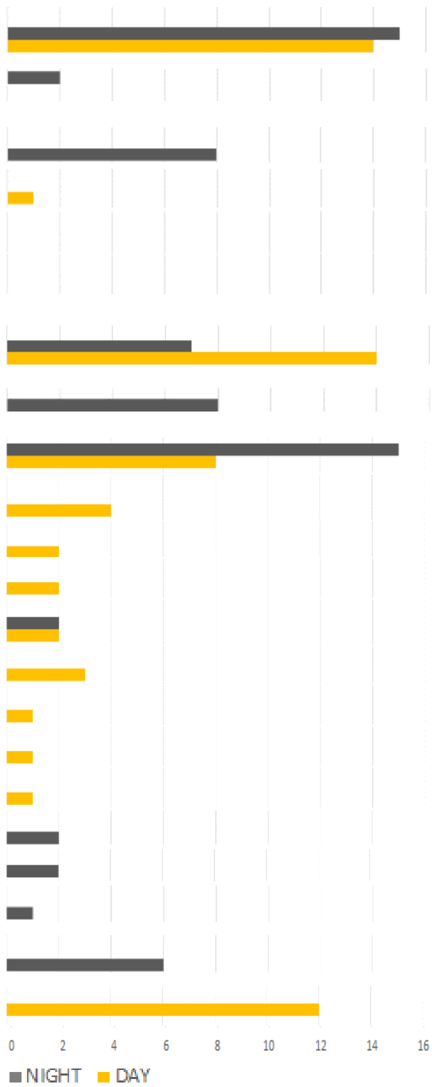
Examining the day and night-time visible edges of these photographs, it becomes clearer, how lighting transforms the perception of Tate Modern. At night, the horizontal lines of the building become stronger and the vertical lines that define the shape of the chimney disappear almost completely. At the same time the shape of the main features of the bridge are still well recognizable, explaining the reason it became the most salient element for those who observed the night-time image of the Tate Modern.

LONDON

TATE MODERN Rank # 12

The analysis of responses

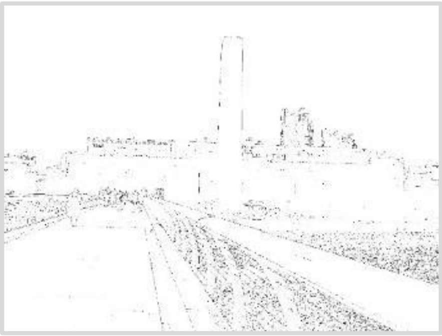
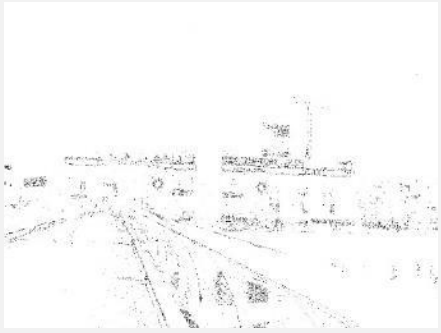
		DAY	NIGHT
Recognition	**Correctly identified**	**14**	**15**
	But unsure	0	2
	But not as the primary object portrayed	0	8
	Not identified	**1**	**0**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	The Tate Modern	14	7
	The Millennium Bridge	0	8
Recognizable features	The Millennium Bridge	8	15
	An industrial building	4	0
	Shape	2	0
	Box appearance	2	0
	Size: big	2	2
	Bricks	3	0
	Distinctive	1	0
	Mysterious	1	0
	Windows	1	0
	Ratio height/length	0	2
	Horizontal line	0	2
	St. Paul's Cathedral	0	1
	Only the bridge allows recognition	0	6
	Chimney	12	0



LONDON

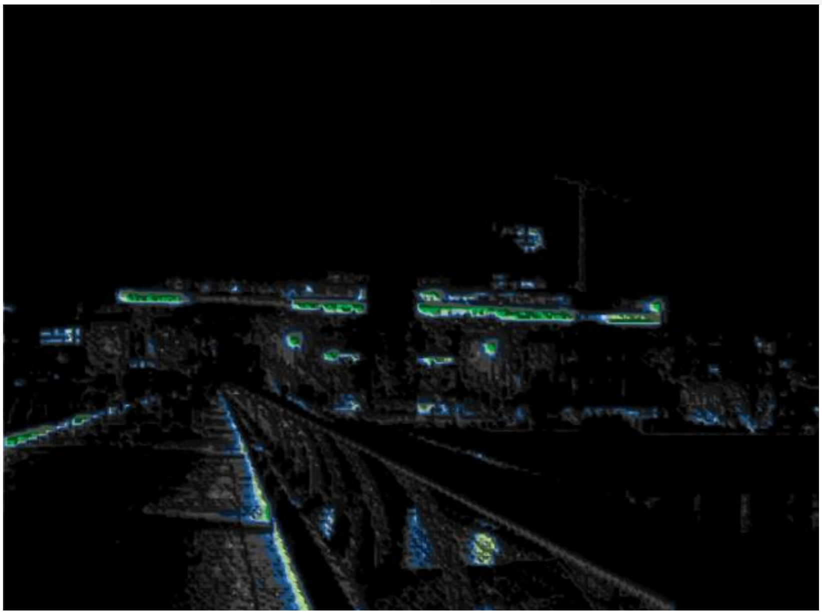
TATE MODERN Rank # **12**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns

(cd/m²)



■ 0.1-0.3 ■ 0.3-0.5 ■ 0.5-1.0 ■ 1.0-2.0 ■ 2.0-4.0 ■ 4.0-8.0 ■ 8.0-16.0 ■ 16.0-32.0 ■ 32.0-64.0 ■ 64.0-100.0

The Gherkin

The statistically relevant differences between day and night-time photographic interviews for The Gherkin regard the number of correct identifications, the number of non identifications, the number of misidentifications and the unconfident correct identifications.

Recognized by all participants who observed the day-time image, its night-time picture was only recognized by those who had either worked nearby or had studied closely the building in the past. Even so, all of the correct recognitions resulting from observing the night-time picture were unconfident assertions, as everyone expressed doubts if indeed they were faced with The Gherkin. There were also a number of misidentifications, with other towers of a completely different shape. However, all participants were able to correctly identify the building when they were confronted with its day-time version at the end of the interview.

The shape of the building was described as the main clue for recognition on the day-time interviews. Due to the almost complete absence of luminance contrast this clue was almost unmentioned at night (with the exception of one participant that was able to point a slightly curved shape). The features which made the recognition possible at night were mainly its criss-cross pattern, the red dots that line the building, and the other surrounding buildings.

As expected there is a small coincidence in the number of common features between the day and night-time version of this element. In fact there is only one common feature, which is the criss-cross pattern.

Euston Tower

Guy's Hospital

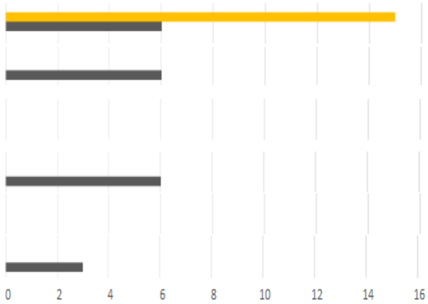
Figure 21. Two of the buildings which were mistaken at night by the Gherkin.

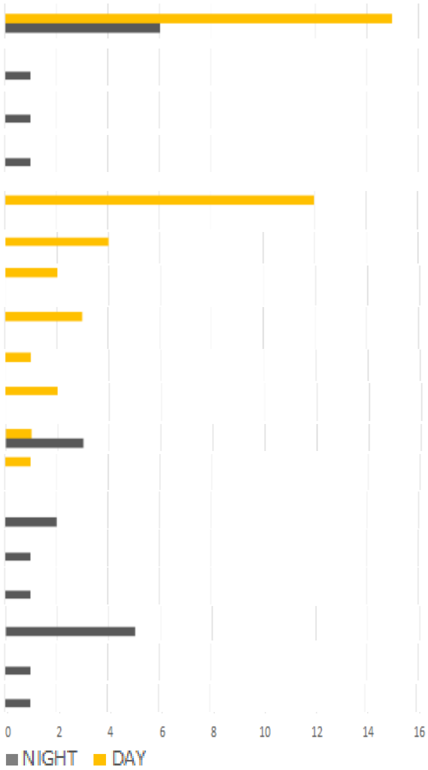
LONDON

THE GHERKIN Rank # 13

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**6**
	But unsure	0	6
	But not as the primary object portrayed	0	0
	Not identified	**0**	**6**
	But recognizes the area	0	0
	Misidentified	**0**	**3**
Primary element recognized	The Gherkin	15	6
	Guy's Hospital	0	1
	79 Euston Tower	0	1
	A tower by Vauxhall Bridge	0	1
Recognizable features	Gherkin shape	12	0
	Glass	4	0
	Metal	2	0
	Different	3	0
	Iconic	1	0
	The City	2	0
	Criss-cross pattern	1	3
	Distinct	1	0
	Red dots	0	2
	Structure	0	1
	Black rock building	0	1
	Participant works near by	0	5
	Heron tower	0	1
	Curved shape	0	1

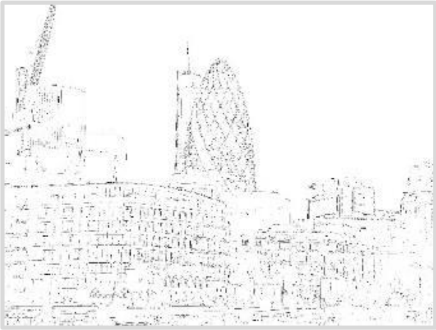
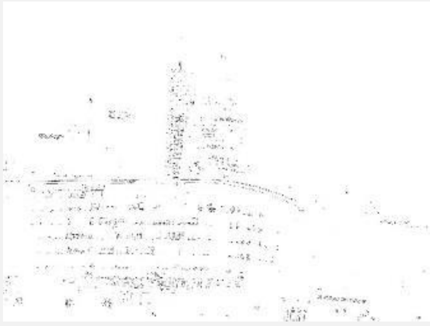




LONDON

THE GHERKIN Rank # **13**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

The Millennium Bridge

The Millennium Bridge was ranked as the 22nd most recognizable element of London in the verbal interviews. The statistically relevant differences between day and night-time photographic interviews for the Millennium Bridge regard the number of correct identifications in which the primary element recognized was not the main target of the picture.

In the interviews in which the participants examined the night-time photograph of the Millennium Bridge, St. Paul's Cathedral was stated by 33% of the participants as the main element depicted, against 0% in its day version. The reason for this result seems to be related to luminance contrast. Even though the bridge is the closer object in the picture, and occupies a larger area than the cathedral.

The contrast ratio of the average luminance of St. Paul's cathedral against its background is higher than that of the Millennium Bridge against its background. The contrast ratio is roughly 30:1[161] for the Cathedral, and 1.5:1[162] for the bridge, thus, making St. Paul's Cathedral more conspicuous than the bridge in the night-time photographs. Furthermore, the bridge is set against a complex background, whereas the cathedral stands against a plain dark sky. Past research[163] suggest that a target becomes less salient as the complexity of its background increases.

The edge detection applied to the Millennium Bridge images confirms how the bridge becomes less clear at night. Its structure and outline are not completely visible, and it stands against a complex background created by the lights of the north bank and its reflections on water.

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[161] L_c estimated at around 6:0.2 cd/m^2

[162] L_c estimated at around 0.3:0.2 cd/m^2

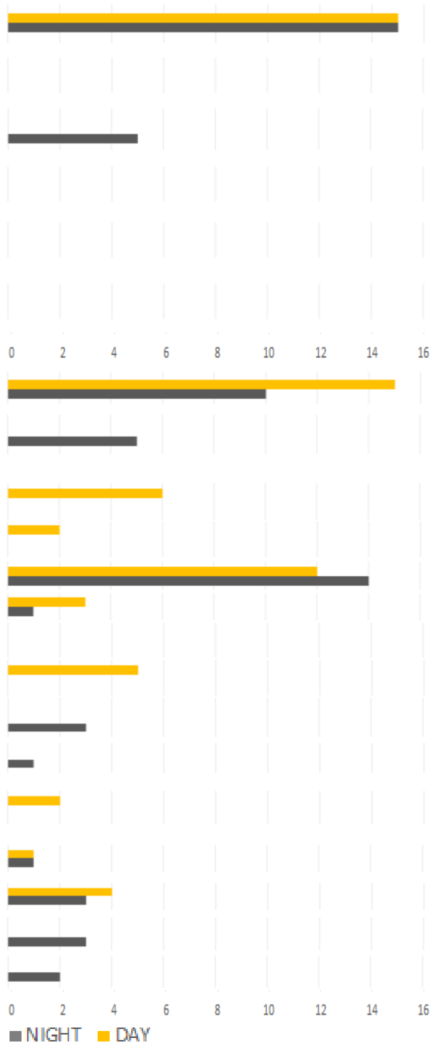
[163163] (Davoudian, 2011), (Turatto, 2000)

LONDON

THE MILLENNIUM BRIDGE Rank # 22

The analysis of responses

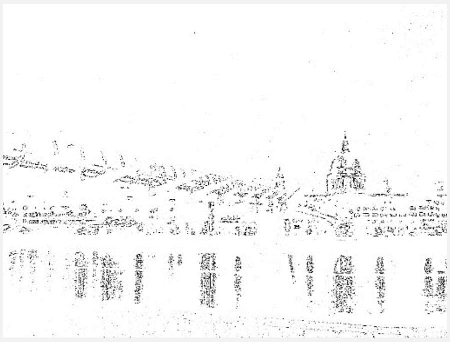
		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**15**
	But unsure	0	0
	But not as the primary object portrayed	0	5
	Not identified	**0**	**0**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	The Millennium Bridge	15	10
	Saint Paul's Cathedral	0	5
Recognizable features	Its shape	6	0
	The cables	2	0
	St. Paul's Cathedral	12	14
	Distinct	3	1
	High bridge	0	0
	Pedestrian bridge	5	0
	The dome	0	3
	The school	0	1
	Connects the Tate to St. Paul's Cathedral	2	0
	The City	1	1
	The structure of the bridge	4	3
	The river	0	3
	Modern design	0	2



LONDON

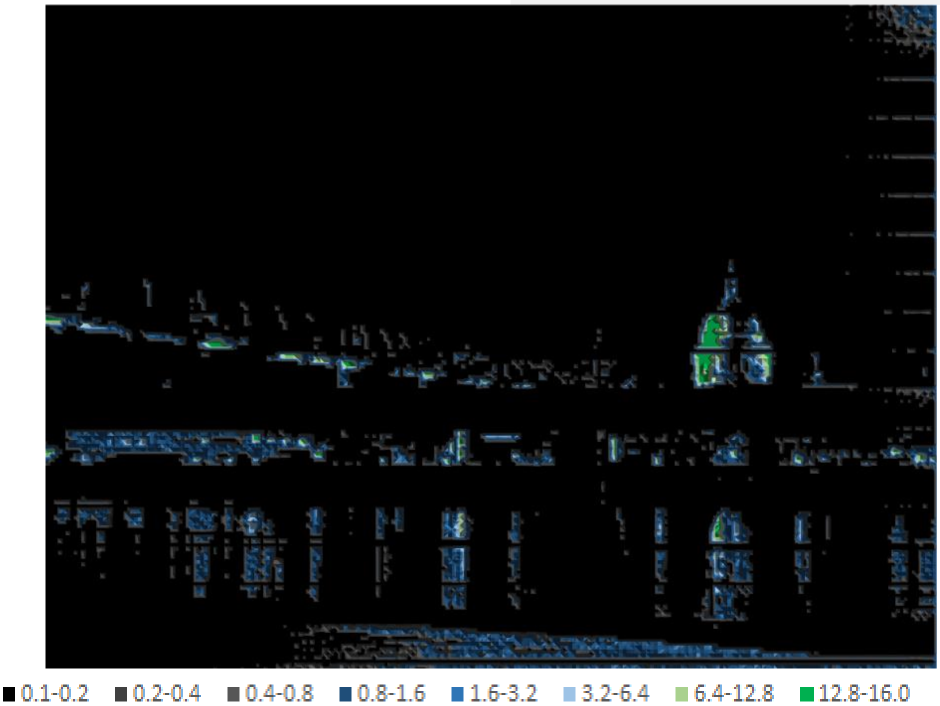
THE MILLENNIUM BRIDGE Rank # **22**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns

(cd/m^2)



Westminster Bridge

Westminster Bridge was ranked as the 25th most recognizable element in London, in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for Westminster Bridge regard the number of correct identifications in which the primary element was not the target of the photograph. Almost half of the participants who observed the night-time image of Westminster Bridge thought that the target of the picture was Big Ben. However, those who observed the day-time photograph all recognized the bridge as the main object depicted in the image.

Big Ben is probably more conspicuous in the night-time photographs than the bridge, due to higher luminance and colour contrast. The reason for the results may also be related to the fact that the day-time photograph was taken in a foggy day, making distant objects, like Big Ben, slightly less visible.

The analysis for the detection of edges for the two images, show that in the night-time picture there were almost no edges detected for the bridge, but that the shape of the tower is well defined. The day-time image presents an opposite scene: The shape of Westminster Bridge was detected and the edges of Big Ben are almost absent.

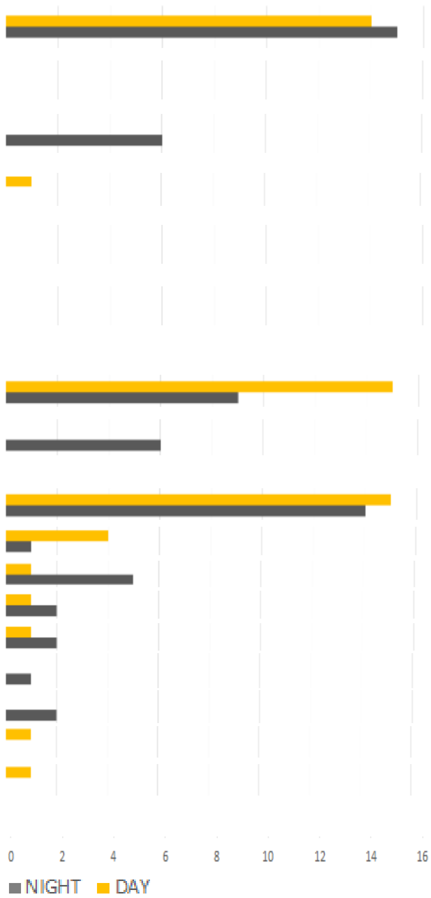
The luminance patterns analysis also show how, in the night-time photograph, the bridge is almost in complete darkness, with an average luminance close to null, and the most conspicuous objects are Big Ben, the lights from the luminaires on the bridge and its reflection on the river surface.

LONDON

WESTMINSTER BRIDGE Rank # 25

The analysis of responses

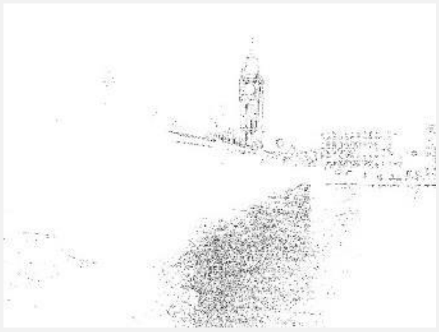
		DAY	NIGHT
Recognition	**Correctly identified**	**14**	**15**
	But unsure	0	0
	But not as the primary object portrayed	0	6
	Not identified	**1**	**0**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	The Westminster Bridge	15	9
	The Big Ben	0	6
Recognizable features	The Big Ben	15	14
	Portcullis House	4	1
	The bridge	1	5
	The river	1	2
	The Houses of Parliament	1	2
	It is a high tower (Big Ben)	0	1
	The clock (Big Ben)	0	2
	The pillars and arches	1	0
	It is an adorned bridge	1	0



LONDON

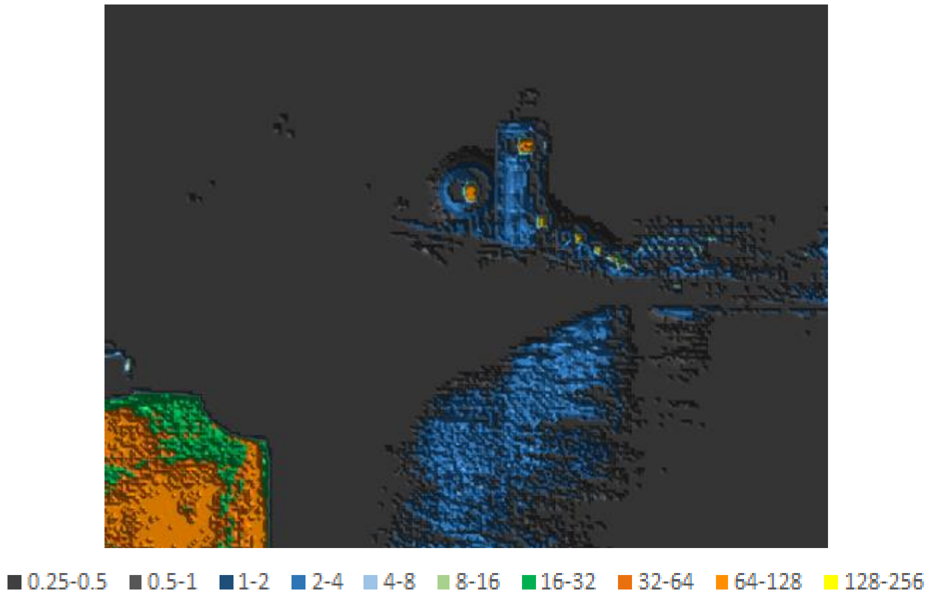
WESTMINSTER BRIDGE Rank # **22**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns

(cd/m²)



Waterloo Bridge

Waterloo Bridge was ranked as the 26th most recognizable element in London, in the verbal interviews. The statistically relevant differences between day and night-time photographic interviews for Waterloo Bridge regard the number of correct identifications, the number of no identifications, and the number of photographs correctly identified but where the primary element recognized was not the target.

Waterloo Bridge had a higher recognition rate in the night-time interviews, most possibly due to the presence of a very conspicuous National Theatre, which, once identified, would in turn allow the identification of the bridge. In fact, in the photographic interviews for night-time images, all of the correct identifications, mentioned the National Theatre as the primary element depicted in the image, instead of Waterloo Bridge. This mistake did not occur in the examinations of the day-time version of the photograph, where people simply mistaken the bridge by another, or did not recognize it.

The clues pointed by those who observed the day-time and night-time photograph of the Waterloo Bridge are almost non coincident. In the first case, the participants enumerated mostly features related to the bridge, but, those who examined the night-time image, described features related to the National Theatre and its lighting. In fact, the prominence of this building seems to be mostly related to its luminance, and particularly its colour contrast.

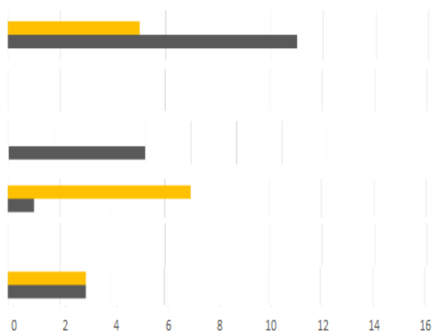
The changes in visual hierarchies are partly confirmed by the edge detector, which reveals much stronger edges at the bridge on its day-time depiction than in the night-time version. The luminance map also shows the salience of the National Theatre against its background.

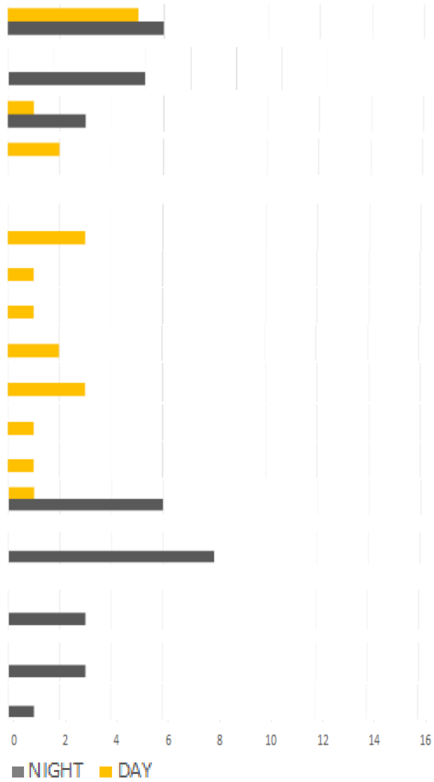
LONDON

WATERLOO BRIDGE Rank # **26**

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**5**	**11**
	But unsure	0	0
	But not as the primary object portrayed	0	5
	Not identified	**7**	**1**
	But recognizes the area	0	0
	Misidentified	**3**	**3**
Primary element recognized	Waterloo Bridge	5	6
	The National Theatre	0	5
	London Bridge	1	3
	Blackfriars Bridge	2	0
Recognizable features	The arches of the bridge	3	0
	An ugly bridge	1	0
	A functional bridge	1	0
	A modern bridge	2	0
	A bridge with simple lines	3	0
	It is made of concrete	1	0
	A TV studios tower behind	1	0
	The National Theatre	1	6
	The lighting/colour of the National Theatre	0	8
	The shape of the National Theatre	0	3
	The Theatre is by the river	0	3
	The Southbank	0	1





LONDON

WATERLOO BRIDGE Rank # **26**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns (cd/m²)

■ 0.125-0.25 ■ 0.25-0.5 ■ 0.5-1 ■ 1-2 ■ 2-4 ■ 4-8 ■ 8-16 ■ 16-32 ■ 32-64 ■ 64-128

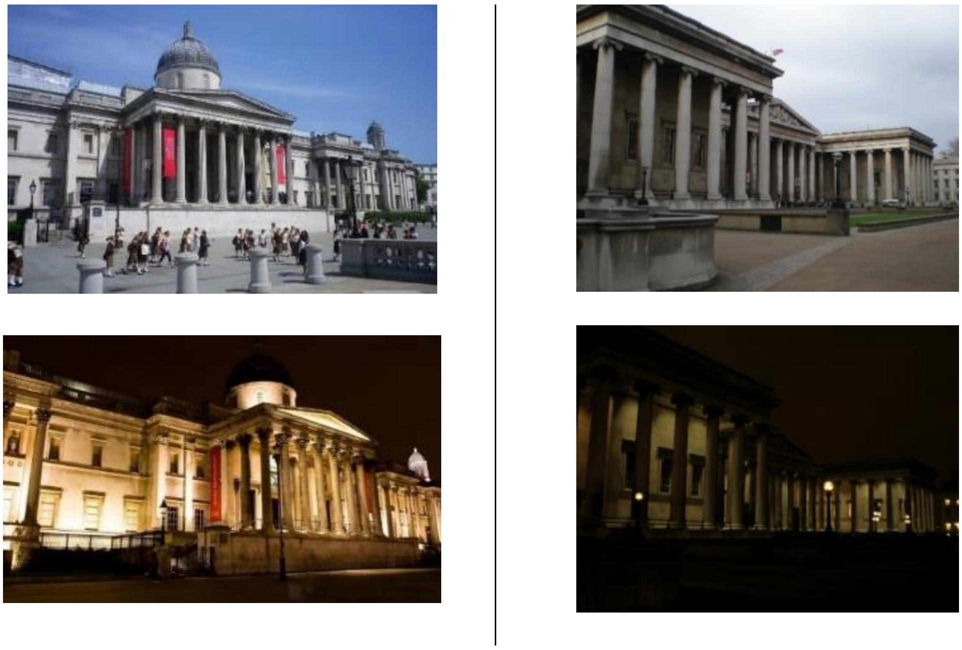
The British Museum

The British Museum was ranked as the 28th most recognizable element in London, in the verbal interviews. The statistically relevant differences between day and night-time photographic interviews for The British Museum regard the number of correct identifications, the number of misidentifications, and the number of participants who correctly identified this element but with doubts.

The Museum was poorly recognized at night, apparently because it is only partly lit, and in such a way that some of its most recognizable features become less apparent. According to the responses of those who observed the day-time image, these were the columns, the architectural style as a whole, and other various features, such as the pediment and the layout of the building. There was little coincidence of recognizable features between the day and night-time photographs of the British Museum. The columns and the architectural style were the only common clues.

At night, the only clues that led to correct identifications were, chiefly, the columns, but these also led to misidentifications with similar buildings. Thus, for the night-time pictures, the museum was consistently confused with the National Gallery and St. Martin's in the Fields church (see Figure 22). The reason for the mistake, as described by the participants after seeing the day-time version of the picture, was the similarity of architectural styles, and particularly the coincident large number of columns in the façades of these buildings. According to the participants, the main factors that would have avoided the misidentification, would have been the perception of the space in front of the museum (specially the grass in front), the perception of depth of the bodies that constitute the façade and of other architectural features such as the pediment.

Six of the eight participants who had misidentified the building were able to recognize it after observing its day-time image.



The National Gallery | The British Museum

Figure 22. A comparison between the daytime (top) and night-time (bottom) images of the National Gallery and The British Museum.

Through the use of the edge detector it is also visible how most of the architectural elements of the building, with the exception of the set of columns, disappear in the night-time picture.

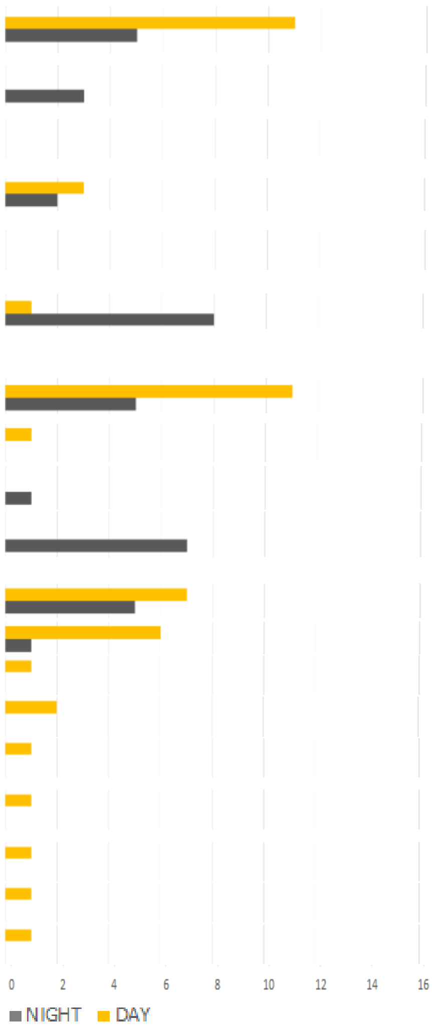
The luminance pattern analysis confirms the transformation in the appearance of the building. The areas of higher luminance are the walls behind the set of columns and the lamps from street lighting. The columns are only perceptible through inverted luminance contrast.

LONDON

THE BRITISH MUSEUM Rank # 28

The analysis of responses

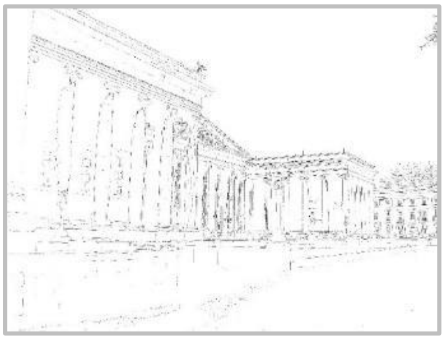
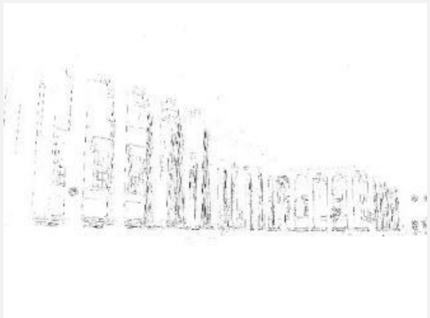
		DAY	NIGHT
Recognition	**Correctly identified**	**11**	**5**
	But unsure	0	3
	But not as the primary object portrayed	0	0
	Not identified	**3**	**2**
	But recognizes the area	0	0
	Misidentified	**1**	**8**
Primary element recognized	The British Museum	11	5
	Greenwich	1	0
	St. Martin-in-the-Fields	0	1
	The National Gallery	0	7
Recognizable features	The columns	7	5
	The architectural style	6	1
	The entrance	1	0
	The pediment	2	0
	The Portico	1	0
	The layout: Two bodies advanced and one back.	1	0
	The steps	1	0
	The shape of the building	1	0
	It is big	1	0



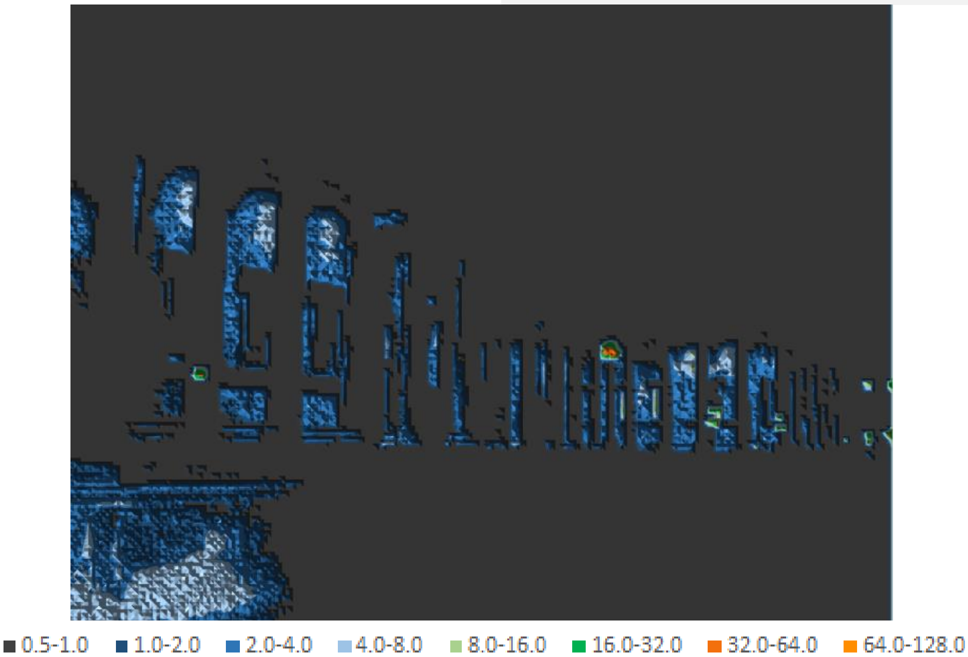
LONDON

THE BRITISH MUSEUM Rank # 28

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns (cd/m²)



St. James's Park

Saint James's Park ranked as the 29th most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for Saint James's Park regard the number of non identifications and the number of participants that did not recognize the element but knew where it was located.

The key feature to both day and night photographic recognition was the Victoria Memorial, which was complemented in the day with observations of the lake and other features of the park. However, in the night-time version, the Memorial, was the only feature that allowed for positive identifications, given that all other features of the park were in almost complete darkness. That may explain the fact that the day picture was correctly identified more often than its night-time version. However, there were only two participants who were able to recognize the park after viewing the day-time version.

Around 30% of the interviewees were unable to recognize the park, but they did recognize the Queen Victoria Memorial, and could therefore place it as being somewhere near Buckingham Palace.

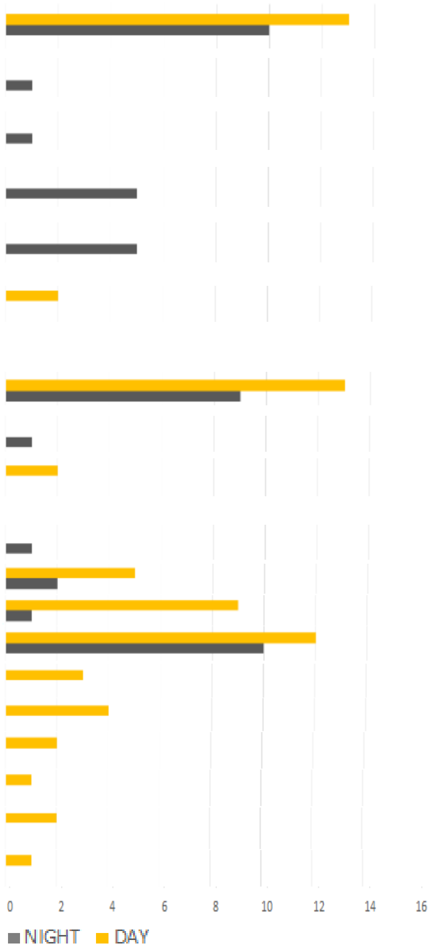
The edge detection software shows that the day-time image is dominated by the edges of trees and elements located in the foreground, whereas the night-time version detects elements located in the background, outside the park. The luminance map confirms that Victoria Memorial seems to be the most salient object there.

LONDON

ST. JAMES'S PARK Rank # 29

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**13**	**10**
	But unsure	0	1
	But not as the primary object portrayed	0	1
	Not identified	**0**	**5**
	But recognizes the area	0	5
	Misidentified	**2**	**0**
Primary element recognized	St. James's Park	13	9
	The Victoria Memorial	0	1
	Hyde Park	2	0
Recognizable features	The trees	0	1
	Buckingham Palace	5	2
	The flags	9	1
	The Victoria Memorial	12	10
	The lake	3	0
	The Mall	4	0
	The gates	2	0
	The flowers	1	0
	The roundabout	2	0
	It is green	1	0



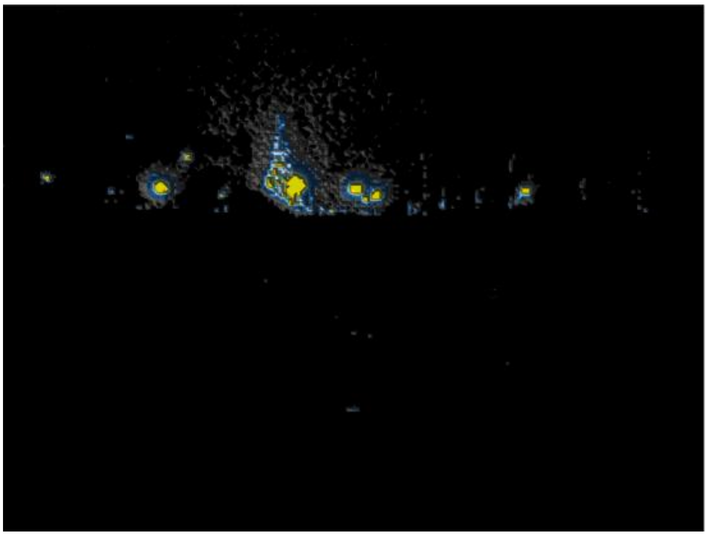
LONDON

ST. JAMES'S PARK Rank # 29

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns (cd/m²)



Harrods

The statistically relevant differences between day and night-time photographic interviews for Harrods regard the number of correct identifications.

In the interviews in which the participants observed the day-time photograph of Harrods, the clues that were more often mentioned as key to identifying this element, were its colour, the green canopies and its flags. These elements were not mentioned in the interviews based on the night-time version of the photograph, with the exception of the flags. The most recognizable feature at night was the lighting of the building. This feature seems to transform the building in such a way, that those who knew the building but were unfamiliar with its night-time appearance, failed to recognize it. Such, that after observing the day-time photograph of the building, at the end of the interview, all participants recognized Harrods.

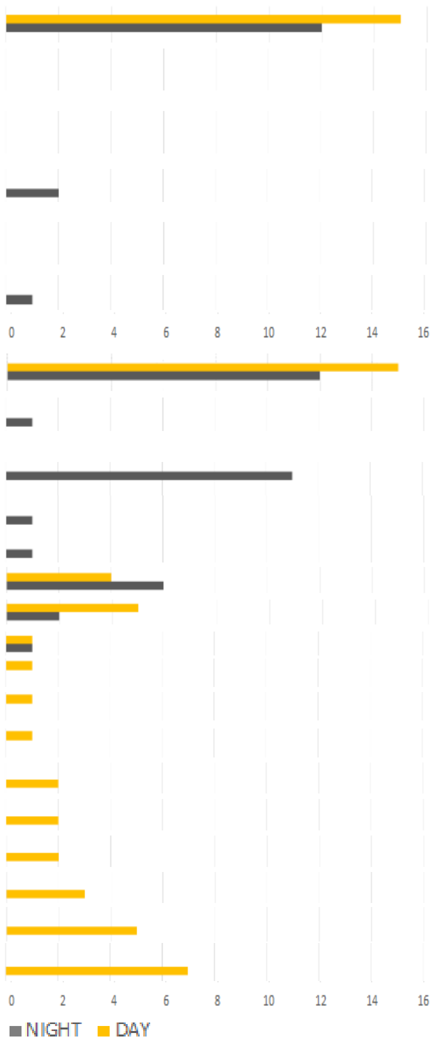
The lighting of the façade of the building is made of lines of light bulbs which enhance the main contours of the building. The edge detector show how the main lines and the shape of the building become reinforced at night, suggesting that its shape was not the most import element for its recognition.

LONDON

HARRODS Rank # **30**

The analysis of responses

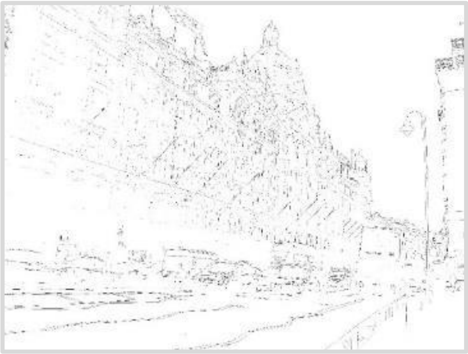
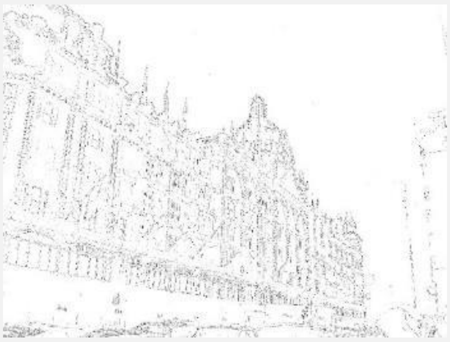
		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**12**
	But unsure	0	0
	But not as the primary object portrayed	0	0
	Not identified	**0**	**2**
	But recognizes the area	0	0
	Misidentified	**0**	**1**
Primary element recognized	Harrods	15	12
	Oxford street	0	1
Recognizable features	Lights	0	11
	Green signs	0	1
	The shape of its corner	0	1
	The dome	4	6
	The flags	5	2
	Big	1	1
	Brick façade	1	0
	Its shape	1	0
	Unique	1	0
	Commercial	2	0
	Iconic	2	0
	The street	2	0
	The windows	3	0
	Canopies	5	0
	The dark brown colour	7	0



LONDON

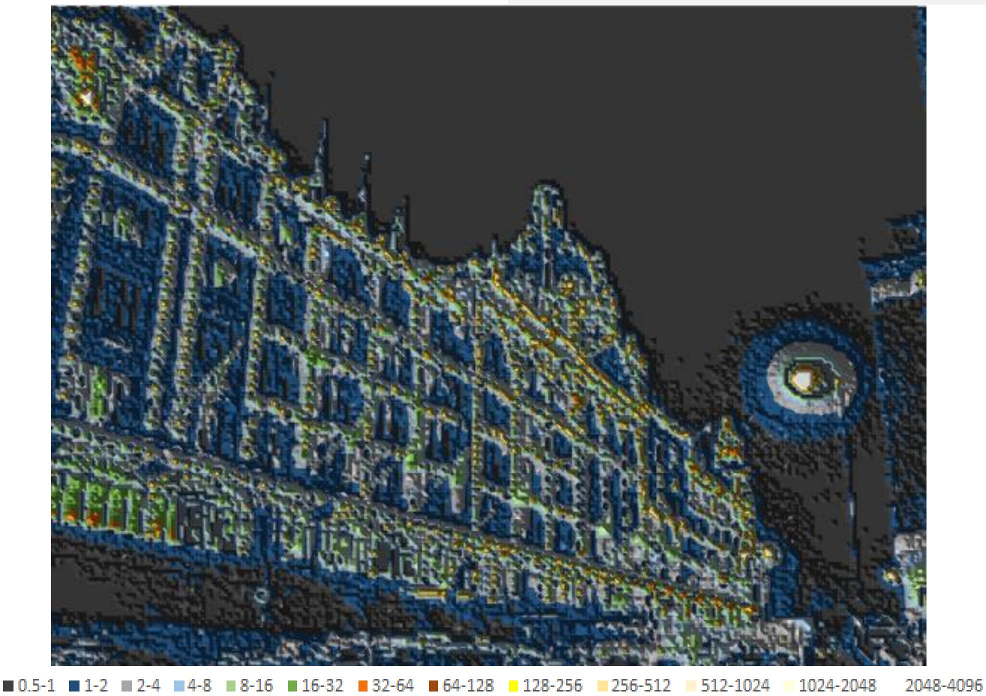
HARRODS Rank # **30**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns

(cd/m²)



Centre Point ranked as the 31st most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for Centre Point regard the number of correct identifications in which the primary element was not the target of the photograph. In fact, a small number of participants thought that the target of the photograph was Tottenham Court Road instead of Centre Point.

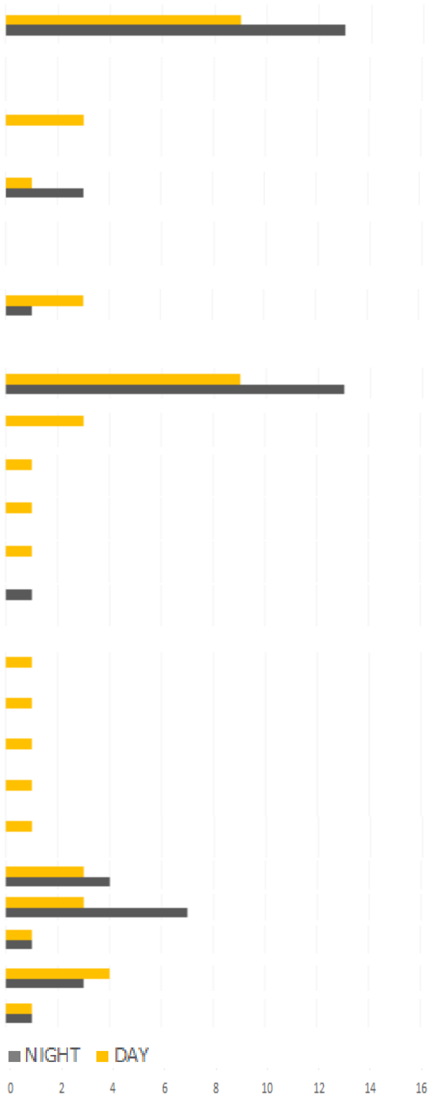
The main clues that differ between the day and the night-time interviews are the perception of the blue colour at the top of the building and the letters reading “Centre Point”, which are only visible at night. These may be the reason why the building is slightly more salient at night. The edge detector shows that the shape of Centre point is better visible in the day-time photograph, and therefore the building appears more salient under daylight than artificial lighting. However, shape was not the main recognizable feature for the identification of this object, thus the edge detector would have been unable to predict its saliency.

LONDON

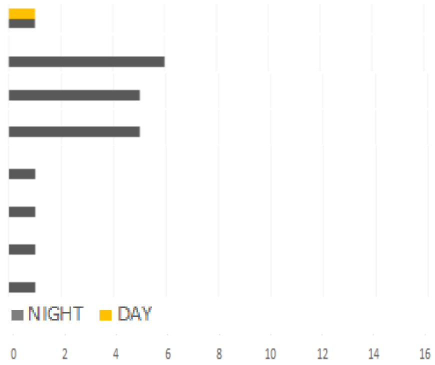
CENTRE POINT Rank # **31**

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**9**	**13**
	But unsure	0	0
	But not as the primary object portrayed	3	0
	Not identified	**1**	**3**
	But recognizes the area	0	0
	Misidentified	**3**	**1**
Primary element recognized	Centre Point	9	13
	Tottenham Court Road	3	0
	Oxford Street	1	0
	Hilton Hotel	1	0
	City Metro Bank	1	0
	Holborn	0	1
Recognizable features	Heels store	1	0
	Building	1	0
	Concrete	1	0
	The 60's	1	0
	Distinctive	1	0
	Tottenham court rd.	3	4
	Tall/ big	3	7
	Ugly	1	1
	Computer stores	4	3
	Structure grid	1	1
	(continues)		



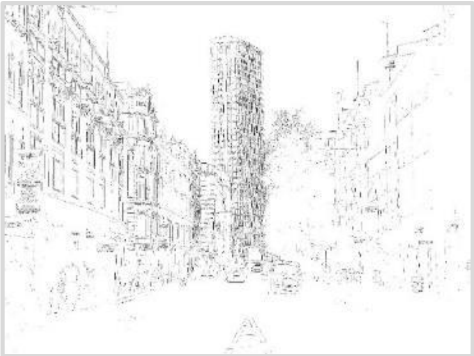
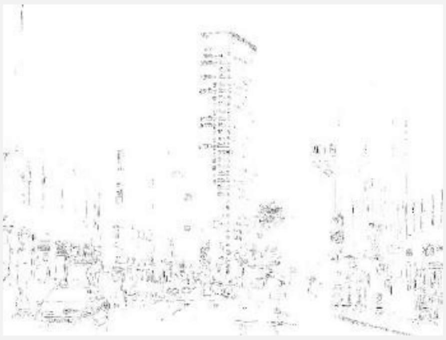
One way street	1	1
Shape	0	6
Blue colour	0	5
It is written centre point	0	5
Homebase	0	1
It provides orientation	0	1
Near oxford street	0	1
Stands alone	0	1



LONDON

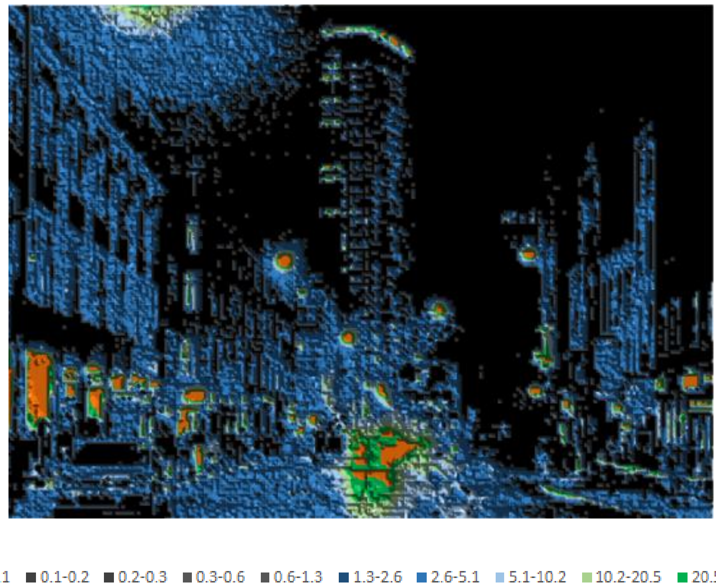
CENTRE POINT Rank # **31**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns

(cd/m²)



The Natural History Museum

The Natural History Museum was ranked as the 32nd most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for the Natural History Museum regard the number of correct identifications and the number of unsure correct answers.

The building was better recognized in the day time photograph, and in fact the only three recognitions that resulted from examining the night-time picture were unconfident responses. The participants could not tell if in fact they were faced with The Natural History Museum.

The main clues described by the participants, who observed the day-time image of this building, were the brick colour and brick work of its facade, its architectonical style and the shape of the building. However, almost none of these features were mentioned in the interviews performed with the night-time version of the picture. This leads one to believe that these features were either invisible or transformed by lighting.

Comparing the two versions of the image of the building, it is clear how at night, the only visible element is the main façade, lit in a uniform fashion. So, the building may appear to be different and to partly lose its depth, since there are no strong visible shadows. On the other hand, the lighting sources[164] seem to provide poor colour rendering, modifying the true colours of the façade, which appears to have a warm and uniform colour, different from its day-time appearance.

Although the difference in results for misidentifications was not revealed to be statistically significant, there were interesting responses in this particular aspect. When observing the day-time photograph, there were four participants who confused the Natural History Museum with three architectonically similar buildings. These were the Westminster Abbey, the Kings College Library and a building at Embankment. The night-time version of the building also elicited misidentifications from nine participants, who confused the museum with Westminster Abbey but more

[164] The facades are lit by luminaires equipped with RGB LEDs tuned to white (according to Mike Simpson, Director of Philips Lighting in the UK, and responsible for the lighting scheme.)

predominantly with the Houses of Parliament. The few three participants who did not make this mistake, and correctly recognized the museum, were unsure of their answer. Apparently, the confusion with the Houses of Parliament was due, not only to the similarity of architectonic styles, which seemed to be reinforced by lighting, but also by the fact that both buildings appear to have a similar colour at night, again induced by the quality of lighting. Interestingly, a small number of participants even pointed Big Ben and the statue of Richard the Lion Heart as being portrayed in the picture, such was the expectation of seeing those elements near the Parliament.

Five out of a total of nine participants, who had misidentified the night-time photograph, were able to correctly identify the Natural History Museum, after seeing its day-time photograph at the end of the interview. Other three declared that they had made a mistake, but were now unable to identify the building. One participant maintained that he was looking at Westminster Abbey from an unusual angle.

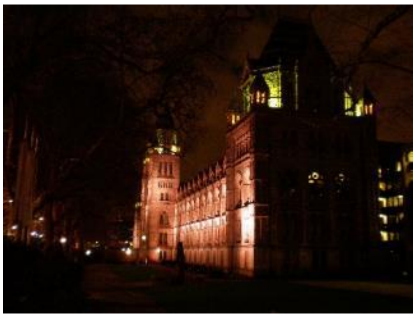


Figure 23. Images of the façades of the Houses of Parliament (on the left), and of the Natural History Museum at night as shown to participants (on the right).

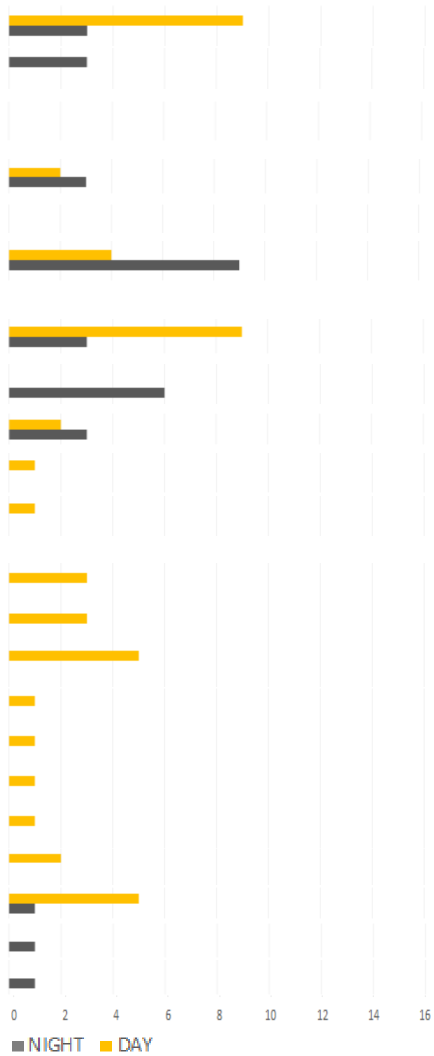
The average luminance contrast of the main façade of the Natural History Museum against its background is low, at around 1:0.1 cd/m^2. Additionally, its lighting scheme seems to create the illusion of an almost flat, long façade. This, allied with a poor colour rendering, the characteristics of the architectonic style, and the specific angle in which the picture was taken, may have contributed for the building to be confused with the Houses of Parliament and Westminster Abbey at night.

LONDON

THE NATURAL HISTORY MUSEUM Rank # 32

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**9**	**3**
	But unsure	0	3
	But not as the primary object portrayed	0	0
	Not identified	**2**	**3**
	But recognizes the area	0	0
	Misidentified	**4**	**9**
Primary element recognized	The Natural History Museum	9	3
	The Houses of Parliament	0	6
	The Westminster Abbey	2	3
	King's College Library	1	0
	A building at Embankment	1	0
Recognizable features	Shape	3	0
	Architectural style	3	0
	Brick work	5	0
	The surroundings	1	0
	Beautiful	1	0
	The gates	1	0
	The decorated façades	1	0
	Turrets	2	0
	Brick colour	5	1
	Tall	0	1
	Windows	0	1



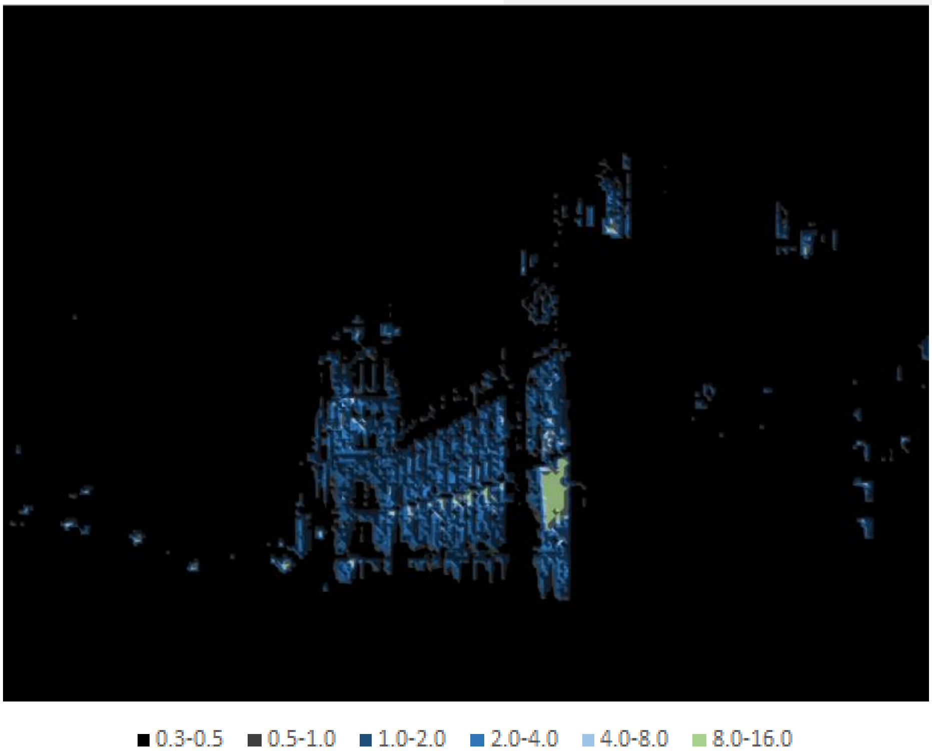
LONDON

THE NATURAL HISTORY MUSEUM Rank # 32

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns (cd/m²)



Green Park

Green Park ranked as the 33rd most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for Green Park regard the number of correct identifications.

Green Park had little recognition for both its day and night-time pictures. However, there were more participants able to make correct identifications at the interviews based in the day-time picture than those based in the night-time photograph. The reason may be related to the lack of any clues, given that the space is very dark at night and there are almost no features with sufficient luminance contrast to be identified.

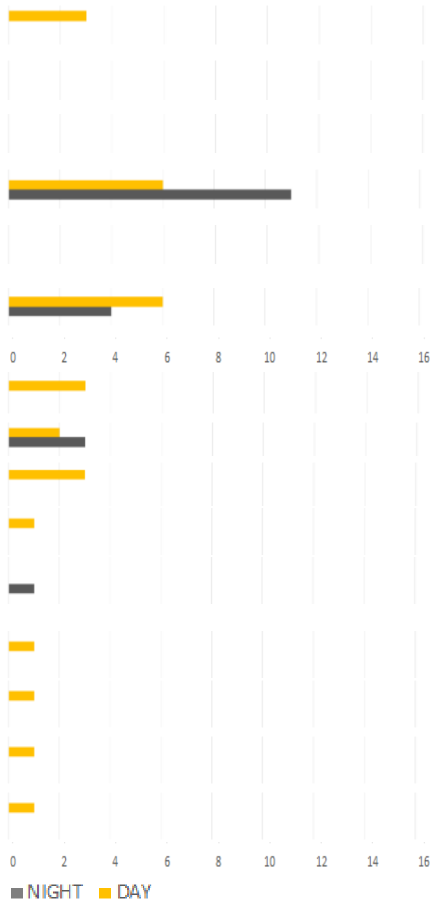
With the exception of one person, after seeing the day-time picture all participants were still unable to identify the park. Thus, the difference in results seems to be of negligible importance, and no further analysis were pursued.

LONDON

GREEN PARK Rank # 33

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**3**	**0**
	But unsure	0	0
	But not as the primary object portrayed	0	0
	Not identified	**6**	**11**
	But recognizes the area	0	0
	Misidentified	**6**	**4**
Primary element recognized	Green Park	3	0
	Regent's Park	2	3
	Hyde Park	3	0
	Battersea Park	1	0
	Southbank	0	1
Recognizable features	The Café	1	0
	The paths	1	0
	The building in the background	1	0
	The Hilton hotel	1	0



Victoria Station

Victoria Train Station was ranked as the 45th most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of unconfident correct identifications.

Both versions of picture of Victoria station had an equal low recognition rate, however, the night-time picture prompted a large number of doubts among those who were able to identify it.

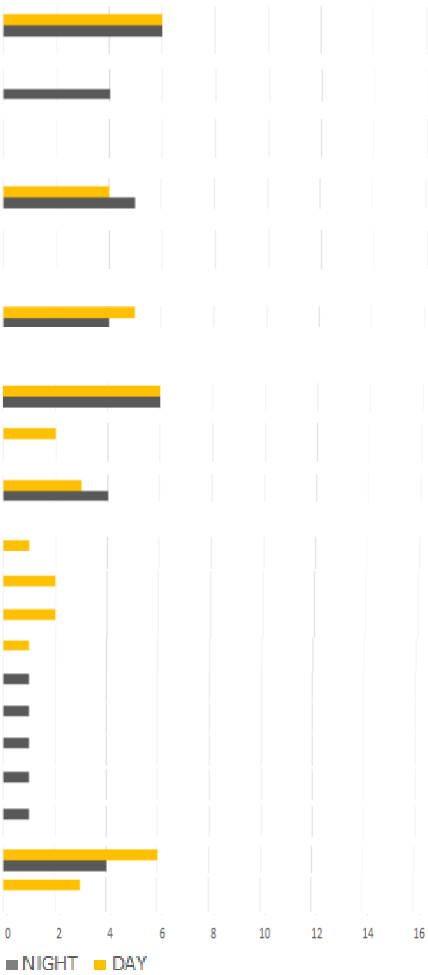
Looking at the images generated by the edge detector it is visible, how, at night, the building seems to have a slight different appearance due to the enhancement of the windows and the entrance. However, the differences in the responses do not seem to be of great relevance, as Victoria station was still unrecognizable by all participants except one, after seeing its day-time image, and those who had doubts maintained that they were still unconfident after seeing the day-time photograph.

LONDON

VICTORIA STATION Rank # 45

The analysis of responses

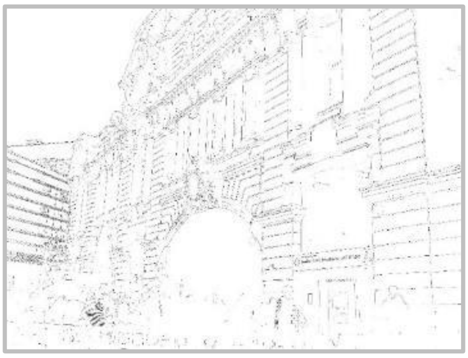
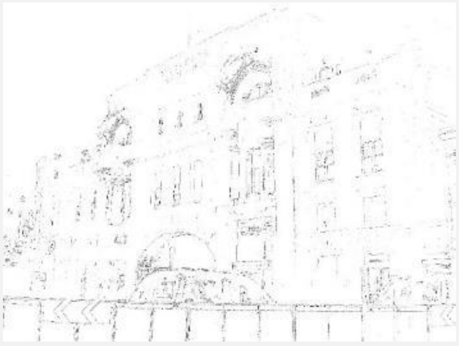
		DAY	NIGHT
Recognition	**Correctly identified**	**6**	**6**
	But unsure	0	4
	But not as the primary object portrayed	0	0
	Not identified	**4**	**5**
	But recognizes the area	0	0
	Misidentified	**5**	**4**
Primary element recognized	Victoria Station	6	6
	Charing Cross Station	2	0
	Waterloo Station	3	4
Recognizable features	Busy	1	0
	Buses	2	0
	Works	2	0
	Theatre near	1	0
	Streets around	0	1
	Arches	0	1
	Near Trafalgar Square	0	1
	Taxies	0	1
	Barriers	0	1
	Southern rail written	6	4
	Architectural style	3	0



LONDON

VICTORIA STATION Rank # **45**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

The National Theatre

The National Theatre was ranked as the 50^{th} most recognizable element of London in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for The National Theatre regard the number of correct identifications.

The National Theatre was slightly better recognized in the interviews where the participants looked at the night time version of the photograph. The reason seems to be related to a high colour and luminance contrast. Such, that the lighting and colour are a clue by themselves to help recognize the building at night. Additionally, there are other elements which emerged as recognizable features at night only, most conspicuously the Oxo tower.

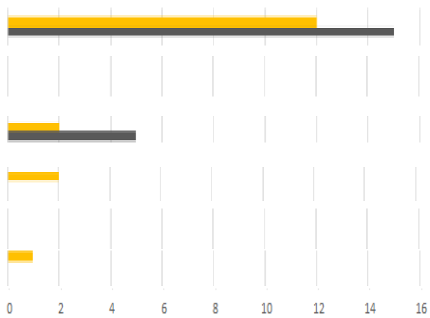
In this case, the luminance patterns and edge detection analysis do not reveal great information regarding the prominence of the National Theatre, given that these are unable to detect colour contrast.

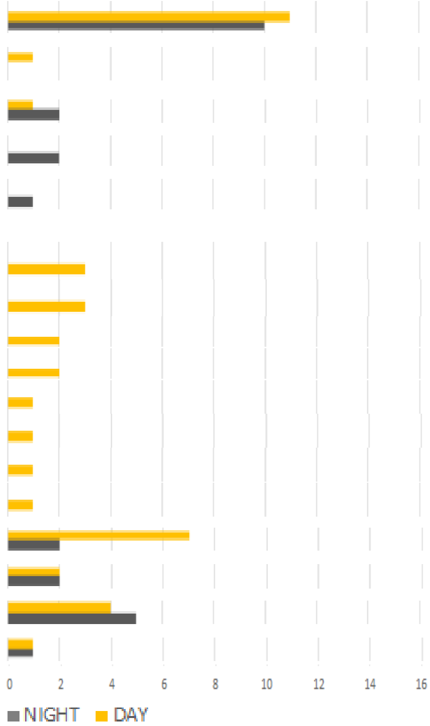
LONDON

THE NATIONAL THEATRE Rank # 50

The analysis of responses

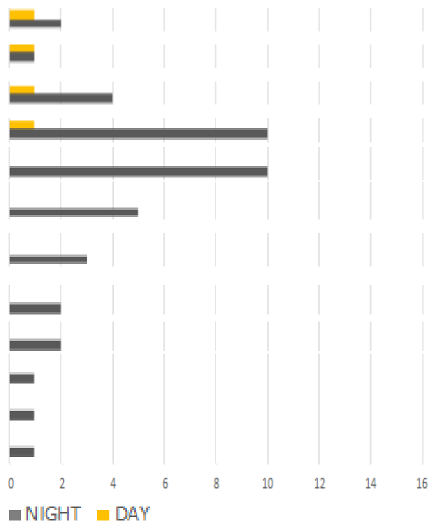
		DAY	NIGHT
Recognition	**Correctly identified**	**12**	**15**
	But unsure	0	0
	But not as the primary object portrayed	2	5
	Not identified	**2**	**0**
	But recognizes the area	0	0
	Misidentified	**1**	**0**
Primary element recognized	The National Theatre	11	10
	The Gherkin	1	0
	Southbank	1	2
	Coloured lighting	0	2
	Oxo Tower	0	1
Recognizable features	Blocks	3	0
	Ugly	3	0
	Architectural style	2	0
	Banners	2	0
	Opera house	1	0
	Theatre	1	0
	Cold	1	0
	Advertisements	1	0
	Concrete façade	7	2
	Trees	2	2
	Southbank	4	5
	Shape	1	1





(continues)

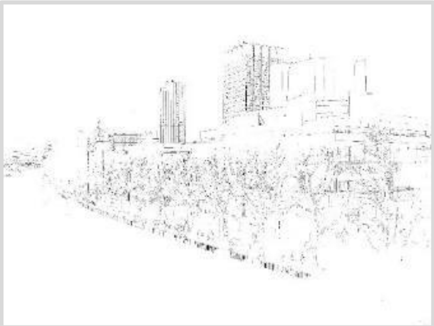
The Gherkin	1	2
The City	1	1
The walking area	1	4
River	1	10
Oxo tower	0	10
Colour	0	5
Lights of the National Theatre	0	3
The Royal Festival Hall	0	2
Distinctive	0	2
Cubes	0	1
Blue lights on trees	0	1
Waterloo Bridge	0	1



LONDON

THE NATIONAL THEATRE Rank # **50**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Conclusions for the photographic interviews in London

The comparison of responses resulting from the observation of day and night-time photographs revealed four main aspects in which responses diverged the most. These were the ability to recognize a given element, recognizing a different object as the target of the photograph, misidentifying the target for another known landmark, and expressing doubts on having correctly identified the target.

The ability to recognize a given element was reduced with some significance for seven elements. Five of these elements were better or even only recognized when photographed under daylight, and other two were better recognized under artificial lighting.

The perceived hierarchies of the objects in the photographs also seem to have changed. Thus, the element recognized as being the target of the photograph was not always coincident between the two sets of interviews. For six different photographs another object in the picture was wrongly pointed as the target. Two of these photographs had been captured in the day and four at night.

The relevant differences in the number of misidentifications and the doubts in recognition happened with three different pictures and when participants observed its night-time versions only.

These results indicate that the image of some of the most prominent urban elements of London can be less recognizable and prone to misidentifications at night. Additionally, the attention of the observer seems to be drawn towards different elements and features when comparing the descriptions of day and night-time viewings, suggesting that the perceptual hierarchies of the city are modified by artificial lighting. However, it also indicates that in some cases it can make an object and its surroundings more recognizable, as it was the case with the National Theatre and Waterloo Bridge.

Divergent results	Photographs	
	Day	Night
Element not identified	Waterloo Bridge The National Theatre	Hyde Park St. James's Park Green Park The Gherkin Harrods
The element identified was not the primary target of the photograph	The river Thames Centre Point	The Tate Modern The Millennium Bridge Westminster Bridge Waterloo Bridge
Misidentified elements	-	The British Museum The Natural History Museum
Correctly identified but with doubts	-	The British Museum Victoria Station

Table 17. Summary table for the results of the photographic interviews in London.

Factors influencing the recognition of the elements

After examining the results, it was found that there were mainly two aspects which could have conditioned the recognition of the photographs of elements. These were the expectations of the participants and modifications in the perception of contrast.

Expectation

The identification or recognition of objects is dependent on past perceptions, which were subjected to a process of classification, and attribution of meaning. Recognition can be educated (in order, for example, to quickly recognize a specific shape) and may change over time (due to the addition of new information), but it can also be biased by previews experiences, expectations, affections or mental attitude. (Blake & Sekuler, 2006) p. 201, (Lam & Ripman, 1992) p.32.

Expecting to see a certain context to a known object seemed to have made some participants more or less likely to recognize an object. For example, a small number of participants declared that they found it difficult to recognize the photograph of

Covent Garden at night, because they expected it to be full of people and the night-time image presented an empty space. A similar situation occurred when participants observed the images of a street in Soho. The main recognizable feature described by them when examining the night-time picture was the number of people in the street. Hence, those who were confronted with the day-time version, which depicted a less crowded street, found it more difficult to identify the area and justified it by the unexpected small amount of persons in the picture.

Figure 24. Daytime and night-time photographs of Covent Garden (top) and Soho (bottom).

Another interesting effect noticed involving expectations was the perception of objects which were not in a picture that the participant had misidentified. That is, some individuals had the illusion of seeing objects which were not in the picture, because they expected them to be there. This happened with three individuals when observing the night-time image of the Natural History Museum. Two participants who had mistaken it by the Houses of Parliament, pointed Big Ben in the background as well as the statue of King Richard, such was the expectation of seeing these features there. The other participant confused it with Westminster Abbey and claimed that he could see the Houses of Parliament behind it.

Contrast

To be detected, an object must be conspicuous; it must differ from its surroundings. The light it reflects must be distinctive from the light reflected by its background and immediate environment, by, for example, having different intensity, spectral content (colour), or differences in the way light is patterned (glossiness). An object can also be more easily detected by having a distinctive shape, size, depth, or by possessing movement in contrast to a still environment. (Blake & Sekuler 2006), (Turatto and Galfano 2000).

Detection, discrimination and identification are closely interrelated, but each serves a different purpose. Discrimination allows to sort important from unimportant objects, according to what is needed, and is dependent of detection. Identification depends on discrimination and requires learning, categorization and memory use.

The main factor that seems to have influenced the ability of detection and identification of the photographs presented to the participants, was the perception of luminance and colour contrast of these images.

Colour contrast

The existence of contrasting coloured lighting seems to have enhanced the detection and even the identification of certain elements at night. This was noticed, for example, when participants observed the images depicting Centre Point, and particularly the National Theatre and Waterloo Bridge. Centre Point was better identified at night, mainly due to the blue colour that lines the top of the building. This quality also contributed for it to be detected from the distance, and thus it helped in the identification of the night-time image of Regent's Park by several participants (around 63% of those who made correct identifications).

Waterloo Bridge, which was recognized by less than half of the participants during the day, was recognized by more than seventy per cent participants at night, mainly due to the unusual pink colour and brightness of the National Theatre façade, located next to it. The National Theatre was the primary element recognized at night, after which the bridge would be identified, inverting the day-time hierarchy. Moreover, five persons thought that the photograph was depicting the Theatre instead of the bridge at night only, such was its contrast.

Another interesting aspect is that the main recognition clues stated by participants regard almost exclusively the National Theatre description, and chiefly its lighting, for the night-time based interviews only.

		DAY	NIGHT
Recognition	**Correctly identified**	**5**	**11**
	But not as the primary object portrayed	0	**5**
	Not identified	**7**	**1**
	Misidentified	**3**	**3**
Primary element recognized	Waterloo Bridge	5	6
	The National Theatre	0	5
	London Bridge	1	3
	Blackfriars Bridge	2	0

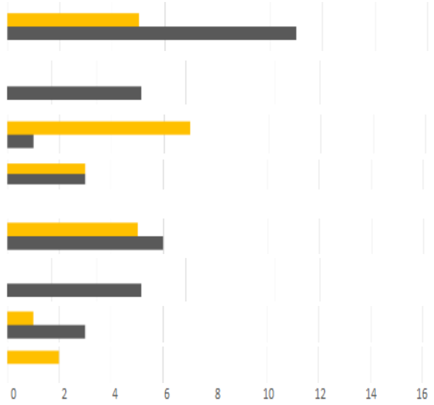


Table 18. The comparison between the day and night-time based photographic interviews for Waterloo Bridge, regarding recognition and the primary element identified as the target of the photograph.

Recognizable features	The arches of the bridge	3	0
	An ugly bridge	1	0
	A functional bridge	1	0
	A modern bridge	2	0
	A bridge with simple lines	3	0
	It is made of concrete	1	0
	A TV studios tower behind	1	0
	The National Theatre	1	6
	The lighting/colour of the National Theatre	0	8
	The shape of the National Theatre	0	3
	The Theatre is by the river	0	3
	The Southbank	0	1

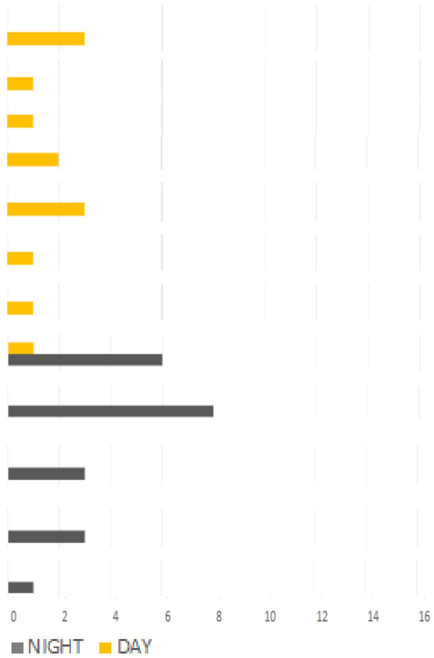


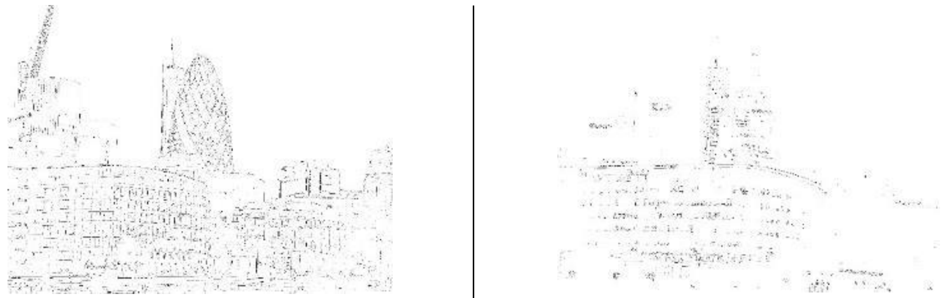
Table 19. The recognizable features of the Waterloo Bridge day and night-time photographs.

Luminance contrast

The luminance contrast seems to have influenced the perception of objects in two different ways: By modifying the perception of the shape of an object and by modifying the luminance ratios of objects or parts of objects in a scene.

The perception of the shape of an object is dependent on the perception of its boundaries, that is, on the existence of a sharp luminance contrast between the edges of the object and its immediate background.[165] The use of an edge detector enabled to visualize weaknesses (such as discontinuities in the edges of an object) and strengths in the perception of the shape of the objects.

Examples of the influence of the perception of the shape of an object on its recognition were found in the results for the pairs of photographs of the Gherkin and the Tate Modern. The shape of the Gherkin became imperceptible at night, affecting its recognition. In the case of the Tate Modern, its shape was also affected at night, hampering recognition and modifying the visual hierarchies.



Recognition	D	N
Correctly identified	**15**	**6**
But unsure	0	6
But not as the primary object portrayed	0	0
Not identified	**0**	**6**
But recognizes the area	0	0
Misidentified	**0**	**3**

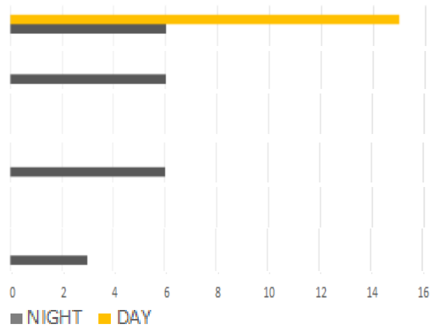


Figure 25. The Gherkin: edge detection in daytime and night-time photographs (top) and the description of results regarding its recognition (bottom).

[165] (Blake & Sekuler, 2006)

Day Night

Recognition	D	N
Correctly identified	**14**	**15**
But unsure	0	2
But not as the primary object portrayed	0	8
Not identified	**1**	**0**
But recognizes the area	0	0
Misidentified	**0**	**0**

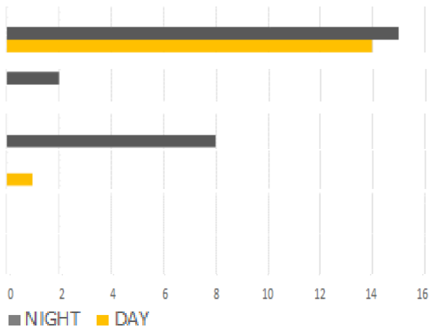


Figure 26. The Tate Modern: edge detection in daytime and night-time photographs (top) and the description of results regarding its recognition (bottom).

Luminance ratios

The existence of different luminance ratios in the night-time pictures resulted in a modification in the perception of hierarchies. This meant that the attention of the observers was diverted to the objects of higher luminance in the night scenes, distorting the hierarchies that had been identified by the other group when observing the day-time version of the same pictures.

The modification of hierarchies was observed by registering the order in which the recognition clues were described and by registering which was the element recognized as the object of the picture. The results suggest that perceptual hierarchies may be transformed under artificial lighting. For example, in the interviews in which participants examined the night-time photographs of the Millennium Bridge, St. Paul's Cathedral was stated by 33% of the participants as the main element depicted, against 0% in its day version. The average luminance contrast ratio of the cathedral was very high, at 30:1[166] for the Cathedral, whereas the Millennium Bridge contrast against the background was practically null. However, when the photograph was taken from the other side of the river, directed at the Tate Modern, the bridge became the most conspicuous element at night only, instead of the Museum.

However, in different circumstances, the inversions of the hierarchies in the urban objects, improved or were even the main factor for the recognition of certain elements. For example, in certain photographs, distant lit landmarks seem to have been essential to allow for the participants to recognize the location of the place where the images were captured from. This was particularly true for the recognition of parks at night, since these elements are in almost complete darkness, thus making distance landmarks almost the only recognition clues available. The existence of distant brightly lit landmarks, such as the BT Tower and Centre Point seen from Regent's Park, and the Victoria Memorial seen from St James's Park, allowed for the recognition of these parks. The other two parks were not recognized at all at night. Green Park was misidentified with other parks both in day and night versions, and the only three persons who were able to identify its day-time picture have all pointed different clues. Hyde Park night-time picture did not show any distant landmark.

The other photographs that featured distant landmarks were the river Thames, Oxford Circus, the City, the Millennium Bridge, Southbank, Westminster and Waterloo Bridges, Tottenham Court Road, The Mall, Westminster and The National Theatre. The distant landmarks in these photographs were not the only recognition clues, as in the pictures of the parks, and thus were not as crucial. However, they seem to have been important for the recognition of the night-time images of The Mall (where Victoria Memorial was the most remarked clue) and of Tottenham Court Road (where Centre Point became the central clue).

[166] 6:0.2 cd/m^2

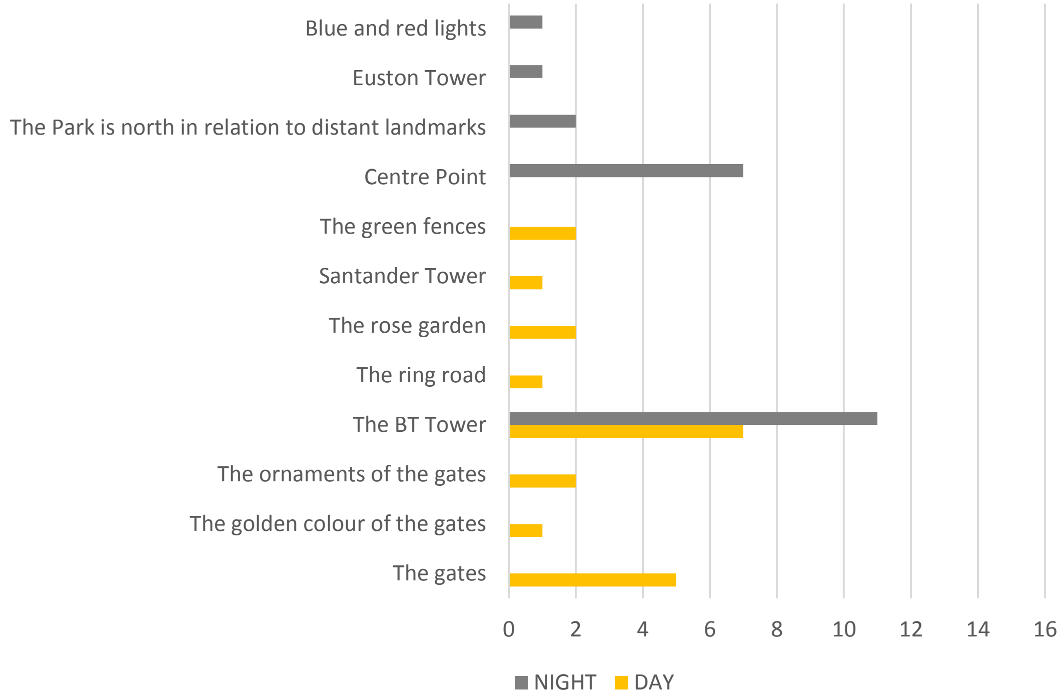


Figure 27. Regent’s Park: recognition clues for the daytime (yellow) and night-time (grey) pictures.

The saliency of the river

The night-time photograph of the river Thames elicited better recognition than its day-time version. That means that those who observed its night-time picture, identified the river as being the target of the photograph in greater numbers than those who viewed the day-time image. These last participants have remarked the Houses of Parliament or another landmark near the riverbanks instead, almost ignoring the presence of the river. This was found to be intriguing, since the river is fully visible in the day, and in almost complete darkness at night.

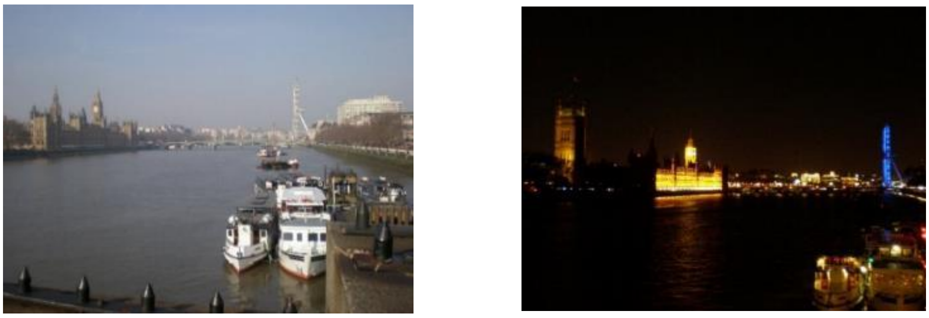
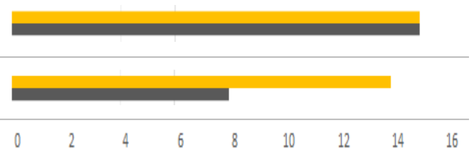


Figure 28. River Thames: The daytime (left) and the night-time (right) photographs shown to participants.

		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**15**
	But not as the primary object portrayed	**14**	8



To find an explanation it was hypothesized that either there were less visible landmarks at night, thus leaving the river as almost the only element available for recognition, or the river acquired a different appearance at night which captured the attention of the observers. Particularly, areas of high luminance contrast of reflected lights on its surface could become the main focus of attention.

To test these hypotheses, all images used in the interviews that featured the river Thames were isolated and examined in greater detail. The analysis showed that the river was mentioned as a recognition clue more often by those who observed the night-time images than by the participants who examined the day-time images (in seven out of ten cases). Even if the differences in responses were not always significant for all pairs of images, it still suggested that, in fact, the visibility of the river in the night-time photographs appeared to the participants as more conspicuous than its day-time version.

The first hypothesis conjectured that there could be less clues visible at night, leaving the river as the most prominent object in the image. However, looking at the number of clues pointed by participants in all photographs that includes the river, it was found that the total number of recognition clues pointed for the night and day-time versions of these photographs was very similar. In fact, in almost all photographs there was a slightly greater number of clues pointed for the night-time pictures. Therefore, this first hypothesis was discarded.

Table 20 compares the distribution, in percentage, of the total number of clues expressed by the participants for all photographs that include the river, for both its day and night-time versions, and the average number of clues expressed per participant.

	Average number of recognition clues per person		Distribution of the total number of clues expressed by the participants (%)	
	DAY	**NIGHT**	**DAY**	**NIGHT**
Waterloo Bridge	2.6	1.9	38%	62%
The National Theatre	4	3.7	38%	62%
The London Eye	1.8	1.9	49%	51%
Big Ben	2.4	2.5	49%	51%
The City	3.1	2.7	53%	47%
The Millennium Bridge	2.3	1.9	56%	44%
Westminster Bridge	1.6	1.8	47%	53%
Tower Bridge	1.9	2.5	43%	57%
The Houses of Parliament	2.2	2.3	49%	51%
The Tower of London	2.9	2.6	51%	49%
The river Thames	2.7	3.3	45%	55%

Table 20. The day and night-time average number of clues per person and the total percentage of clues elicited by each photograph which featured the river.

Table 21 shows how often the river was remarked in the pictures where it features. This table does not include the evaluation of the photograph that depicts the river Thames itself, because, being the targeted element of the picture it was not scored as a recognition clue for those who correctly identified it as the main target of the photograph.

The photographs that feature the river	**Number of participants who remarked the river when observing the photographs**	
	D	**N**
The National Theatre	1	10
Waterloo Bridge	0	3
Millennium Bridge	0	3
Big Ben	1	3
The Westminster Bridge	1	2
The London Eye	2	3
The Houses of Parliament	4	5
Tower Bridge	1	1
The City	4	3
The Tower of London	9	7

Table 21. The photographs where the river appears and the number of times it was mentioned for each picture, in the day and night-time versions.

The photograph of the National Theatre was the picture which elicited the greater difference in the number of day and night-time observers who mentioned the river, with ten participants remarking on it in the night-time image against one in its day version. When observing photographs of Waterloo Bridge and the Millennium Bridge no one mentioned the river looking at the day version, but three participants pointed it in the night-time image. There were also slightly more participants mentioning the river in the night-time versions of the photographs of Big Ben, the Westminster Bridge, the London Eye and the Houses of parliament, although with a very small difference. Finally, the two versions of Tower Bridge had the exact same response, and in the images of the City and of the Tower of London, the river was pointed more often in the day-time than in the night-time photographs.

Thus, the photographs could be separated in three different groups for analysis. The first group including those images that elicited a better recognition of the river in the night-time versions by a larger difference. The second, constituted by those which prompted a slightly better recognition at night, by a very small difference. The third set including the pictures of those elements where the river was equally or better recognized in the day images.

Group 1

Day	Night	Nº of participants who remarked the river	
		D	N
 The National Theatre		1	10
 Waterloo Bridge		0	3
 The Millennium Bridge		0	3

Figure 29. Group 1. The three pairs of photographs in which there was a greater gap in the acknowledgement of the river as a recognition clue between the day and the night-time photographic interviews. The river was remarked as a clue for recognition more often in the examination of the night picture than of the day-time one in this set.

Examining the pictures above it can be observed that in the day images the body of water looks reasonably uniformly lit. The reflections in the surface of the water are few and only slightly darker than the water itself, thus representing small areas of low contrast.Thus, in the day-time images the river appears as a more or less constant element. But in the nigh-time photographs, the opposite happens: there are several spots of bright lights reflected mainly from street lighting above water, which occupy a large area of the picture with high contrast against the very dark waters. This fact becames clearer when looking at the edge detection for these photographs:

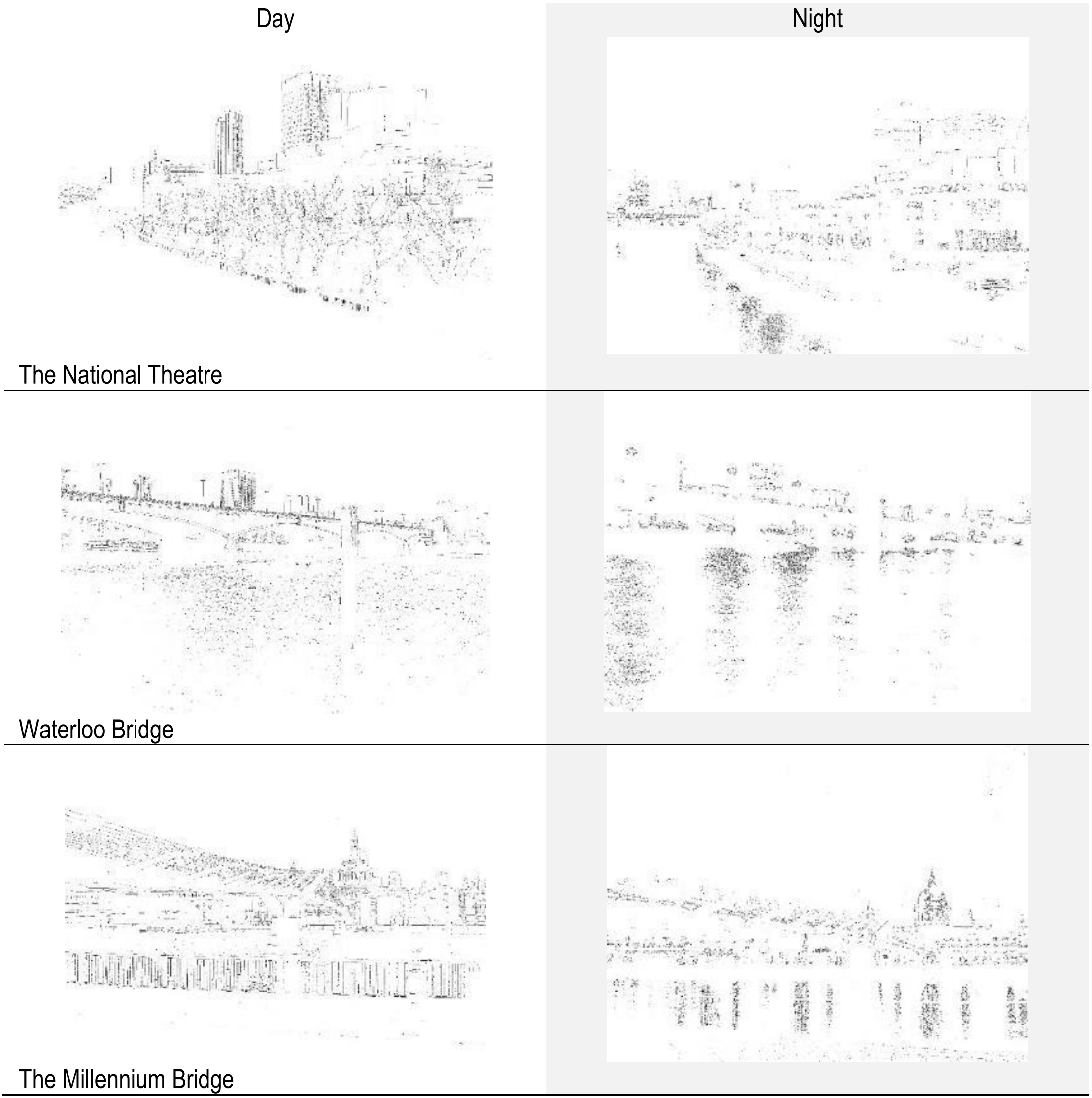


Figure 30. The edge detection for Group 1 photographs.

The software is always able to detect areas of sharp differences in luminannce contrast at the river in night-time pictures. However, in the day pictures almost no contrast is detected over the water.

The luminance pattern analysis confirms the existence of some luminance contrast between the areas of reflected lights and the rest of the river surface at night. For example, the average luminance contrast of the reflected lights of the Millennium Bridge on the water against the average luminance contrast of the rest of the river is around 1.5:0.01 cd/m^2. The reflected lights of the façade of Saint Paul's Cathedral has an average contrast ratio against the average luminance of the rest of the river of around 2.5:0.01 cd/m^2.

Group 2

The next set of pictures show those elements in which the river was still more often refered to as a clue at night, yet with lower difference between the day and night time interviews.

The Big Ben night-time photograph depicts the river with very large areas of bright reflections on water, but perhaps so large that it almost makes the river as uniformly lit as in daylight, even if more intensely and in contrast with the dark sky above. There is, however, an area that lacks reflected light, due to the façade of the Parliament being partly unlit.

Both day and night-time photographs of Westminster Bridge show large areas of luminance contrast on the surface of the river.

The night-time photograph of the London Eye shows a small area of blue colour in the surface of the river set against dark waters.Its day-time picture an uniforme surface, apparently with little or no contrasts.

The Houses of Parliament photographs are a similar case to the ones that depicted Big Ben (they actually depict the same scene but from a diffferent angle). In the night picture there is a large area of high luminance reflection on water, corresponding to the lit façade of the Parliament. In the day-time image there is a small area of dark contrast corresponding to a tower, against a uniform river.

When comparing these sets of photographs through the edge detection technique, it seems that the areas of luminance contrast on the river are similar between the day and the night-time images. It should be noted that the edge detector is not able to recognize colour contrast, and therefore the blue colour contrast in the night-time image of London Eye is not apparent through this technique.

Day	Night	Nº of participants who remarked the river	
		D	N
 Big Ben		1	3
 The Westminster Bridge		1	2
 The London Eye		2	3
 The Houses of Parliament		4	5

Figure 31. Group 2: The four pairs of photographs in which there was a smaller gap in acknowledgement of the river as a recognition clue. Big Ben, Westminster Bridge, London Eye and The Houses of Parliament.

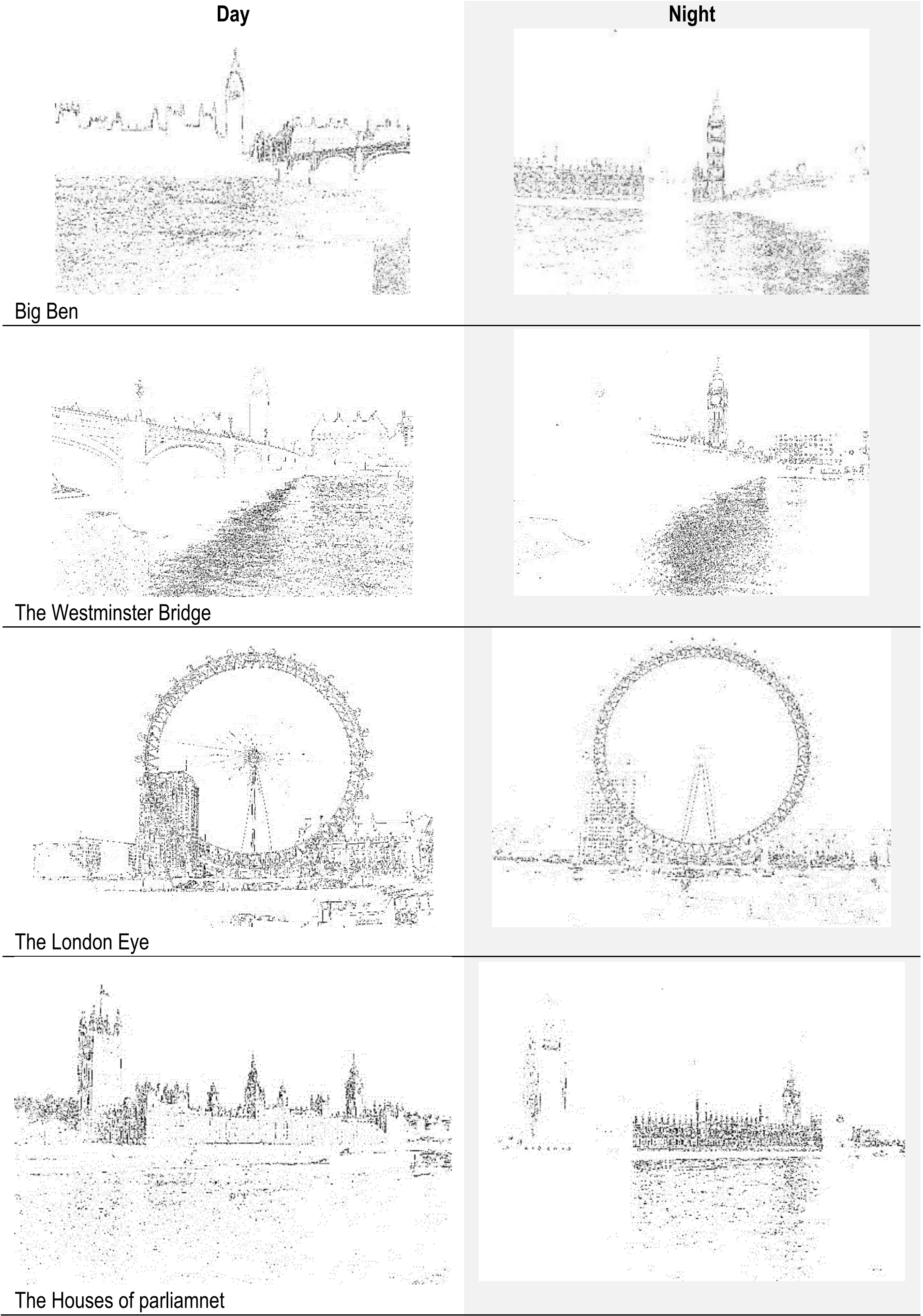


Figure 32. Edge detection for Group 2 photographs.

Group 3

The third group of photographs is constituted by those images in which the river was better detected as a clue in the day pictures, with the exception of the photograph of the Tower Bridge (which elicited an equal number of responses).

As it can be observed in the pictures and the edge detection results, there seems to be an equal or very similar area of luminance contrast in the case of Tower Bridge, similar to the results in group 2, which may explain the equal number of responses. The other two pictures show a poorly illuminated river surface at night, with very few, if any areas of luminance contrast. The day-time pictures also show a more or less uniform river, but with a slightly greater number of reflections than in the night-time pictures.

Day	Night	Nº of participants who remarked the river	
		D	N
 Tower Bridge		1	1
 The City		4	3
 Tower of London		9	7

Figure 33. Group 3. The three pairs of photographs in which there was either no difference in acknowledgement of the river as a recognition clue, or a higher recognition for the day-time photographs. Tower Bridge, The Tower of London and the City.

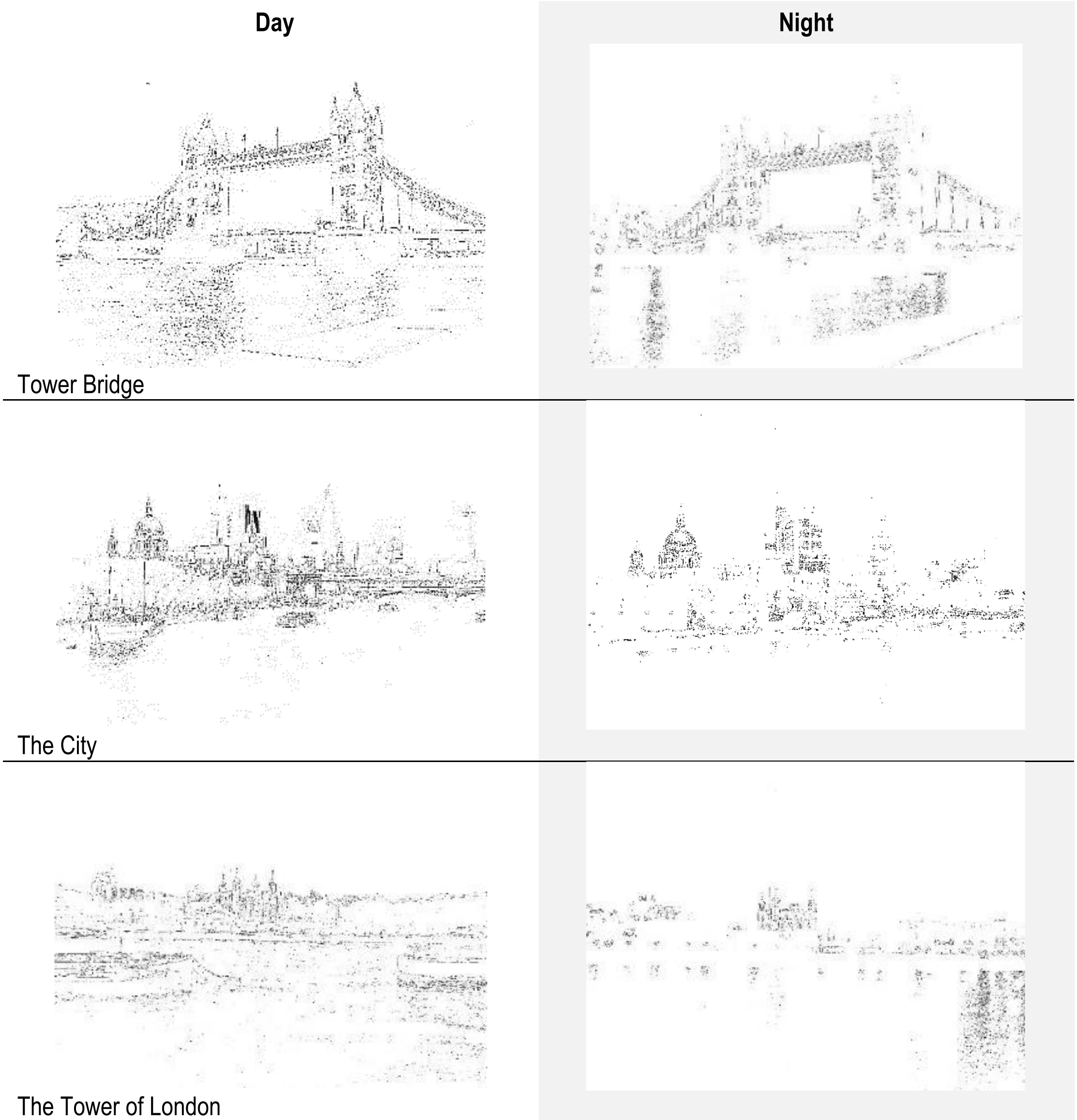


Figure 34. Edge detection for Group 3 photographs.

The sample of participants was too small to arrive at any definitive conclusions, and most differences in responses were not significant. It is possible however, that the river becomes more likely to be detected if it presents distinct areas of luminance contrast on its surface. Further analysis would be needed to test this hypothesis, which was found to be slightly beyond the scope of the present study. However, the present examination of the visibility of the river reinforces the suggestion that elements can be perceived differently at night due to the effect of luminance contrast.

THE RESULTS IN LONDON

For the walking interviews

As previously described, in this set of interviews the participants were asked to walk from the north side of Covent Garden Market to the Houses of Parliament. They were free to select which ever route they preferred and take as much time as they needed. However, they were not allowed to look at any maps or devices for orientation purposes and were unaware of the nature of the study. For both sets of interviews, about half of the participants declared having an average or good knowledge of the area and the other half stated having a poor knowledge[167].

The wayfinding process

There were distinct moments in which participants briefly paused to organize a strategy on how to arrive at the Houses of Parliament. These were at the departure point, when the destination was disclosed, and whenever a decision was required, such as at intersections. The nature of the strategy was found to be based in two different factors: evoking a mental map of the area and choosing a route based on subjective preferences. The latter was mostly true for those who had an average or good knowledge of the area

.

[167] Respectively 8 and 7 subjects.

THE PREFERENCES FOR ROUTE SELECTION	DAY	NIGHT
The most direct route	2	2
The shortest/quickest route	1	2
Most pleasant route	1	1
Best known route	3	2
Does not express a preference	8	8

Table 22. The subjective preferences for path selection as declared by the participants.

Nearly all participants who did not express a preference for the selection of a route had poor knowledge of the area and were mainly focussed in finding a familiar object. The remaining participants either followed a previously known route or the most direct, quickest or shortest itinerary. Only one individual in each set of interviews declared he was choosing the most pleasant route. There were no significant differences between day and night-time interviews.

The first moment in which participants paused in order to think of a strategy to arrive at the designated destination was at the departure point, before commencing the task. When asked to describe what they were thinking most said they were mentally going through the nearby reference points to decide which route to take. It was found that most participants used intermediate reference points or landmarks to be able to navigate towards the final destination. This finding is consistent with the studies that indicate landmarks as important components of mental maps[168] that act as anchors to calibrate distances and directions [169] and to help to recall the procedures required to get to a destination[170].

The next table shows which were the intermediate points or landmarks that the participants used to organize their mental maps before starting the task. A number of individuals started walking randomly, with no pre-established strategy, due to poor

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168 (Lynch, 1960), (Golledge, 1999)

169 (Darken & Sibert, 1996)

170 (Sadeghian & Kantardzic, 2008)

knowledge of the area, or lack of orientation to where they were in regards to the destination point. It was observed that the reference points were roughly coincident for the participants in both sets of interviews. The exception was Embankment, which only emerged in the night-time interviews. This may suggest that the differences in results, between the day and the night-time tasks, were due to variables in the field rather than the different subjective strategies.

INTERMEDIATE MENTAL NAVIGATION LANDMARKS AT STARTING POINT	DAY	NIGHT
The river Thames	8	8
Charing Cross Road	1	0
Trafalgar Square	5	5
The Strand	1	1
Whitehall	2	0
Westminster tube station	2	0
The London Eye	2	0
Leicester Square	3	2
Nelson’s Column	1	0
The National Gallery	1	0
Starts navigation randomly. No mental map	3	2
Piccadilly Circus	0	1
Westminster Bridge	0	1
The tube stations around Covent Garden	0	1
Embankment	0	3

Table 23. The list of intermediate landmarks described by participants at the starting point, before the beginning of the wayfinding task.

This idea is further reinforced when analysing the landmarks, or clues, by which individuals actually guided themselves when walking through the city. In this case there were less coincident markers between the day and night-time interviews as it can be observed in the next chart. The data was obtained from the descriptions and account of clues that the participants acknowledged while performing the task. These provide an insight of how landmarks could have conditioned the perception of space and of route choice.

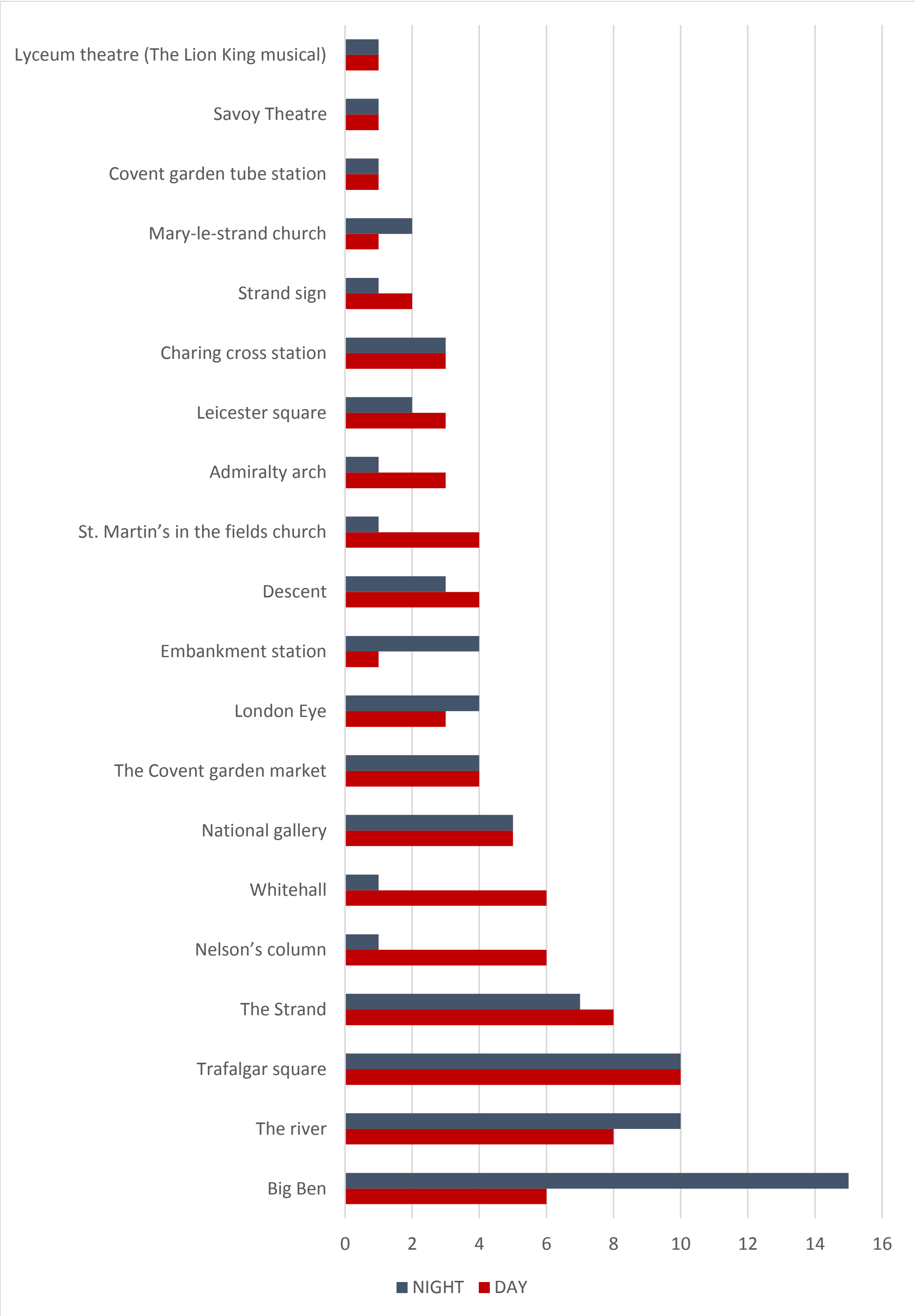

Figure 35. The landmarks remarked upon by participants during both the day and night-time interviews.

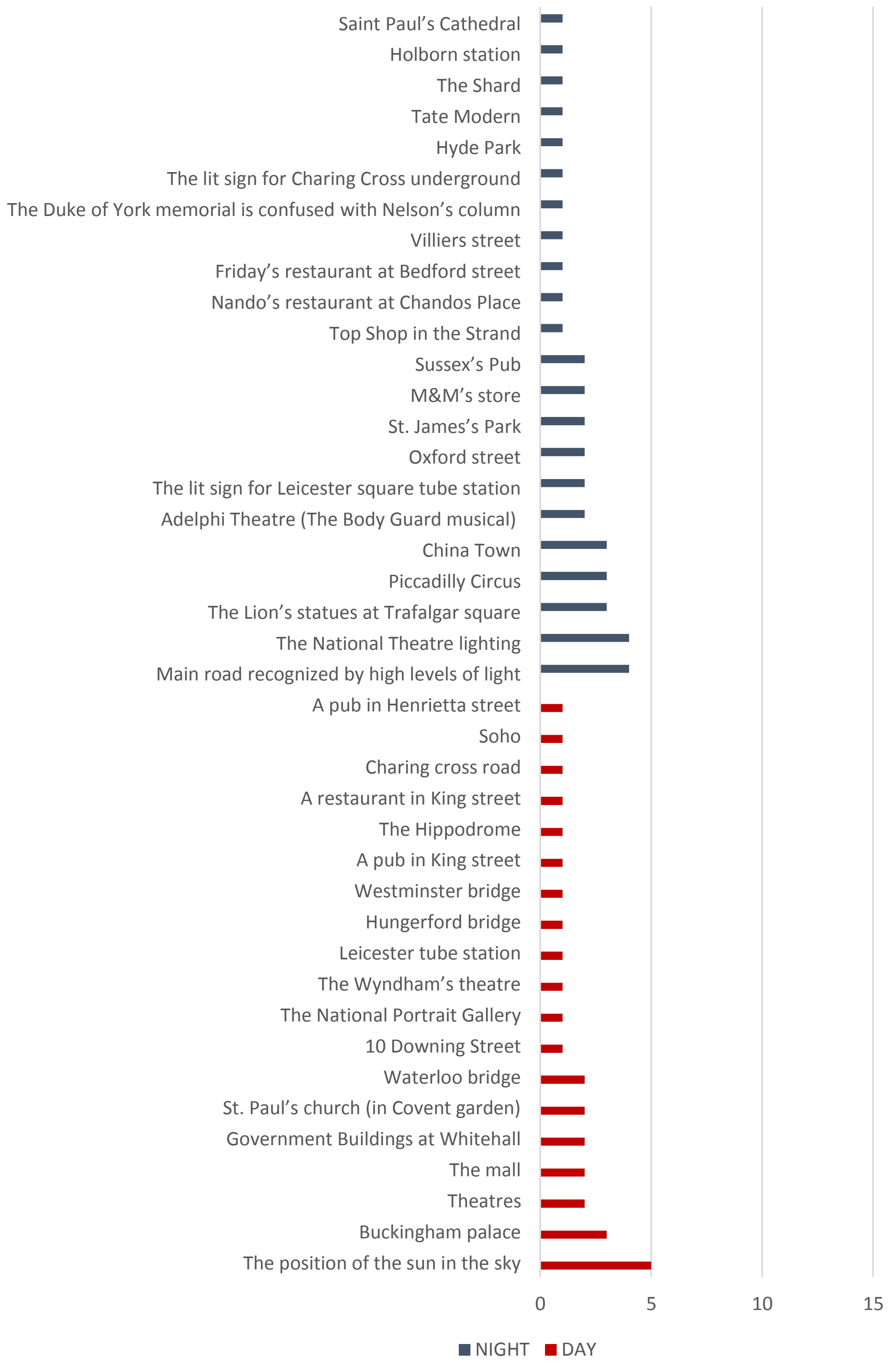

Figure 36. The landmarks remarked upon by participants during the day or night-time interviews only.

Distant landmarks became especially conspicuous for orientation purposes at night. For example, The National Theatre, St. Paul's Cathedral and The Shard were only detected at night, and Big Ben was mentioned by all participants in the night interviews, but only by about half in the day-time.

At the same time, at night, certain landmarks almost disappeared as guidance clues, as was the case with Nelson's Column, detected by only one person at night and by six in the day-time. It is interesting how this was an important distant landmark during the day, marking the location of Trafalgar Square, and how it became almost unnoticed at night, except from a close distance. A few participants pointed the lions that lay at its pedestal but did not acknowledge it as being Nelson's column. Thus, this element becomes almost useless as a guidance clue at night. The luminance contrast of Nelson's statue against its background, when observed from The Strand, near Carting lane, was almost null.

The National Gallery was remarked upon the same number of times, in both sets of interviews, although at night its luminance contrast ratio against its context does not make it highly noticeable[171], at around 2:1 (11.4:5.9 cd/m^2), when observed from Duncannon Street. However, its main features[172] which allow it to be recognized are well visible, such as the dome and the columns.

As certain landmarks become less conspicuous at night, other clues are used for orientation purposes. Thus, the main roads were easily spotted for the amount of lighting particularly from lit signs, window shops and traffic. One participant justified her choice of direction by describing herself "like a moth being drawn in by lights". Another four individuals declared they were looking for the street with the greatest amount of lighting, which would represent a main road from which they would be able to find further clues. The stores, theatres and stations with lit signs were also often mentioned, meaning that they became better clues.

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[171] According to ILE (2005) this value of luminance contrast is classified between a *not noticeable* and *just noticeable* object.

[172] As extracted in the previous stages of this study (see the photographic interview section).

These results become clearer when observing the position of these landmarks on a map (see Figure 37 in the next page).

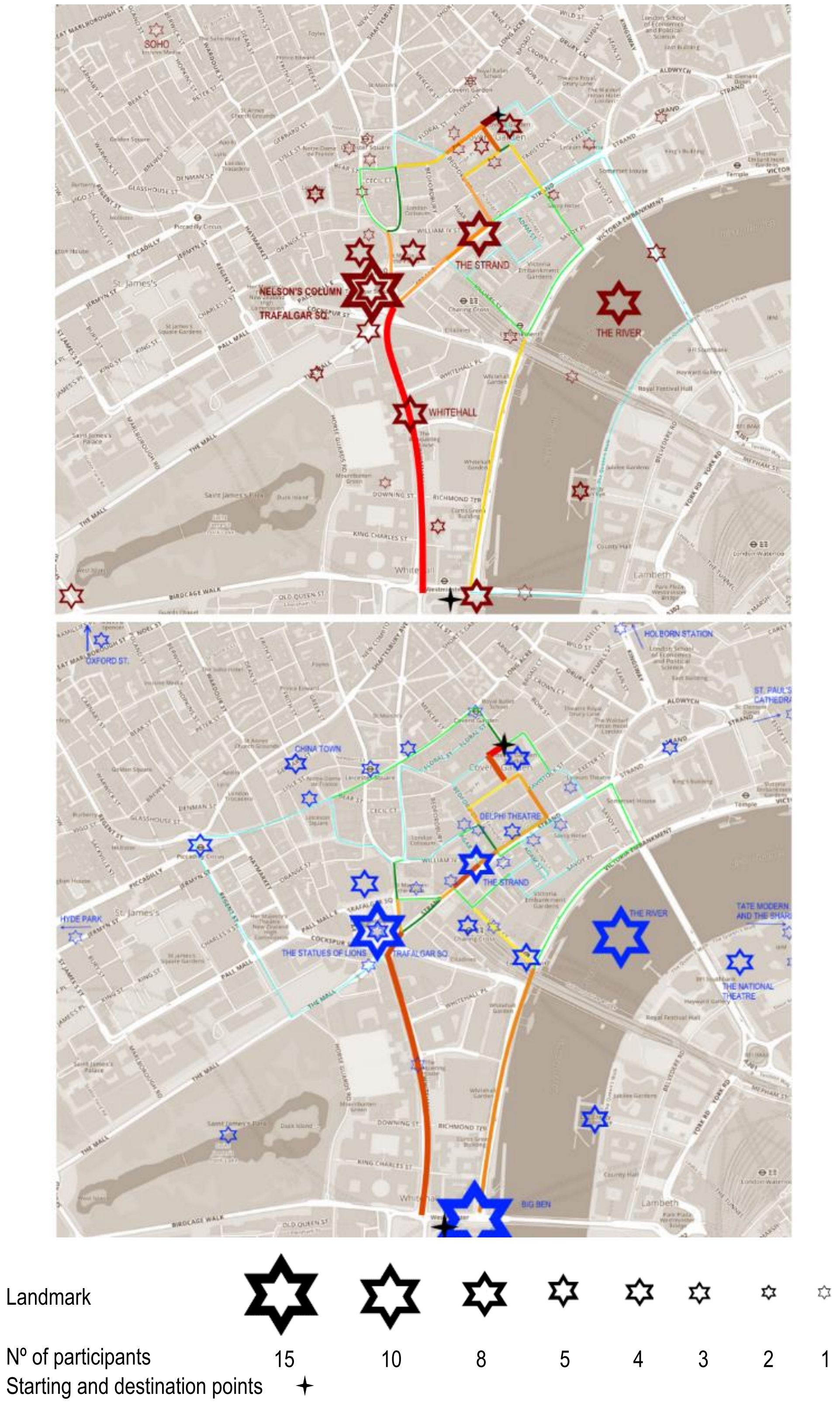


Figure 37. Landmarks remarked on by the participants during the daytime interviews marked on a map (top) and those landmarks mentioned during the night-time walks (bottom) during night-time walks. The coloured lines represent the routes taken by participants.

In the day-time there is a concentration of landmarks around the Covent Garden market, Leicester and Trafalgar Squares. There were very few landmarks mentioned beyond the area which was travelled. At night there is an increase of distant landmarks, beyond the paths walked by the participants. At the same time the main cluster of distinct elements moves from the Covent Garden market area to The Strand, where a number of lit stores and theatre signs attracted the attention of the participants.

There are two possible reasons to the differences in the elements mentioned as clues in the day and night-time. The first is that people took different paths, thus were confronted with different clues. The other is that people took different paths because different clues were visible under distinct lighting conditions.

It appears that both hypothesis can be true. There were obviously certain elements detected only by those who took a certain route (such as those who travelled to Leicester Square and beyond, in the night-time), but there was also a difference, between day and night, in the type of clues remarked upon at the same routes travelled by a similar number of people. For example, in both sets of interviews there were at least 9 persons arriving at The Strand from different intersections and looking both ways. However, if under day light the detection of Nelson's Column seemed to be almost the only clue detected, at night it was substituted by a number of highly lit shop windows and theatres' billboards. Another example is the high number of landmarks detected on the south bank of the river at night only.[173] This was probably due to the enhanced prominence of these elements provided by lighting, allowing them to be identified from a longer distance. At the same time the bridges were lost as clues.

Another interesting aspect was the different ways found by participants to make sense of directions. In the daytime many would look at the position of the sun in the sky. But on overcast days, and particularly at night, they would rather calibrate their position in regards to the location of nearby tube stations. They declared they had memorized the London underground map, which relates to cardinal directions, and that after

[173] There were respectively 4 and 6 subjects walking parallel to the river, through Victoria Embankment in the day and night-time.

locating one or two stations they would be able to deduce to which way the destination point was. This strategy could explain why people travelled greater lengths, sometimes in the wrong direction at night. In fact, as it will be discussed ahead, three participants who walked in the opposite direction from the destination point, right in the first node, did so, looking for the tube stations, possibly attracted by the lit sign of Covent Garden tube station.

STRATEGY FOR WAYFINDING	DAY	NIGHT
Looking at the position of the sun in the sky	6	0
Looking for a descent that may lead to the river	1	2
Looking for tube stations and recalling the tube map	2	6
Relies solely on past experience and knowledge of the area	6	4
Looking for a street with high levels of light which indicate it being a main road	0	3

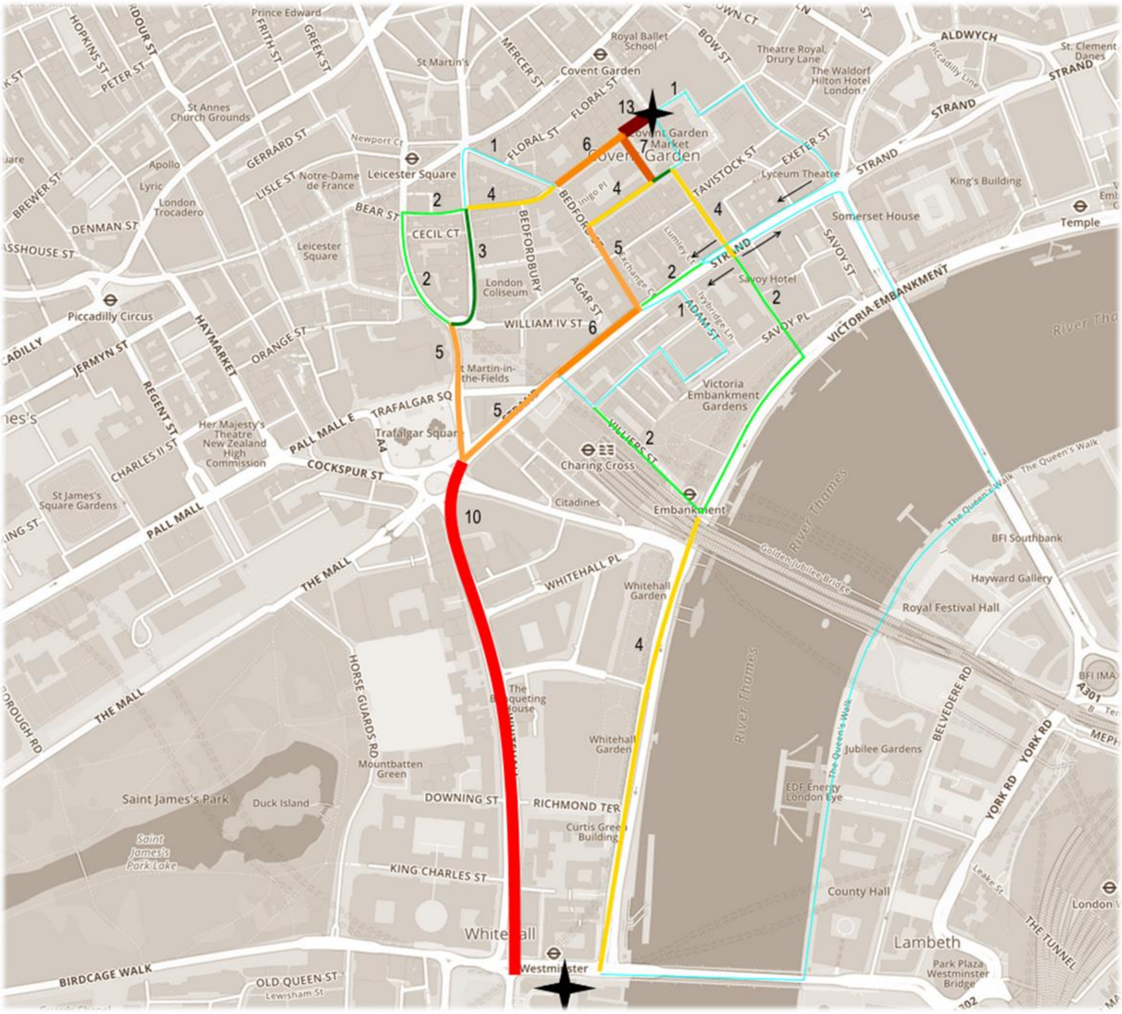
Table 24. The description of the strategies employed by the participants in order to calibrate their position towards the destination in London.

In summary, the landmarks of the mental maps that the participants of both sets of interviews evoked before starting the task were roughly similar. The preferences for route selection were also alike. However, the strategies for wayfinding and the landmarks which were actually used as clues differed. This leads to belief that the differences in behaviour were due to variables in the field, and particularly to the distinct lighting conditions. This hypothesis will be explored in the next chapters.

The differences in route choice between day-time and night-time interviews

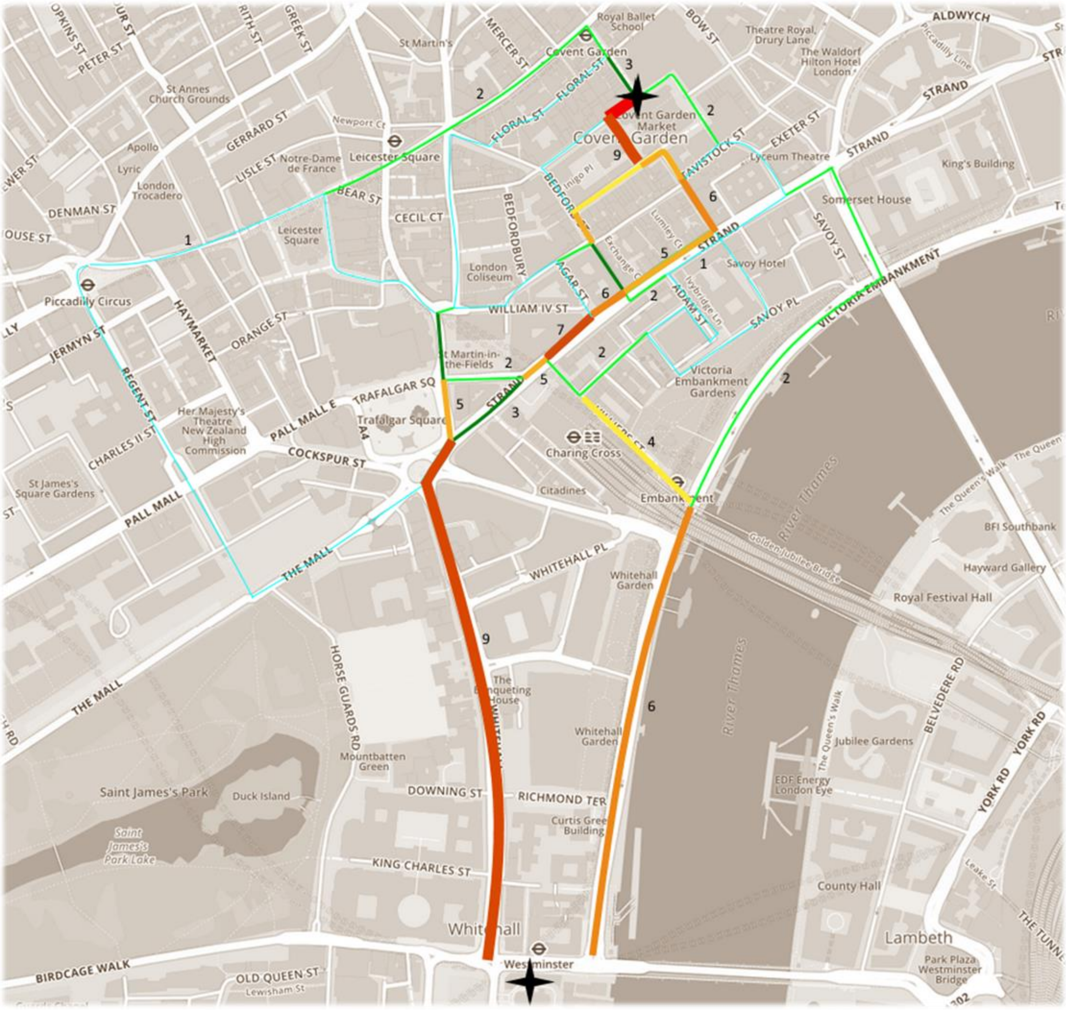
The routes travelled by day and night were different. Additionally, at night the participants seemed to have wandered through a greater number of different streets and dispersed wider in space. In the day-time interviews there were less streets covered by the participants, originating a smaller number of routes travelled.

The differences started to be drawn on the first node, where, at night, a total of five individuals went on the opposite direction of the destination point. The second important point of divergence was at King Street, selected to be travelled by only one person at night against six in the day-time. These were the main decision points that originated a different pattern of routes between the two sets of interviews, as it can be observed in the next sets of images. The difference is particularly visible when comparing those routes that were travelled by 4 or more participants.



PATH	NUMBER OF PARTICIPANTS	PERCENTAGE (%)
	15-13	>80
	12-10	>60
	9-7	>40
	6	40
	5	33
	4	27
	3	20
	2	13
	1	7

Figure 38. The map representing the total results for the day-time walking interviews.



PATH	NUMBER OF PARTICIPANTS	PERCENTAGE (%)
	15-13	>80
	12-10	>60
	9-7	>40
	6	40
	5	33
	4	27
	3	20
	2	13
	1	7

Figure 39. The map representing the total results for the night-time walking interviews.

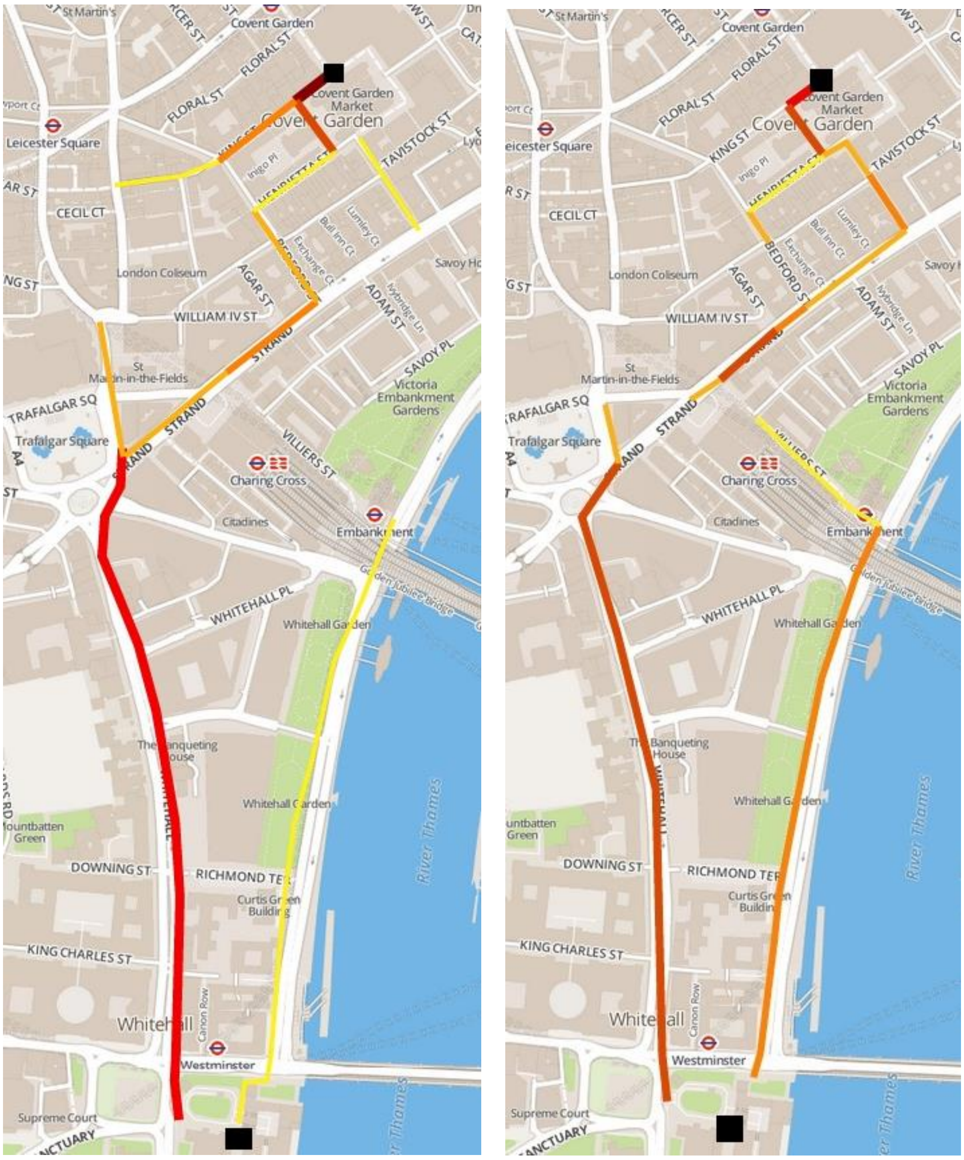


Figure 40. The routes taken by four or more participants. On the left in the day, and on the right at night.

In a complex environment such as this, it is difficult to isolate one variable and point it as the explanation to the behaviour of all individuals. However, looking closely at each node where the route choices diverged the most, between the two sets of interviews, it may be possible to extract some possible reasons.

In London five nodes were closely examined. These were labelled from A to E in alphabetic order, from north to south, and their locations are represented on a map in Figure 41. The nomenclature *NA*, *NB*, *NC*, *ND* and *NE* (see Figure 43) are an abbreviation for nodes *A*, *B*, *C D* and *E*. *R1* to *R4* refer to the routes that derive from the nodes.

Figure 41. The location of the nodes which presented greater differences in route choice between the two sets of interviews.

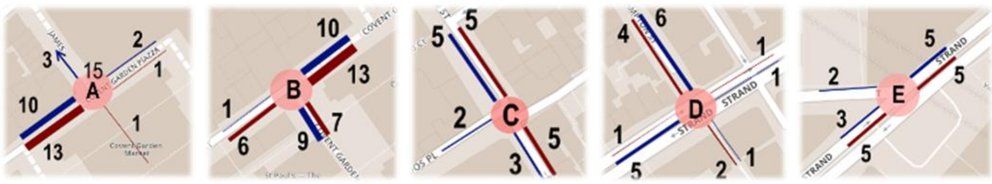


Figure 42. The number of participants travelling from the selected nodes during the day (red) and night (blue).

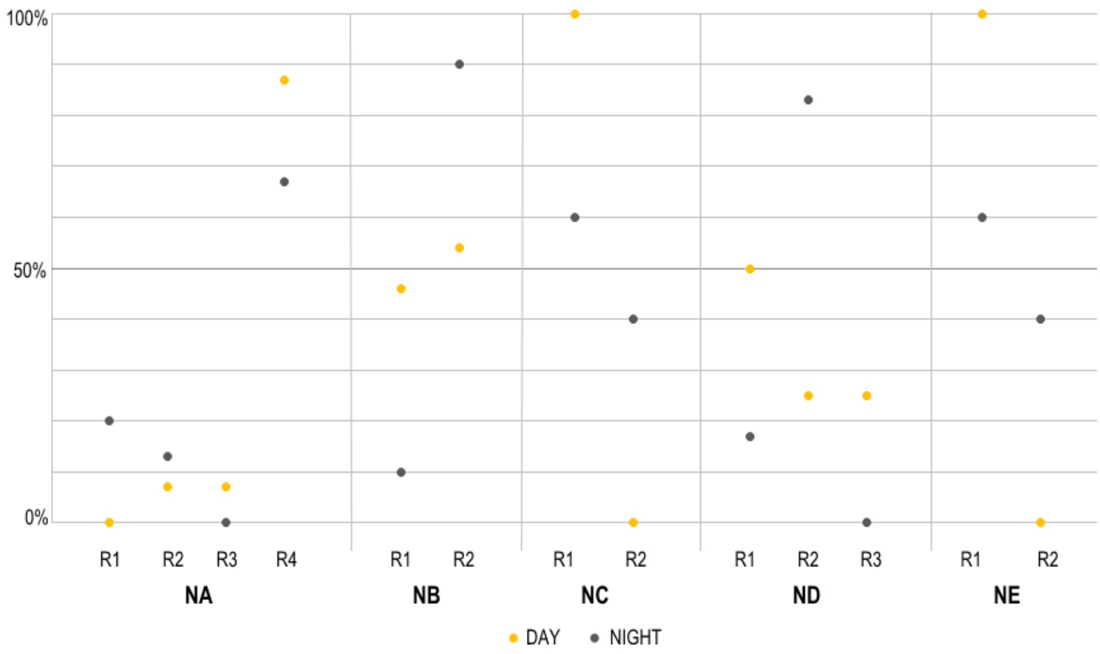


Figure 43. The distribution of participants at each node, in London, during the day and night-time interviews, as a percentage.

All the nodes which were selected for analysis present differences in the results between the two sets of interviews, which are particularly accentuated on nodes *B*, *C* and *E*. In most cases there was a preference for one particular route, as it was the case in *NA R4* for both day and night-time, *NB R2* and *ND R3* for night-time or *NC R1* and *NE R1* in day-time interviews (see Figure 43). There were only three cases where the participants distributed almost evenly between the available routes, which took place in day-time at node *B* and at night at *nodes C* and *E*.

The next pages show a detailed description of each node, covering those attributes that were thought to be critical to decision making, based on the overall explanations of the participants. These were the description of the routes coming out of each node, its liveliness, lighting conditions, and the analysis of the choices made by the participants.

The description of the routes consisted of the number of global and subjective landmarks visible from the node in each street, the street gradient and its direction. The first parameter is meant to inform of the existence of any landmarks that could have guided the participants, and whose visibility can differ depending on lighting conditions. The street gradient was remarked upon by a number of participants as an important clue, but also as a potential discouraging factor if a street was too steep. Although in London there were no sharp elevations that was not the case in Lisbon.

The liveliness of a street was characterized by the number of people there and also by the number of businesses open, which can be dissimilar at different hours. Some participants associated these aspects to the feeling of safety at night, along with the perception of the lighting conditions in the streets ahead. The account of people was achieved by observing and recording the number of people in the streets in different occasions at the time the interviews took place[174]. However, this was not performed systematically for all interviews, thus it is meant to be a guide only. The information regarding the number of businesses open was retrieved by consulting their opening hours.

The description of the lighting equipment and measurements for each street is applicable for the night-time only. It is meant to examine how lighting may have influenced the route choice, but it describes the characteristics of the public street lighting equipment alone. The data was obtained from the city council of Westminster, in London.

There are mainly two types of light sources in use in Westminster. These are gas lighting and ceramic metal halide lamps (denominated as MASTER Cosmo White CPO by the manufacturer Philips lighting, and thus abbreviated to CPO in these pages).

The characteristics of the light sources were described by colour temperature and colour rendering index, information which was retrieved from the technical description of the product provided by the manufacturer. These were considered to be the characteristics that would better characterize the quality of lighting. Gas lighting, however, is more difficult to characterize. According to Westminster[175] the colour temperature of mantle gas lighting when working properly should be between 2500 K and 2900 K. It was not possible to obtain information on its colour rendering index.

[174] The account was taken at three different occasions for each set of interviews.

[175] (City of Westminster, 2010)

The section "measurements" conveys information on the survey performed, in the field, at each street that derives from the nodes in question. These were the average luminance of each scene (L_{av}), as observed from the node, and the vertical (E_v) and horizontal illuminances (E_h). The first data was obtained by taking a number of spot luminance measurements from diverse surfaces from each street, coupled with capturing the scene at different exposure times with a digital camera. Afterwards, the technique of approximate field measurements was applied, in order to obtain approximate values of luminance for the entire image. This was achieved with the help of software (*ImageLum*), which allowed to calculate an approximate value for the average luminance of each street, as viewed from the node.[176]

There is also a section for luminance contrast (L_c), also obtained by using the technique described above. This field was only added for the images of those streets that had an object or an area of high luminance contrast, suspected of having influenced decisions.

The vertical illuminance was captured, from the node and near the beginning of the street of interest, by placing an illuminance meter at the height of the eyes of the observer[177]. The horizontal illuminance measurements were performed at each street, approximately three metres away from the intersection, and from a height of about 0.2 metres from the pavement.

The last sections of results describe the number of participants present at the node and their route choices. It is complemented by an account of the level of local knowledge by the participants who took each route.

After the description of the overall characteristics of the node and its streets, a new table was elaborated to convey additional detailed information for each route, coming out of the node. These contain the justifications given by the participants for choosing that particular route, associated with the declared level of knowledge of the individuals and the corresponding remarked landmarks. The column designated as *K* provides information on the level of knowledge, with the letter P standing for poor knowledge,

[176] This method is described in greater detail in the chapter of *Methods of analysis*.

[177] Corresponding roughly to 1.60 metres.

and the letter G for good or average knowledge. These letters are usually preceded by a number so that, for example, 1P/2G means that for 3 participants who gave the same justification for route selection, one declared that he had poor knowledge and the other two stated that they had a good knowledge of the area.

The column regarding the remarked landmarks was labelled with the symbol ✡. When a landmark was considered subjective, that is, not necessarily known to everyone as a global reference point, the letter (s) was added. Additionally, the table also adds further details on the lighting measurements, by presenting a luminance map and an illustration for the illuminance measurements. There is also a detailed analysis for areas of high luminance contrast when they existed or were thought to have affected route choice.

Node A

At the departure point, which was designated as *node A*, there were four possible paths of choice. Two of these paths (*R1* and *R2*) distanced the participant from the destination point, while the other two led them in the right direction (*R3* and *R4*).

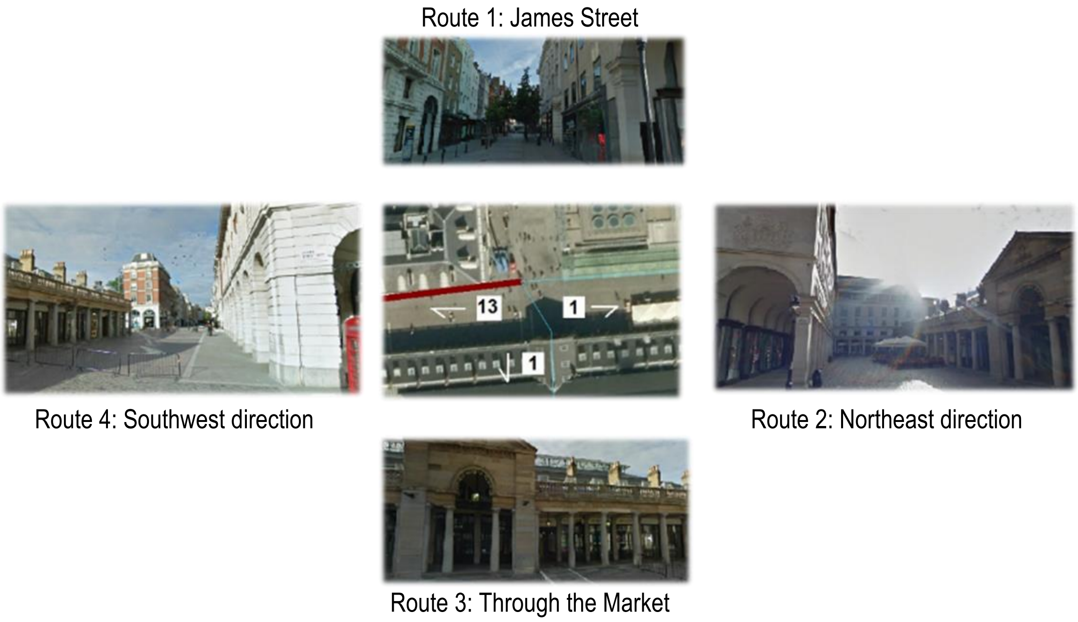


Figure 44. The possible routes from *node A* and the routes selected in the day-time interviews.

James Street (*R1*) leads northwest and is mostly flat. It comprises a number of stores and the Covent Garden underground train station. Route 2 leads northeast parallel to the Market, where several stores and a restaurant are present. Route 3 crosses the Market through its northwest facing façade, and route 4 leads southwest towards King Street. The liveliness of all routes is similar.

The main difference in results between the two sets of interviews was the fact that some participants chose to head towards James Street (*R1*) at night only. Observing all variables and reviewing the reasons for selection, it seems that at night, given the absence of the sun as a clue, there was a stronger tendency to follow the position of underground stations, as stated by the participants. However, although in overcast days these also substituted the sun position as clues, no one chose the direction of the underground station then. Thus, the night-time visibility of the Covent Garden underground sign could have played a role in attracting attention and the movement of people towards it. As it can be observed in the table for *node A R1*, in the next pages, the lit underground sign is small and is among a number of other bright areas.

However, the luminance contrast between the sign and its immediate background[178] is high at 37:1[179] and the contrast against the rest of the image is also high at 28:1.[180]

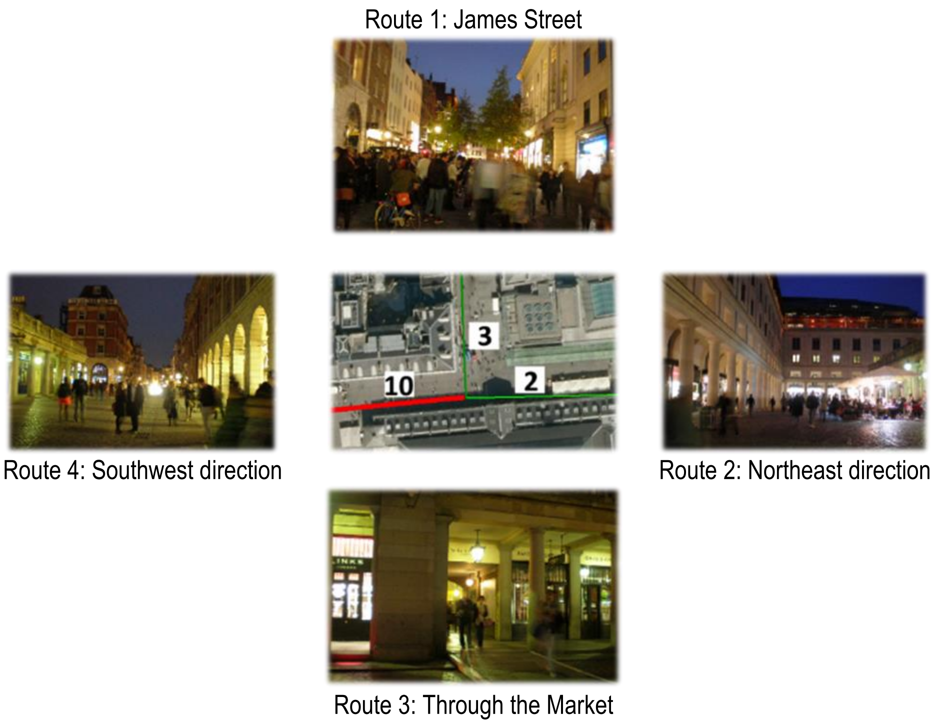


Figure 45. The possible routes from node A and the routes selected in the night-time interviews.

Summary of results	Route 1 was selected at night only.
	At night and in overcast days the participants recalled the underground map and the location of nearby tube stations for directions.
	The underground sign on route 1 is visible from the node with a luminance contrast of 1:28
	The two routes with the highest average luminance were also the least travelled at night (*R3* and *R2*)

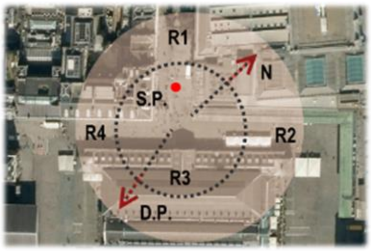
[178] The immediate background was considered as an area of approximately 12 cells around the target.

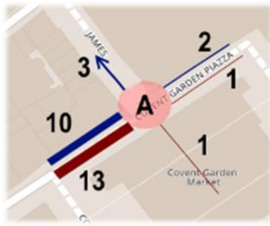
[179] 128:3.5 cd/m^2

[180] 128:4.57 cd/m^2.

LONDON

NODE A





		DAY				NIGHT			
		R1	R2	R3	R4	R1	R2	R3	R4
Route description	Number of global landmarks visible at the route	0	1	1	1	1	1	1	1
	Number of subjective landmarks	0	0	0	0	0	0	0	0
	Street gradient	Flat	Flat	Descent	Descent				
	Route direction	NW	NE	SE	SW				
Liveliness	Average number of people in the street	>10	>10	>10	>10	>10	>10	>10	>10
	Number of businesses open	>10	7	>10	5	>10	7	>10	5
Lighting equipment	Light source					Gas	Gas/ CPO	Gas/ CPO	Gas/ CPO
	Colour temperature (ºK)					2700	25-2900/ 2800	25-2900/ 2800	25-2900/ 2800
	CRI					-	-/62	-/62	-/62
Measurements	L_{av} (cd/m²)					4.6	11.4	18.2	4.8
	E_v (lux)					7	15	15	6.5
	E_h (lux)					5/3/180	5.3/7.7/ 26	8.4/22/ 190	10/9.4/ 11
	L_c of selected object					28:1			
Route choice	Number of participants	0/15	1/15	1/15	13/15	3/15	2/15	0/15	10/15
	Percentage (%)	0	7	7	87	20	13	0	67
Area knowledge	Good/fair (%)	-	100	100	46	33	50	-	60
	Poor (%)	-	0	0	54	67	50	-	40

LONDON

NODE A

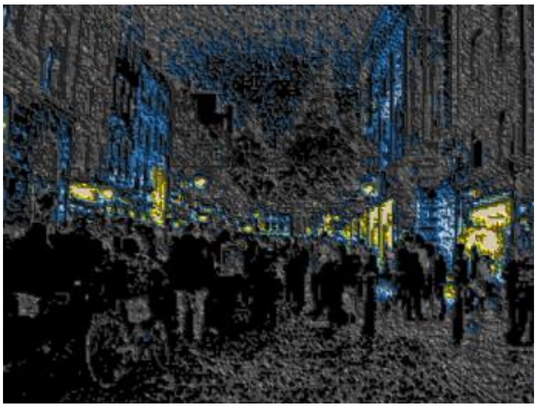
James Street

R1

Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Looking for underground stations from where to calibrate directions.	0	-	-	1	G	Underground station
Looking for Leicester Square underground station from where he expects to find Trafalgar Square.	0	-	-	1	G	" "
Looking for Piccadilly Circus	0	-	-	1	P	" "

Lighting measurements in detail

Luminance map (cd/m²)



Area of luminance contrast

Object: The underground sign

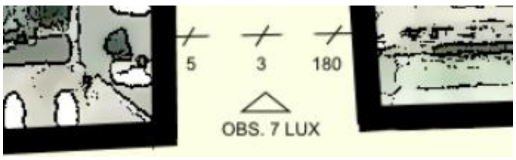
Contrast:

L_{av} of the object	128 (cd/m²)
L_{av} immediate background	3.5 (cd/m²)
L_{av} rest of the picture	4.6 (cd/m²)

Images:

■0.1-0.3 ■0.3-0.5 ■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-256.0 256.0-512.0

Illuminance measurements (lux)



LONDON

NODE A

Piazza (NE)

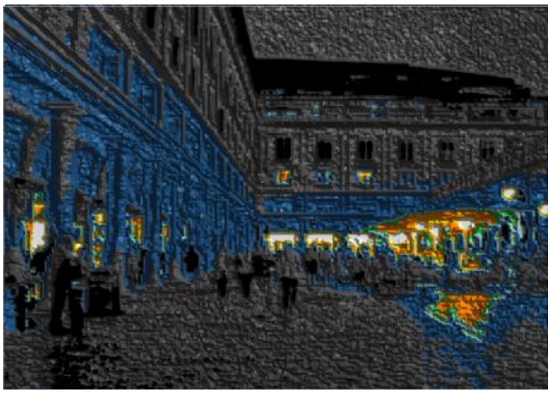
R2

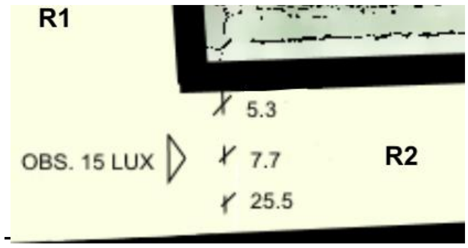
Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Heading (erroneously) towards Nelson's Column.	1	G	-	0	-	-
Heading towards embankment and then the river	0	-	-	1	P	-
Heading towards the river. The path looked correct because there are less buildings in sight.	0	-	-	1	P	-

Lighting measurements in detail

Luminance map (cd/m²)

Illuminance measurements (lux)





0.125-0.25 | 0.25-0.5 | 0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512 | 512-1024

LONDON

NODE A

The Market

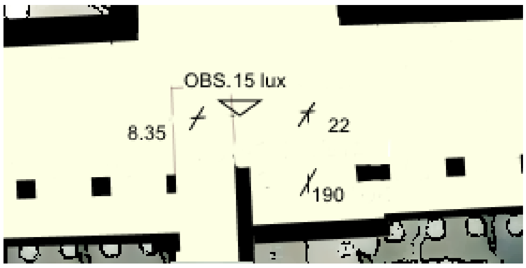
R3

Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Heading towards the river	1	G	The Market	0	-	-

Lighting measurements in detail

Luminance map (cd/m²)

Illuminance measurements (lux)



0.25-0.5 0.5-1 1-2 2-4 4-8 8-16 16-32 32-64 64-128 128-256 256-512 512-1024

LONDON

NODE A

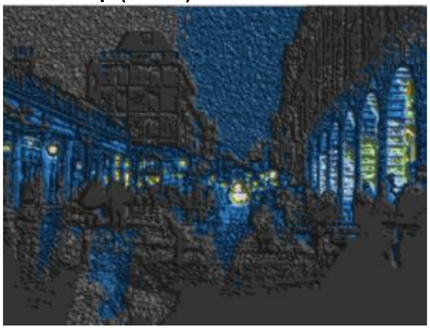
Piazza (SW)

R4

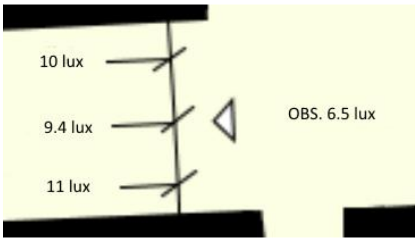
Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Heading towards Trafalgar Square	1	G	-	3	1P/2G	-
Heading towards The Strand	0	-	-	1	G	-
Heading towards Leicester Square and Trafalgar Square	0	-	-	1	G	-
Heading towards Leicester Square	2	1P/1G	-	0	-	-
Heading towards Embankment	0	-	-	1	G	-
The opposite direction seems to lead to a dead end, this way is open.	0	-	-	1	P	-
Random choice, looking for reference points	4	P	-	3	2P/1G	-
Heading West after determining the position of the sun	1	G	-	0	-	-
Towards Westminster tube station	2	P	-	0	-	-
Towards Charing Cross Road	1	G	-	0	-	-
Going around the market towards the river	2	P	-	0	-	-

Lighting measurements in detail

Luminance map (cd/m²)



Illuminance measurements (lux)



0.1-0.3 0.3-0.5 0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0 8.0-16.0 16.0-32.0 32.0-64.0 64.0-128.0 128.0-256.0 256.0-512.0

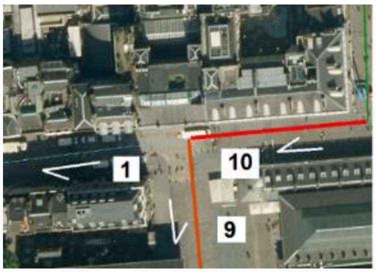
Node B

Node B is located in the beginning of King Street. There were two possible routes: R1 following King Street and R2, heading southeast alongside the west façade of the market.

Route 1: King Street

Route 2: Southeast direction

Route 1



Route 2

Figure 46. The routes taken by participants from node A in the day-time (at the top) and in the night-time (below).

The main difference between the two sets of interviews is the fact that in the day-time participants divided between the two routes, whereas in the night-time only one person took *R1*. Nine in ten participants turned left instead of going straight ahead through King Street.

The explanations given by the participants to justify the route selection were similar for both sets of interviews, with the exception of those who headed south taking the position of the sun as a clue. The remaining individuals were either looking for intermediate landmarks or were randomly searching for clues. However, these intermediate landmarks differed between the day and night-time interviews. Only at night were there participants in search of the river and Trafalgar Square, and these turned left on *R2.* Additionally, only in the day-time were there people who searched for Leicester Square, Charing Cross Road or Westminster, and these went straight ahead through *R1*. Thus the reason for the difference in behaviour could have been simply the coincidence of the two groups of people having selected different intermediate landmarks, in the day and night-time, to orientate their navigation towards the Houses of Parliament. However, there could have been other underlying factors that weighted in the selection.

Given the disparity in the night-time results, it was investigated if lighting could have influenced, even if unconsciously, the decision to take *R2* instead of *R1*. The average luminance of the two routes is not greatly different, nor are the characteristics of the light sources from public lighting. However, the distribution of lighting is different, and the predominant light sources do not seem to be from public lighting. In the case of *R1* in particular there are several signs, facades and windows of stores highly lit, all of which use different light sources. At *R2* the main visible lighting was that of a restaurant which seemed to be using fluorescent lamps attached to parasols. It was found that the areas of higher luminance were dispersed throughout the scene horizontally through clusters of diverse spots of light in *R1*. In *R2*, there was one single area of high luminance contrast with a ratio of around 26:1 (59:2.3 cd/m^2) against the background.

The only comment on the lighting conditions was made by one participant who had poor knowledge of the area and chose to follow *R1* attracted by the bright lights at the end of the street, hoping it meant finding clues for directions.

The attraction for *R2* at night could have been due to coincidently all participants searching for similar intermediate landmarks situated in the direction of that route. However, the large area of high luminance contrast at *R2* could eventually also have attracted their attention and consequently the direction of their travel.

Summary of results	There was a clear preference for *R2* at night only
	The participants declared that their route choice was based on reaching intermediate landmarks.
	The intermediate landmarks in day time were different from those in night-time interviews.
	R2 has a specific area of very high luminance contrast. On R1 there are several areas of high luminance contrast dispersed throughout the scene.

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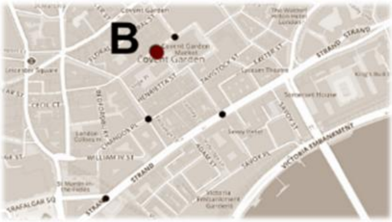
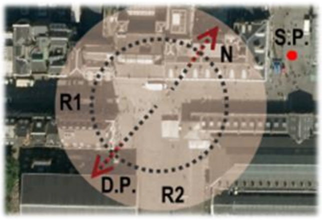
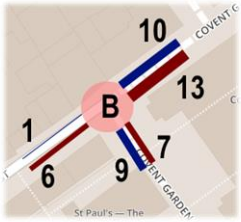
NODE B







		DAY		NIGHT	
		R1	R2	R1	R2
Route description	Number of global landmarks visible at the route	0	2	0	2 (Church, market)
	Number of subjective landmarks	1	0	0	0
	Street gradient	Flat	Descent 3^0		
	Route direction	SW	SE		
Liveliness	Average number of people in the street	>10	>10	>10	>10
	Number of businesses open	>10	5	7	4
Lighting equipment	Light source			CPO	Gas/ CPO
	Colour temperature (K)			2800	25-2900/2800
	CRI			62	-/62
	Others			diverse	Possibly fluorescent
Measurements	L_{av} (cd/m²)			14.5	11.4
	E_v (lux)			4	4.5
	E_h (lux)			67/3/117	1.5/2/3
	L_c of selected object				26:1
Route choice	Number of participants	6/13	7/13	**1/10**	**9/10**
	Percentage (%)	46	54	**10**	**90**
Area knowledge	Good/fair (%)	50	43	0	56
	Poor (%)	50	57	100	44

LONDON

NODE B

King street

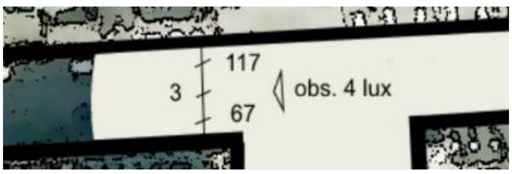
R1

Route choice explanation	DAY Nº	K	✩	NIGHT Nº	K	✩
Quickly escape the confusion of street performances and crowd. Thinks it leads to Westminster.	1	P		0	-	
Heading towards Leicester Square	2	1P/1G		0	-	
Selected route randomly in search of references.	1	G		0	-	
Selected the route because the participant knows a pub in the street ahead	1	P	Pub	0	-	
Heading towards Charing Cross Road	1	G		0	-	
Attracted by lighting ahead indicating there is a big road there.	0			1	P	

Lighting measurements in detail

Luminance map (cd/m²)

Illuminance measurements (lux)



0.1-0.1 0.1-0.3 0.3-0.5 0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0 8.0-16.0 16.0-32.0 32.0-64.0 64.0-128.0 128.0-256.0 256.0-512.0 512.0-1024.0 1024.0-2048.0 2048.0-4000.0

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NODE B

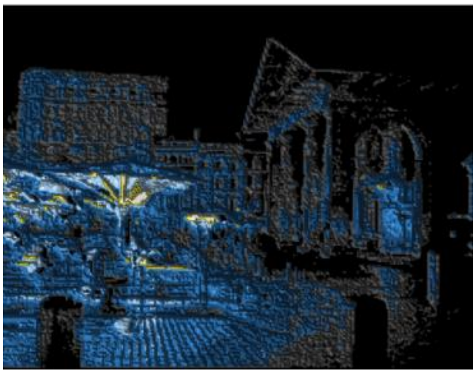
R2

Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Turns in this direction to head South	3	1P/2G		-	-	
Heading towards The Strand	1	G		2	2G	
Going around the market to have a sense of direction, search randomly for reference points.	3	3P		2	1P/1G	
Towards the river	-	-		3	2P/1G	
Towards Trafalgar Square	-	-		2	1P/1G	

Lighting measurements in detail

Luminance map (cd/m²)



Area of luminance contrast -

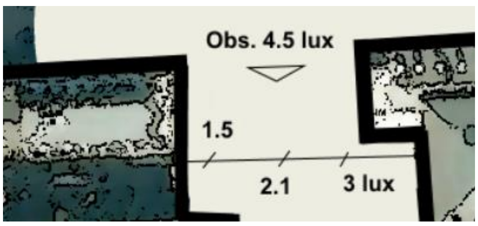
Object: Restaurant area

Contrast: L_{av} of the object: 59 (cd/m²); L_{av} of the context 2.3 (cd/m²)

Images:

0.1-0.3 · 0.3-0.5 · 0.5-1.0 · 1.0-2.0 · 2.0-4.0 · 4.0-8.0 · 8.0-16.0 · 16.0-32.0 · 32.0-64.0 · 64.0-128.0 · 128.0-256.0 · 256.0-512.0 · 512.0-1,024.0 · 1,024.0-2,048.0 · 2,048.0-4,000.0

Illuminance measurements (lux)



Node C

Node C is located at the intersection of Bedford Street (*R1*) with Chandos Place (*R2*). There were five participants standing at the node in both sets of interviews, making a different selection of paths. In the day-time all five individuals chose to go straight ahead towards The Strand through *R1*, but at night only three participants made that same choice, while the other two turned to Chandos Place (*R2*). Although looking at a very small sample it was thought worth to examine if there could have been an influence of lighting on the attraction towards *R2* at night.

Route 2: Chandos Place

Route 1:Bedford Street

Route 2: Chandos Place

Route 1:Bedford Street

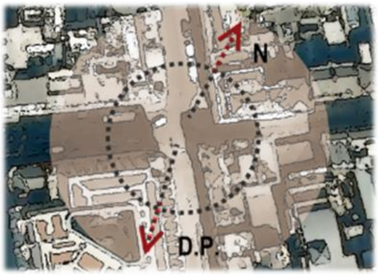
Looking first at the explanations provided by the participants, it was found that in the day-time most of them had a good knowledge of the area and were looking for intermediate landmarks. However, at night, almost all participants who stood at that intersection had poor knowledge of the area. Those who followed *R1* were mainly attracted by the amount of light ahead, or by the fact that the street descends, and those who followed *R2* explained they were going towards Trafalgar Square.

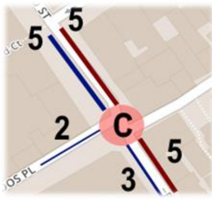
The lighting analysis showed that the average luminance of the view from the node towards Bedford Street is higher than that of Chandos Place by a ratio of roughly 3:1. However, the scenes are not uniformly lit. In both streets there is an area of high luminance contrast, produced mainly by lit facades, which could have acted as focal points. The ratio of luminance contrast for the brightest area of the image against its background was estimated at around 10:1 (12:1.2) at *R1* and around 14:1 (8.1:0.6) at *R2*.

Summary of results	All participants chose route 1 in the day-time.
	The night-time participants chose almost equally between the two routes.
	Average luminance is larger in one of the routes, but it doesn't appear to make a large difference for route selection.
	The difference in route selection could be related to the existence of large areas of high luminance contrast that act as focal points on both routes.

LONDON

NODE C





		DAY R1	DAY R2	NIGHT R1	NIGHT R2
Route description	Number of global landmarks visible at the route	0	0	0	0
	Number of subjective landmarks	0	0	0	1
	Street gradient	Descent 1⁰	Flat		
	Route direction	SE	SW		
Liveliness	Average number of people in the street	0-5	0-5	0-5	0-5
	Number of businesses open	6	5	6	4
Lighting equipment	Light source			Gas	Gas
	Colour temperature (ºK)			25-2900	25-2900
	CRI			-	-
Lighting	L_{av} (cd/m²)			**3.6**	1.6
	E_v (lux)			1.7	1
	E_h (lux)			24/3/1.4	1/2/3.2
	L_c of selected object			10:1	14:1
Route choice	Number of participants	**5/5**	**0/5**	**3/5**	2/5
	Percentage (%)	**100**	**0**	**60**	40
Area knowledge	Good/fair (%)	60	-	0	50
	Poor (%)	40	-	100	50

LONDON

NODE C

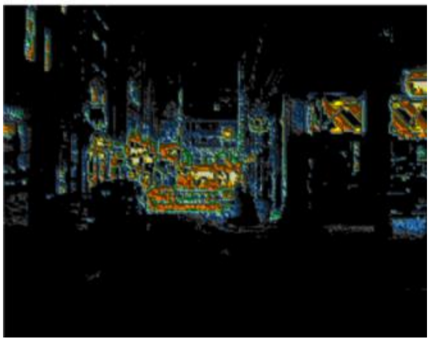
Bedford Street

R1

Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Is attracted by the main road ahead that should provide him with more clues.	1	G		1	P	
The street descends so eventually it will lead to the river	1	G		1	P	
Heading to The Strand to get to the river	1	G		-	-	
Unsure, but decide to go South, thus straight ahead, using the position of the sun as a clue, because the river and Westminster are located in that direction.	2	2P		-	-	
Attracted by lighting from The Strand which indicates it is a main road	-	-		1	P	

Lighting measurements in detail

Luminance map (cd/m²)



■0.1-0.3 ■0.3-0.5 ■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-256.0 ■256.0-300.0

Area of luminance contrast -

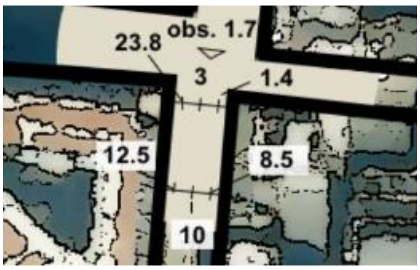
Object: Facades at the end of the street

Contrast: L_{av} of the object 12

L_{av} of the context 1.2

Image:

Illuminance measurements (lux)



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NODE C

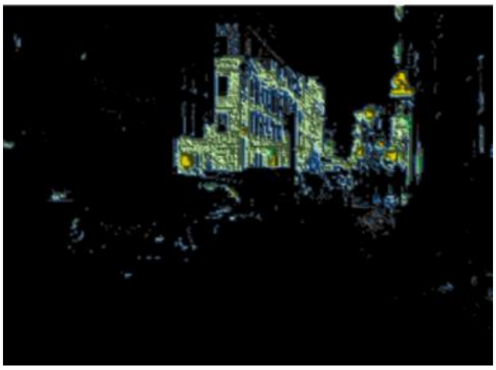
Chandos Place

R2

Route choice explanation	DAY Nº	DAY K	DAY ☆	NIGHT Nº	NIGHT K	NIGHT ☆
Knows the restaurants Friday's and Nando's which are located in that street. Thinks it's the shortest route towards Trafalgar Square.	-	-	-	1	P	Restaurants (s)
Trying to be efficient with the route, making a diagonal to Trafalgar Square instead of going directly to The Strand.	-	-	-	1	G	-

Lighting measurements in detail

Luminance map (cd/m²)



■0.1-0.3 ■0.3-0.5 ■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-200.0

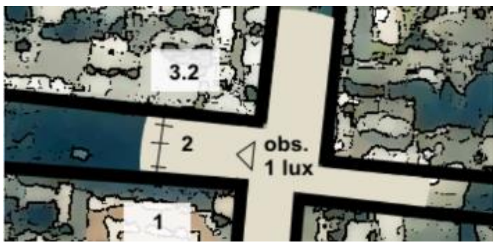
Area of luminance contrast -

Object: Facades at the end of the street

Contrast: L_{av} of the object 8.1 (cd/m²); L_{av} of the context 0.6 (cd/m²)

Images:

Illuminance measurements (lux)



Node D

Node *D* is located at the exit of Southampton Street, where it intersects The Strand, and it allowed the choice of three routes: Straight ahead through Carting Lane (*R1*), turning right on The Strand towards the southwest and Trafalgar Square (*R2*) or turning left at The Strand towards the Northeast and the City (*R3*).

The main difference on the behaviour of the day and night-time participants was the fact that in the day time everyone took different paths, with a slight preference for *R1*, whereas in the night all but one took *R2*.

Route 2: The Strand to SW

Route 3: The Strand to NE

Route 1:Carting Lane

Route 2: The Strand to SW

Route 3: The Strand to NE

Route 1:Carting Lane

Figure 47. The routes taken by participants from node E in the day-time (above) and in the night-time (below).

In the day-time four participants stood at the intersection: two followed *R1*, one turned right to *R2* and one turn left to *R3*. At night six persons stood at the node and all turned on *R2* with the exception of one who went through *R1*.

The main factors that stand out as probable causes for the differences in route selection are the level of knowledge that the participants had of the area and the ability to detect and identify landmarks. In the day-time only one individual had good knowledge of the area, whereas in the night time all participants except one had poor knowledge of the area. This was probably the reason why no one went on the opposite direction of the destination, through *R3* in the night-time. However, the visibility of landmarks may also have influenced the decisions. At night there were no landmarks visible on any route, whereas under daylight it was possible to detect at least one landmark visible on the street. Most conspicuously, the main incentive for those who took *R1* in the day-time was the detection of the river, which was not visible at night. A similar situation occurred in *R2*, where in the day-time the only person who took that route did so because he was able to see Nelson's column. However, at night, no one detected this landmark, and the decision to follow *R2* was due to the perception of brightness ahead. Three participants who took this direction declared that they were attracted by the quantity of light ahead and that the other routes seemed too dark.

The analysis of the lighting shows that the average luminance of *R2* is slightly larger than that of the other routes.

Summary of results	Most participants took route 2 in the night-time, although it wasn't the preferred route in day-time interviews.
	At night there are no global landmarks visible at any route.
	The detection of the river seemed to be the main attraction for choosing route 1 in the day-time.
	At night the participants declared being discouraged of taking route 1 because it looked dark. Additionally the river is no longer visible from the node in that direction.
	Average luminance is slightly larger at route 2.

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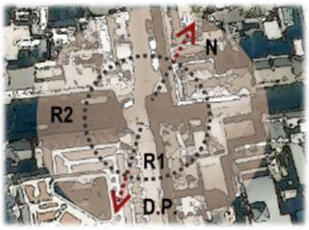
NODE D



		DAY R1	DAY R2	DAY R3	NIGHT R1	NIGHT R2	NIGHT R3
Route description	Number of global landmarks visible at the route	1 (The river)	1 (Nelson's Column)	1 (St Clement's Church)	0	0	0
	Number of subjective landmarks	0	0	0	0	1	0
	Street gradient	Descent	Descent	Ascending			
	Route direction	SE	SW	NE			
Liveliness	Average number of people in the street	0-3	>10	>10	0	>10	>10
	Number of businesses open	0	>10	>10	0	>10	>10
Lighting equipment	Light source				Gas/ CPO	CPO	CPO
	Colour temperature (K)				25-2900/ 2800	2800	2800
	CRI				-/62	62	62
Lighting	L_{av} (cd/m²)				10.4	15.5	11.5
	E_v (lux)				17	19	21.4
	E_h (lux)				30/29/ 30	31/14/ 13	76/16/ 20.7
	L_c of selected object						
Route choice	Number of participants	2/4	1/4	1/4	1/6	**5/6**	0/6
	Percentage (%)	50	25	25	17	**83**	0
Area knowledge	Good/Fair	50	0	0	0	80	-
	Poor (%)	50	100	100	100	20	-

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NODE D

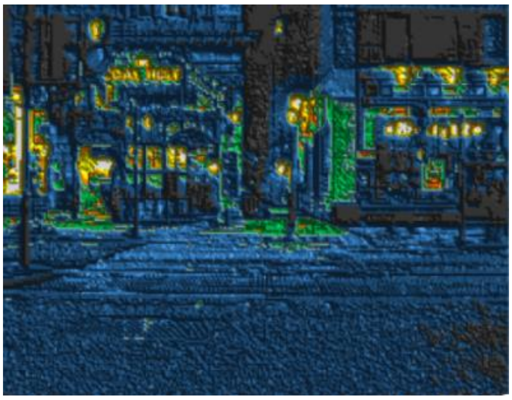
Carting lane

R1

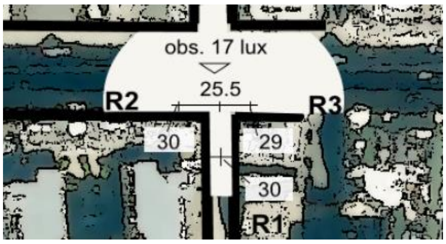
Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Going straight ahead towards the river. The participants are able to see water from The Strand.	2	1P/1G	The river and The Strand			
Remembers that the river is located across The Strand.				1	G	The Strand

Lighting measurements in detail

Luminance map (cd/m²)



Illuminance measurements (lux)



0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512

LONDON

NODE D

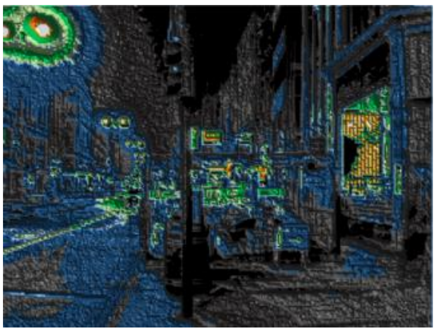
The Strand (SW)

R2

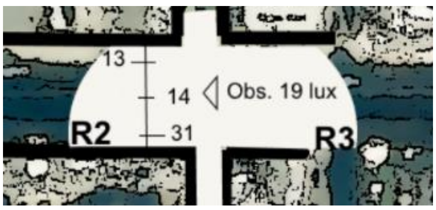
Route choice explanation	DAY Nº	DAY K	DAY ✩	NIGHT Nº	NIGHT K	NIGHT ✩
Initially heading towards the river, the participant stops at The Strand because he recognizes it as a main road. There he detects Nelson's Column and decides to follow in its direction.	1	P	Nelson's Column			
Recognizes The Strand and heads towards Charing Cross station or Trafalgar sq.				2	1P/1G	The Strand
Recognizes The Strand due to a Theatre. Does not go left because it looks dark, and although initially she was thinking of heading towards the river, decides not to go straight ahead because it's dark.				1	G	The Strand / Theatre (s)
Follows the direction of a bus. Had Arrived at The Strand attracted by the quantity of light.				1	G	
Heading to Embankment. Tries Carling Lane first, but the participant does not recognize it.				1	G	

Lighting measurements in detail

Luminance map (cd/m²)



Illuminance measurements (lux)



0.125-0.25 | 0.25-0.5 | 0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512 | 512-1024 | 1024-2048

LONDON

NODE D

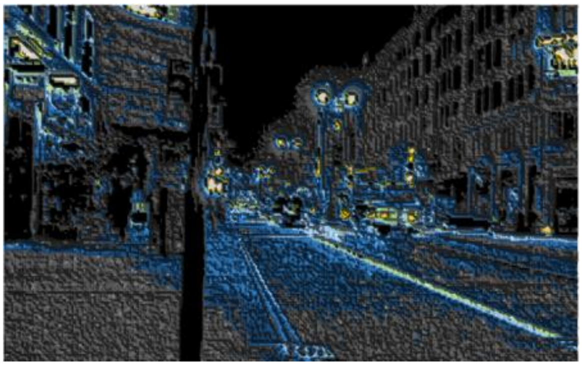
The Strand (NE)

R3

Route choice explanation	DAY			NIGHT		
	Nº	K	☆	Nº	K	☆
Turns in that direction randomly and because he detects a green area which indicates an open space. The open space should give him more opportunity to detect landmarks.	1	P	-	-	-	-

Lighting measurements in detail

Luminance map (cd/m²)



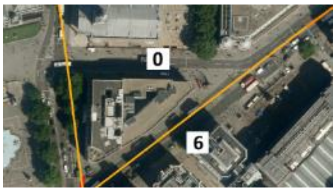
Illuminance measurements (lux)

0-0 ■ 0-1 ■ 1-1 ■ 1-2 ■ 2-4 ■ 4-8 ■ 8-16 ■ 16-32 ■ 32-64 ■ 64-128 ■ 128-256 ■ 256-512 ■ 512-1,024 ■ 1,024-1,200

Node E

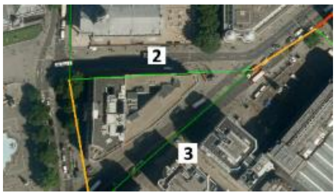
Node E is located at The Strand and allowed the choice of two routes: Straight ahead continuing on The Strand (*R1*), or turning right through Duncannon Street (*R2*).

In the day-time six participants stood at the intersection, and all choose to go straight ahead through route 1. At night, there were five persons at the node. Three took route 1 and the remaining two took route 2.



Route 1: The Strand

Route 2:
Duncannon Street



Route 1

Route 2

Figure 48. The routes taken by the participants from node E in the day-time (above) and in the night-time (below).

The recognition of landmarks seems of great importance for route selection here. In the day-time most participants noticed Nelson's Column in advance when walking through The Strand and that seemed to prompt the route choice. The recognition of Charing Cross Station seems to have been determinant for selecting a route, as most participants who went straight ahead recognized it, confirming they were on the right path, in both day and night interviews. All of those who followed route 2 in the night-time interviews were attracted by The National Gallery and did not recognize Charing Cross Station.

Day	Remarked landmarks	Number of participants	Selection	Route choice
	Nelson's Column	2	R1	R2=0/5
	The London Eye	1	R1	
	Charing Cross Station	3	R1	
	The National Gallery	1	R1	R1=5/5
Night	Charing Cross Station	1	R1	
	The National Gallery	3	2 to R2/ 1 to R1	**R2**=2/5
	Not mentioned	1	R1	**R1**=3/5

Table 25. Detailed description of the selection of routes at node E.

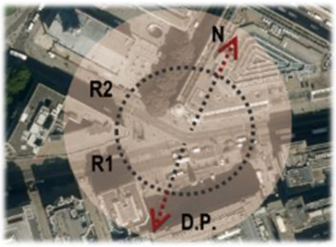
The lighting analysis shows that route 1 has a higher average luminance than route 2, at a ratio of roughly 3:1. However, the National Gallery seems to have attracted the attention of the participants to route 2, even though the luminance contrast ratio of this element against the background was estimated, not very high, at around 2:1 (11.4:5.9 cd/m^2).

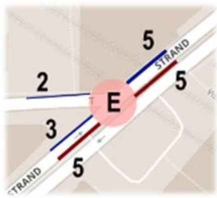
Unfortunately the photograph of node E was taken when the sky was not completely dark, altering the contrast that the participants were confronted with. Because it was not possible to capture the images and measurements again, the sky was considered to have a luminance of 0, as to calculate the immediate background average luminance of the National Gallery as seen from node E.

Summary of results	In the day-time, all participants chose route 1, but at night, the participants divided almost equally between the two routes.
	The main factor for the differences between day and night-time interviews seems to be the recognition of landmarks and The National Gallery acting as an attraction for some. Those that recognized Charing Cross Station went through Route 1, those who didn't followed route 2 attracted by The National Gallery.
	In the day-time Nelson's column visibility from afar was also a determinant element for the selection of route 1. This landmark wasn't visible at night.

LONDON

NODE E





		DAY		NIGHT	
		R1	R2	R1	R2
Route description	Number of global landmarks visible at the route	1	1	0	1
	Number of subjective landmarks	0	0	0	0
	Street gradient	Flat	Descent 1^0		
	Route direction	SE	SW		
Liveliness	Average number of people in the street	>10	>10	>10	>10
	Number of businesses open	6	3	3-4	2-3
Lighting equipment	Light source			CPO	CPO
	Colour temperature (K)			2800	2800
	CRI			62	62
Lighting	L_{av} (cd/m^2)			**18.5**	6.6
	E_v (lux)			28	28
	E_h (lux)			16.5/18.5/22.5	16.5/6.2
	L_c of selected object			-	11.4:5.9
Route choice	Number of participants	**5/5**	**0/5**	3/5	2/5
	Percentage (%)	**100**	**0**	60	40
Area knowledge	Good/fair (%)	60	-	67	50
	Poor (%)	40	-	33	50

LONDON

The Strand (NE)

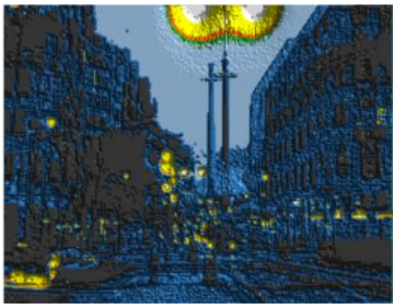
NODE E

R1

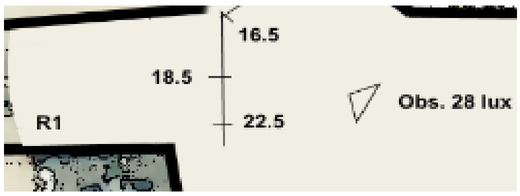
Route choice explanation	DAY Nº	DAY K	DAY ✡	NIGHT Nº	NIGHT K	NIGHT ✡
Sees Nelson's Column from the distance, in The Strand and decides to go straight ahead to reach it. Knows he will be able to see Big Ben from there.	1	P	Nelson's Column	0	-	-
Recognizes Charing Cross Station which confirms he is on the right path and continues ahead.	3	G	Charing Cross Station	0	-	-
He sees The London Eye from The Strand and follows its direction going straight ahead.	1	P	The London Eye	0	-	-
Wants to go straight ahead until the end of The Strand.	0			3	1P/2 G	1 Charing Cross station 1 The National Gallery 2 Trafalgar Square

Lighting measurements in detail

Luminance map (cd/m²)



Illuminance measurements (lux)



0.5-1 1-2 2-4 4-8 8-16 16-32 32-64 64-128 128-256 256-512 512-1024

LONDON

NODE E

The Strand (NE)

R2

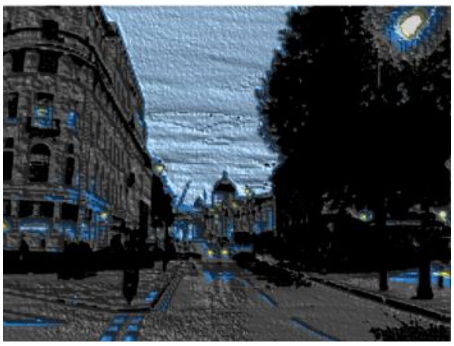
Route choice explanation

Does not recognize Charing Cross Station and is attracted by the National Gallery as being an important landmark from which he will be able to find another clue.

DAY			NIGHT		
Nº	K	✡	Nº	K	✡
0	-	-	2	1P/1G	The National Gallery

Lighting measurements in detail

Luminance map (cd/m²)



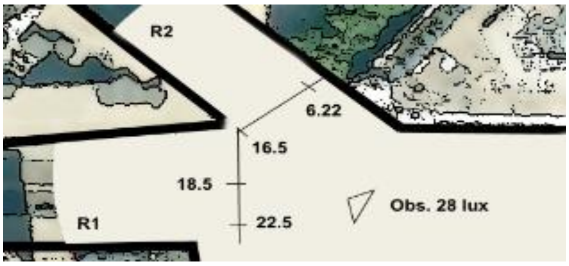
Area of luminance contrast -

Object:	The National Gallery	
Contrast	L_{av} object	11.4 (cd/m²)
	L_{av} context	5.9 (cd/m²)
	L_{av} dome	9.7 (cd/m²)

Images:

■ 0.5-1 ■ 1-2 ■ 2-4 ■ 4-8 ■ 8-16 ■ 16-32 ■ 32-64 ■ 64-128 ■ 128-256 ■ 256-512 ■ 512-1024 1024-2048

Illuminance measurements (lux)



Conclusions for the walking interviews in London

Most participants, both in day and night time interviews, constructed a strategy before starting walking based on the use of a mental map composed of a number of anchor points or landmarks, such as a main square, building or road, towards which they intended to walk to. However, during the progression of the wayfinding task, it was found that the participants would change their first intended route according to visual cues found on route or in face of other recognizable landmarks. These could be globally known landmarks or of subjective nature to the participant alone, and usually related to past memories.

Although the individuals were instructed to use the path they would usually take to get to the destination point, those who were familiar with the environment often chose to go through the shortest or most direct route.

In the daytime interviews a number of individuals justified their navigation based on the cardinal directions. This was not observed in the night-time.

A number of those who declared having poor knowledge of the city seemed to navigate using a mental map of the transportation system, specifically the tube, as guidance. Probably because most participants arrived using the underground system.

Through literature review and after analysing the answers of the participants, it was found that route choice at an intersection is related to a large number of factors. The visibility of a reference point, either globally known or of subjective nature, helps to provide a sense of direction, the number of people on the street and the perception of levels of lighting relates to the feeling of safety and may attract or repel the individuals from taking a certain route. At night, the existence of a focal point, that is, a specific area of high luminance contrast which attracts attention may lead people towards its direction.[181]

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[181] As suggested by (Michel, 1996), (Kang, 2004)

THE RESULTS IN LISBON

For the verbal interviews

For the photographic interviews

For the walking interviews

THE RESULTS IN LISBON

For the verbal interviews

The results of the verbal interviews were mainly important to extract the basic elements that compose the image that the inhabitants of Lisbon have of their city. In total, a number of one hundred and eighty five distinct elements were extracted for Lisbon, which were classified under Lynch's nomenclature as *landmarks, nodes, paths, edges* and *districts* and ranked from high to low recognisability. The number resulted from the account of distinct elements that were drawn and described as distinctive. The element that was more frequently remarked upon and drawn was the roundabout and statue *Marquês de Pombal*, 60 times in total. This means it was mentioned as distinctive by all participants and it appeared in all sketches. There were dozens of elements which were only mentioned or drawn once, making them the lower ranked elements.

#	Element	Total frequency	Classification
1	Estátua e rotunda Marquês de Pombal	60	N/L
2	Praça do Comércio	42	N/L
3	Avenida da Liberdade	38	P
4	Rossio	38	N
5	Castelo de São Jorge	32	L
6	Rio Tejo	25	E
7	Bairro Alto	22	D
8	Restauradores	21	N
9	Rua Augusta	19	P
10	Baixa Pombalina	18	D
11	Parque Eduardo VII	18	D
12	Praça Saldanha	18	N
13	Alfama	16	D
14	Chiado	16	D
15	Avenida Fontes Pereira de Melo	15	P
16	Mosteiro dos Jerónimos	12	L
17	Avenida da República	11	P
18	Ponte 25 de Abril	11	P/L
19	Torre de Belém	11	L

20	Amoreiras	10	D
21	Praça da Figueira	10	N
22	Campo Grande	9	D
23	Largo de Camões	9	N
24	Sé de Lisboa	9	L
25	Teatro D. Maria II	9	L
26	Arco da rua Augusta	8	L
27	Belém	8	D
28	Estação do Rossio	8	L/N
29	Rua da Prata	8	P
30	Rua do Ouro	8	P
31	Estação de Santa Apolónia	8	L
32	Cais do Sodré	7	N
33	Princípe Real	7	D
34	Centro Cultural de Belém	6	L
35	Elevador de Santa Justa	6	L
36	Jardim da Estrela	6	D
37	Largo do Rato	6	N
38	Mouraria	6	D
39	Praça de Touros	6	L
40	Parque das Nações	5	D
41	Graça	5	D
42	Martim Moniz	5	N
43	Miradouro de São Pedro de Alcântara	5	L
44	Miradouro da Graça	5	L
45	Padrão dos Descobrimentos	5	L
46	Rua Garrett	5	P
47	Assembleia da República	4	L
48	Avenida 24 de Julho	4	P
49	Estátua de D. José	4	L
50	Estátua Fernando Pessoa	4	L
51	*Praça do Municipio*	*4*	*N*
52	*Rua do Alecrim*	*4*	*P*
53	*Rotunda de Entrecampos*	*4*	*N*

Table 26. Table of those elements that emerged from the verbal interview of Lisbon with a frequency of 12% or above. The elements which are highlighted with a grey background are the 50 most distinct elements which were presented in the photographic interviews.

As it can be observed in the figure below, the image of Lisbon seems to be distributed in two distinct clusters of landmarks, one in the centre and another in the west side of Lisbon, corresponding to *Belém* district. As in London, the only edge that appeared in the interviews with a frequency above 12% was the river (rio Tejo).

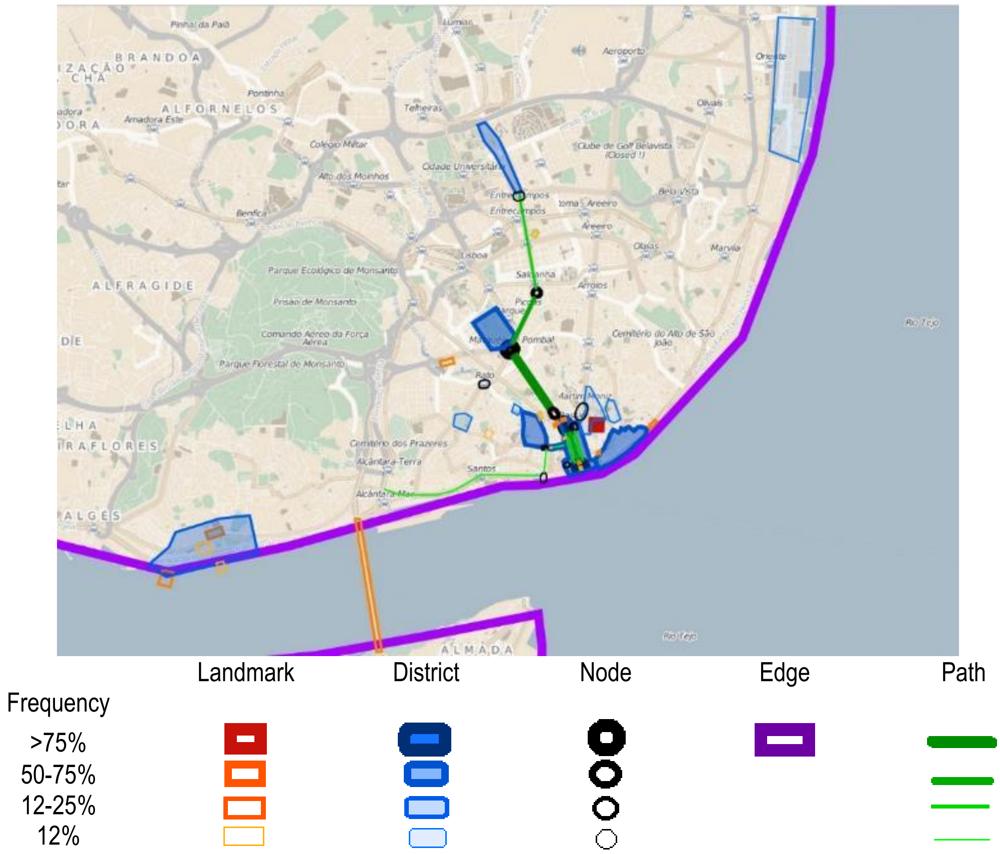


Figure 49. Mapping of all elements drawn and mentioned by participants. *Landmarks* in red, *districts* in blue, *nodes* in black, *edges* in purple, and *paths* in green colour. The borders correspond to those elements described in the interview and the coloured areas to the elements that were drawn.

The main five landmarks that were pointed out by the participants were *Estátua Marquês de Pombal* (which is located at a node), *Praça do Comércio*, *Castelo de São Jorge* (the city castle, located on the top of a hill), *Mosteiro dos Jerónimos* and *Ponte 25 de Abril* (the first bridge to cross the river from Lisbon to the South side). The next picture represents all landmarks that emerged from the verbal interview with a frequency above 12%.

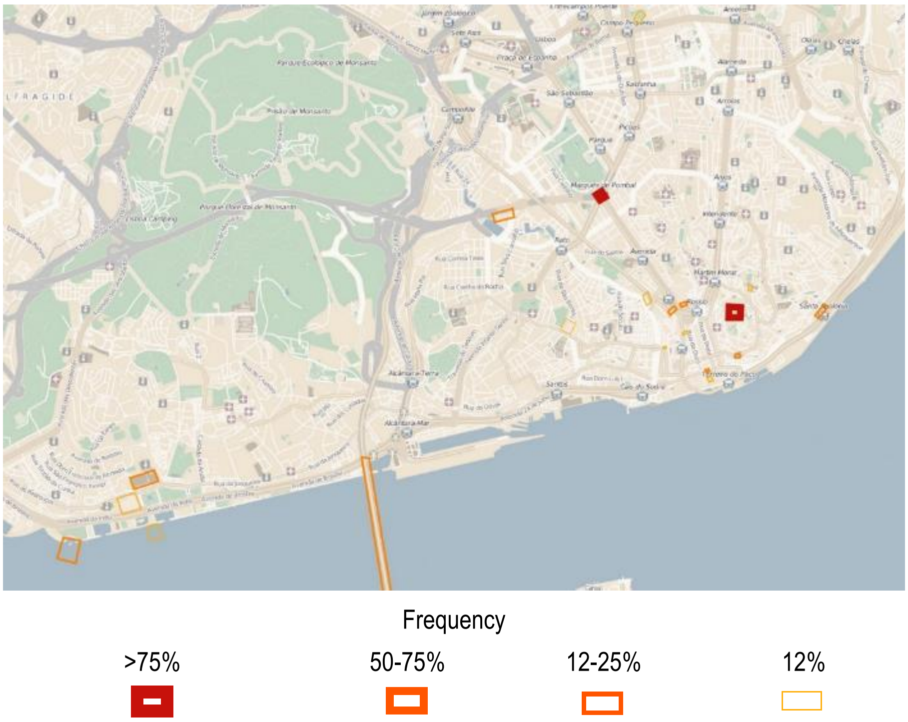


Figure 50. Location on map of the results of the verbal interviews for all *landmarks* with a frequency equal or above 12% in Lisbon.

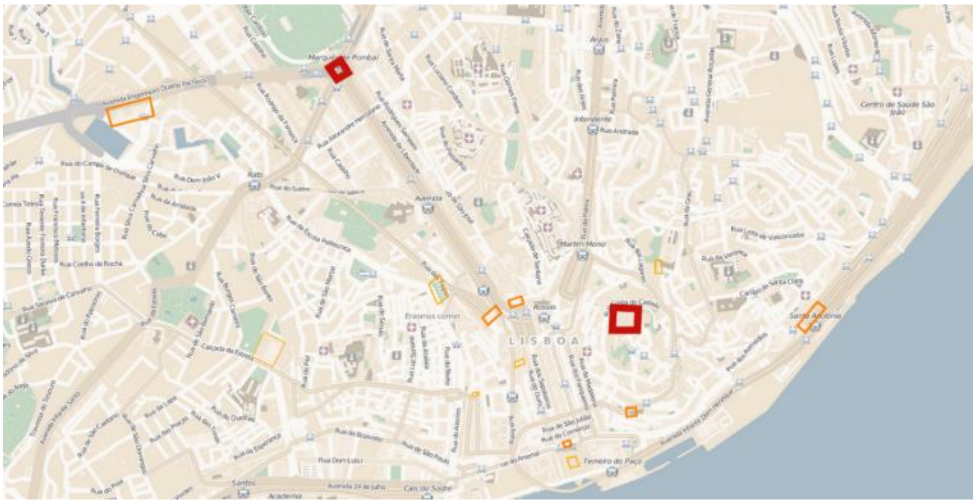


Figure 51. A detail of the area where the greatest concentration of *landmarks* was detected.

The most distinctive nodes were found to be, by order: *Rotunda Marquês de Pombal*, *Praça do Comércio*, *Rossio*, *Restauradores* and *Praça Saldanha*. With the exception of the first, which is a roundabout, they are all some of the main squares of the city.

Figure 52. Location on map of the results of the verbal interviews for all *nodes* with a frequency equal or above 12% in Lisbon.

The five most frequently remarked upon and drawn districts were *Bairro Alto, Baixa Pombalina, Parque Eduardo VII, Alfama* and *Chiado*.

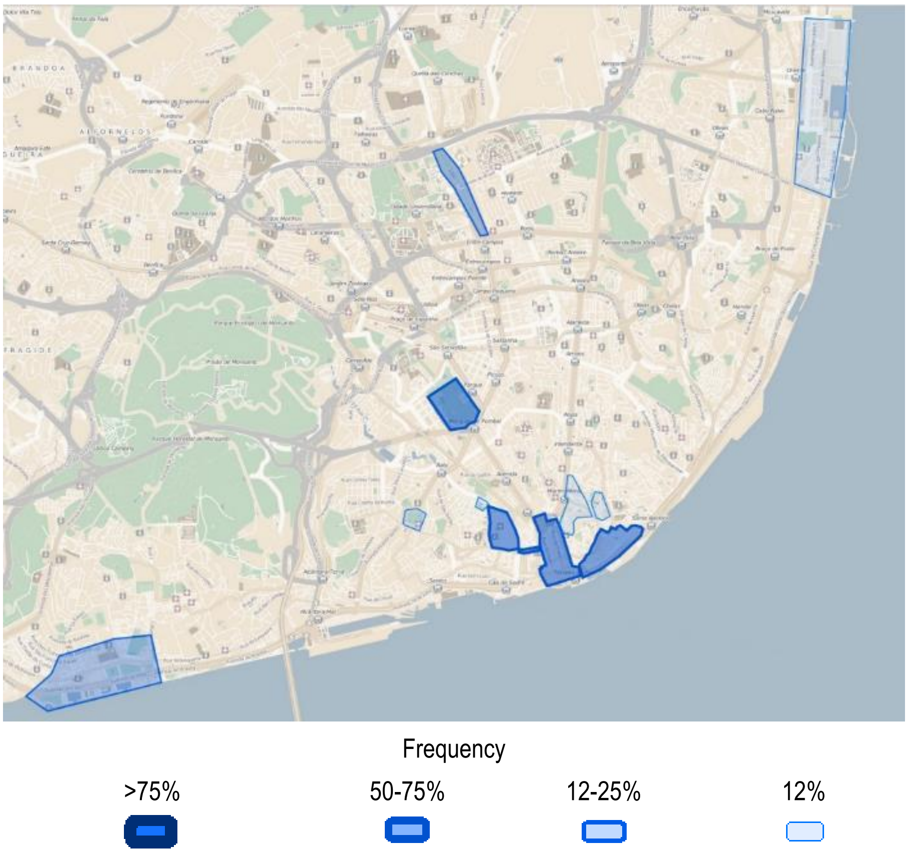


Figure 53. Location on map of the results of the verbal interviews for all *districts* with a frequency equal or above 12% in Lisbon.

The paths with a stronger image in Lisbon were, first *Avenida da Liberdade, Rua Augusta, Avenida Fontes Pereira de Mello, Avenida da República, Ponte 25 de Abril* (which was mainly considered a landmark), *Rua da Prata* and *Rua do Ouro*.

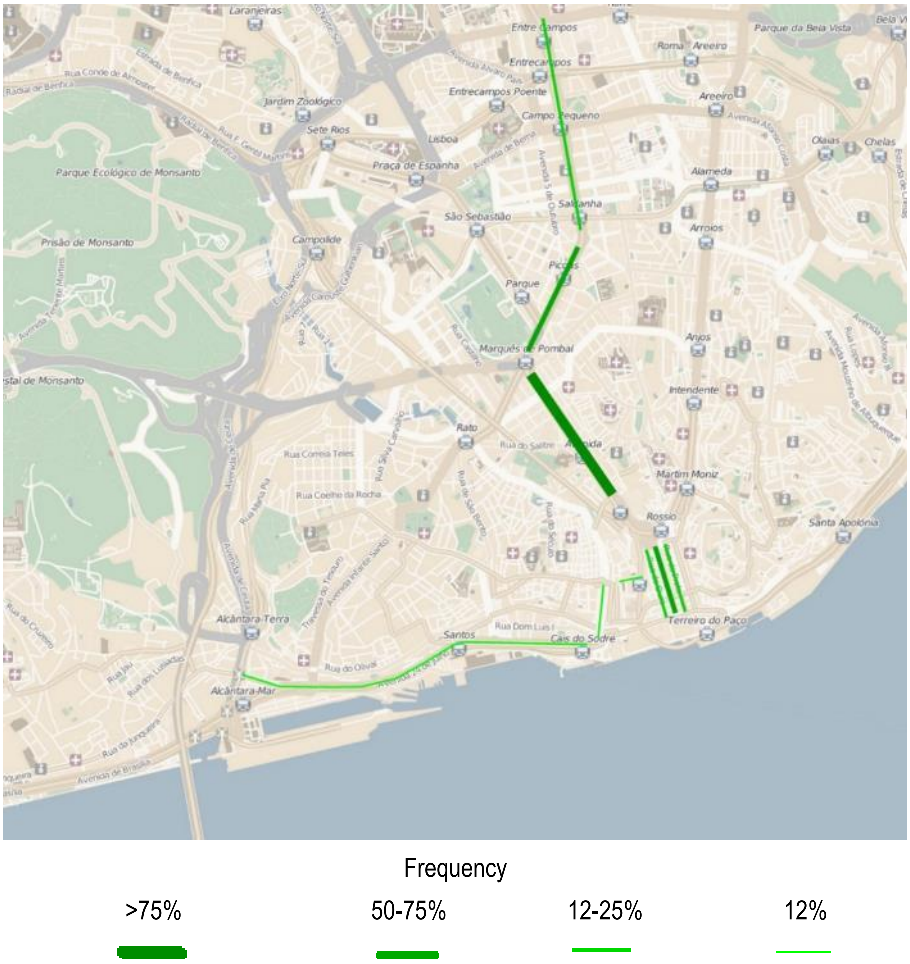


Figure 54. Location on map of the results of the verbal interviews for all *paths* with a frequency equal or above 12% in Lisbon.

The fifty most distinctive elements distilled at this stage were afterwards photographed to be utilized in the next stage of the study: the photographic interviews.

THE RESULTS IN LISBON

For the photographic interviews

As in London, in Lisbon there were only a certain number of elements which revealed statistically relevant differences between the day and night time interviews. To understand the reasons for the discrepancies in responses, these were examined in greater detail. The results will be described through the previously established order[182] of the recognisability of the elements, from high to lower recognisability. The results of the interviews for these specific elements will be presented next. These are (in order of recognisability): Bairro Alto, Avenida da República, Amoreiras, Campo Grande, Rua do ouro, Estação de Santa Apolónia, Jardim da Estrela and Martim Moniz.

The strength of the differences in results when comparing the responses between the day and night-time photographs varied. The same colour scheme used to express these differences in London, was adopted for Lisbon: A different colour was applied at each parameter as it can be observed in the table on the next page.Thus:

	Orange colour for when the pairs of results were tested for power and significance at the conventional values of respectively 5% and 80%
	Dark yellow for power set at the conventional value, but significance at 10%.
	The light yellow colour corresponds to significance set at 10% and power at 70%

This colour scheme was also applied when presenting the detailed results for each element.

[182] The elements were ranked according to its recognition level, from 1 to 50, in the verbal interviews.

		NUMBER OF CORRECT IDENTIFICATIONS		NOT IDENTIFIED		MISIDENTIFIED		CORRECTLY IDENTIFIED BUT THE PRIMARY ELEMENT IDENTIFIED WAS ANOTHER OBJECT IN THE PICTURE		NOT IDENTIFIED BUT RECOGNIZES THE AREA		CORRECTLY IDENTIFIED BUT WITH DOUBTS	
#	**ELEMENTS**	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT	DAY	NIGHT
1	Marquês de Pombal	0	0	0	1	0	0	0	0	0	0	0	0
2	Praça do Comércio	15	15	0	0	0	0	1	2	0	0	0	1
3	Avenida da Liberdade	13	15	2	0	0	0	0	0	0	0	2	1
4	Rossio	15	15	0	0	0	0	1	0	0	0	2	4
5	Castelo	15	15	0	0	0	0	1	0	0	0	0	0
6	Rio Tejo	15	15	0	0	0	0	8	11	0	0	0	0
7	Bairro Alto	8	15	3	0	4	0	0	0	0	0	7	2
8	Restauradores	13	15	1	0	1	0	0	0	0	0	1	0
9	Rua Augusta	15	13	0	2	0	0	0	0	0	2	0	2
10	Baixa Pombalina	15	13	1	2	0	0	1	4	0	0	2	1
11	Parque Eduardo VII	15	15	0	0	0	0	0	1	0	0	0	0
12	Praça Saldanha	14	14	1	1	0	0	0	0	0	0	1	0
13	Alfama	4	4	2	7	9	4	0	0	0	0	1	1
14	Chiado	13	12	1	2	1	1	0	0	1	0	2	0
15	Avenida Fontes Pereira de Melo	4	9	5	5	4	1	0	0	2	1	2	1
16	Jerónimos	15	15	0	0	0	0	0	0	0	0	0	0
17	Avenida da República	12	15	3	0	0	0	0	2	0	0	7	1
18	Ponte 25 de Abril	15	15	0	0	0	0	5	2	0	0	0	0
19	Torre de Belém	15	15	0	0	0	0	0	0	0	0	0	0
20	Amoreiras	15	12	0	3	0	0	0	1	0	0	0	3
21	Praça da Figueira	15	13	0	2	0	0	0	0	0	0	1	0
22	Campo Grande	12	6	1	8	2	1	0	0	0	0	2	1
23	Largo do Camões	15	15	0	0	0	0	0	0	0	0	1	0
24	Sé de Lisboa	15	13	0	2	0	0	0	0	0	0	1	0
25	Teatro Dona Maria II	15	15	0	0	0	0	3	6	0	0	0	0
26	Arco da Rua Augusta	15	15	0	0	0	0	2	5	0	0	0	0
27	Belém	15	15	0	0	0	0	0	3	0	0	0	0
28	Estação do Rossio	15	15	0	0	0	0	0	0	0	0	0	0
29	Rua da Prata	4	2	0	0	11	13	0	0	1	2	4	4
30	Rua do Ouro	11	10	0	3	0	2	2	0	0	2	6	8
31	Estação de Santa Apolónia	12	15	3	0	0	0	0	0	0	0	0	2
32	Cais do Sodré	14	15	1	0	0	0	0	0	0	0	0	1
33	Principe Real	7	11	3	1	5	3	0	0	0	0	0	2
34	CCB	15	15	0	0	0	0	0	0	0	0	0	0
35	Elevador de Santa Justa	15	15	0	0	0	0	0	1	0	0	0	0
36	Jardim da Estrela	15	11	0	4	0	0	0	0	0	0	3	1
37	Largo do Rato	10	12	4	3	1	0	0	0	0	0	0	1
38	Mouraria	8	5	6	7	1	3	0	0	0	0	0	1
39	Praça de Touros	15	15	0	0	0	0	3	3	0	0	0	0
40	Expo	13	15	1	0	1	0	0	0	0	0	0	0
41	Graça	2	1	9	12	4	2	0	0	0	0	0	0
42	Praça Martim Moniz	1	6	14	8	0	1	0	0	0	0	0	2
43	Miradouro de S. Pedro de Alcântara	13	12	1	2	1	1	0	0	0	0	0	0
44	Miradouro da Graça	6	3	4	9	5	3	0	0	0	0	2	2
45	Padrão dos Descobrimentos	15	15	0	0	0	0	0	0	0	0	0	0
46	Rua Garrett	15	15	0	0	0	0	4	5	0	0	2	0
47	Assembleia da República	15	15	0	0	0	0	0	0	0	0	0	0
48	Avenida 24 de Julho	10	6	4	5	1	4	0	0	0	0	3	1
49	Estatua a D. José	15	13	0	0	0	2	4	6	0	0	0	1
50	Estátua Fernando Pessoa	15	15	0	0	0	0	4	3	0	0	0	0
51	Praça do Municipio	12	8	1	4	2	3	0	0	0	0	2	1

Table 27. Summary table for the differences in results between the day and night-time photographic interviews in Lisbon.

The detailed analysis of urban elements

Bairro Alto

Bairro Alto ranked as the 7th most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of correct identifications, the number of non identifications, and the number of misidentifications.

Bairro Alto is an historic district located in the city centre, and it is a very popular destination for the local youth at night due to the number of bars and restaurants which are open until late. Thus, it appears that its night-time image is better recognized than its day-time one. In fact, all participants were able to recognize the picture at night, but most of those who observed the day-time picture either did not identified it or misidentified it with another historic district in Lisbon. Additionally, those who were able to make a correct identification were unconfident with the exception of one individual. Almost all participants who examined the day time picture were not sure if it depicted *Bairro Alto* or another area of the city.

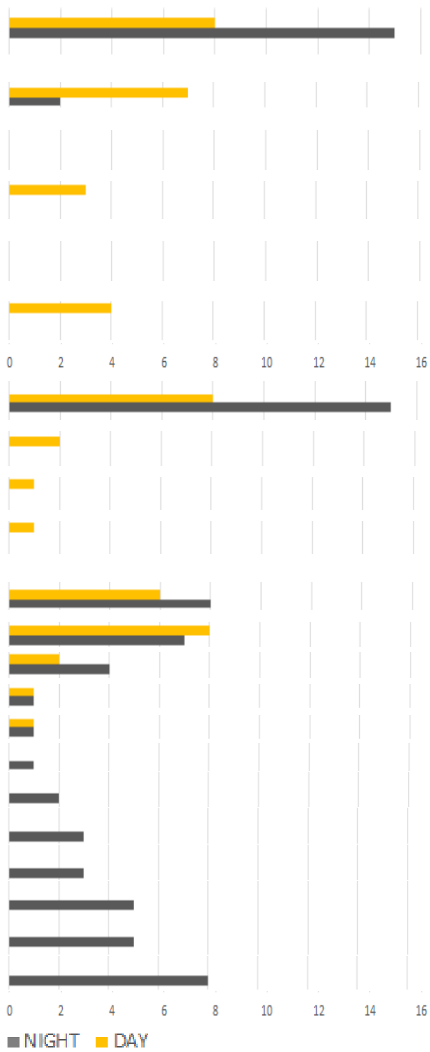
As a result, the number of recognizable features pointed by the participants who observed the night-time image was higher than that by those who examined the day-time photograph. The main differentiation clues between the two images seems to be the number of people in the street, the recognition of bars and the perception of the existence of nightlife.

LISBON

BAIRRO ALTO Rank #7

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**8**	**15**
	But unsure	7	2
	But not as the primary object portrayed	0	0
	Not identified	**3**	**0**
	But recognizes the area	0	0
	Misidentified	**4**	**0**
Primary element recognized	Bairro Alto	8	15
	Mouraria	2	0
	Alfama	1	0
	Baixa Pombalina	1	0
Recognizable features	Narrow street	6	8
	Architecture of the buildings	8	7
	Slope	2	4
	Lanterns	1	1
	Balconies	1	1
	Lighting	0	1
	Parking	0	2
	Bars	0	3
	Pavement	0	3
	Narrow sidewalk	0	5
	Night life	0	5
	People on the street	0	8



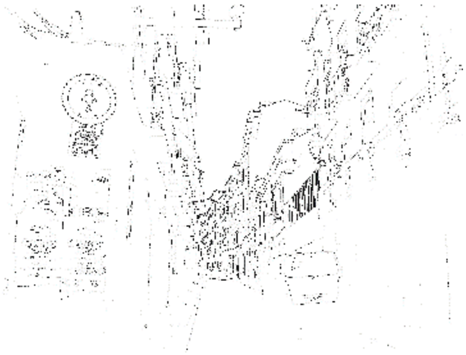
LISBON

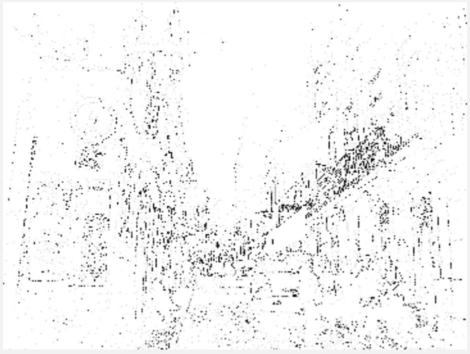
BAIRRO ALTO Rank # **7**

The analysis of the photographs

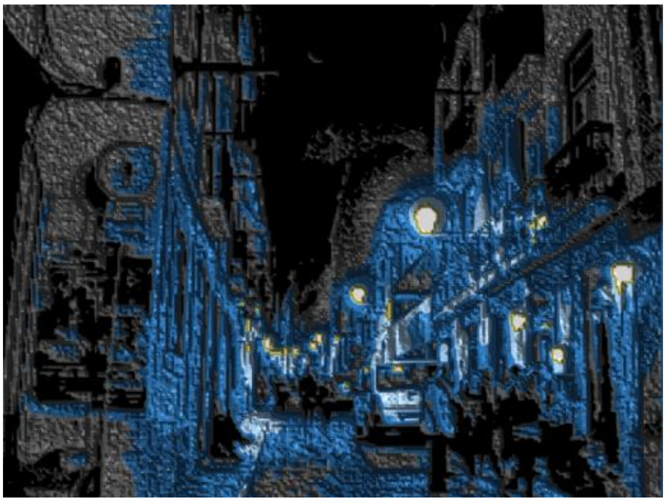
DAY | **NIGHT**

Edge detection





Luminance patterns



Avenida da República

Avenida da República is one of the main avenues of Lisbon and ranked as its 17th most recognizable element in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of doubts in the correct identifications.

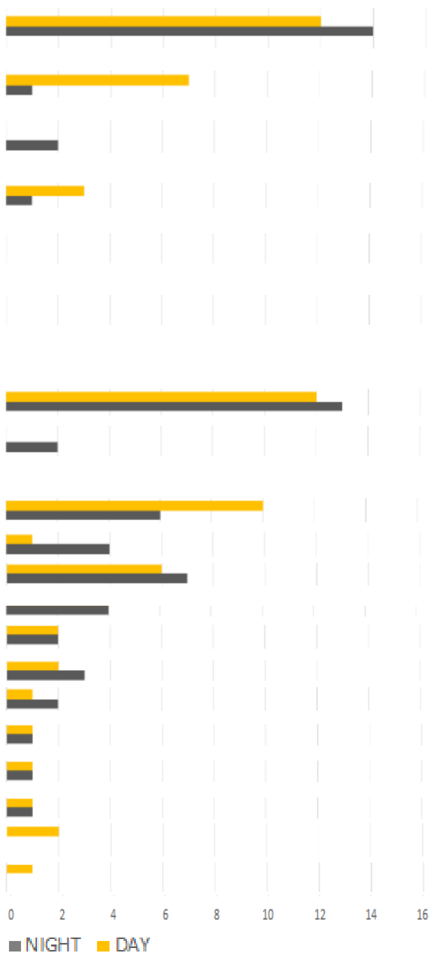
There were more unconfident answers on the recognition of the day-time image of this avenue than of its night-time version. Most of the descriptions of recognizable features do not show any important differences between the day and night-time, with one exception. The perception of the lighting of *Atrium Saldanha*, a well-known building located in a square further ahead, seems to be the missing clue in the day-time observations. The acknowledgement of the location of this building indicates that the participants were confident about the recognition of the avenue (*Avenida da República*) that leads to it, and about the exact position where the image was captured from. This is further reinforced by the fact that a great number of participants who observed the night-time picture remarked that it depicted *Campo Pequeno*, the area where the picture was taken from, but which is not visible in the image.

LISBON

AVENIDA DA REPÚBLICA Rank #17

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**12**	**14**
	But unsure	7	1
	But not as the primary object portrayed	0	2
	Not identified	**3**	**1**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	Avenida da República	12	13
	Campo Pequeno	0	2
Recognizable features	Buildings	10	6
	Campo Pequeno	1	4
	Tunel	6	7
	Atrium Saldanha lighting	0	4
	Avenida João XXI	2	2
	Avenida de Berna	2	3
	It is a big avenue	1	2
	Avenida 5 de Outubro	1	1
	Red wall	1	1
	Advertisement panels	1	1
	Saldanha	2	0
	Tribunal de Contas	1	0



LISBON

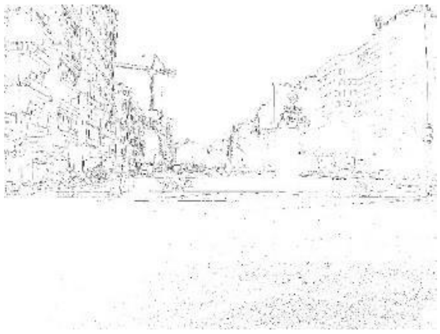
AVENIDA DA REPÚBLICA Rank # **17**

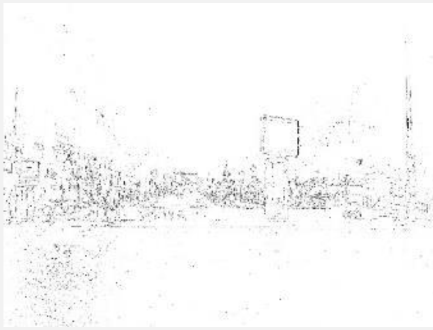
The analysis of the photographs

DAY

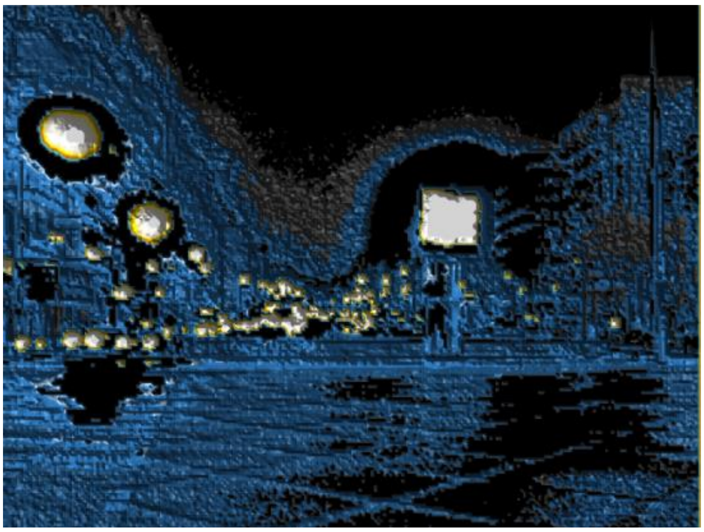
NIGHT

Edge detection





Luminance patterns



0.3-0.5 0.5-1.0 1.0-2.0 2.0-4.0 4.0-8.0 8.0-16.0 16.0-32.0 32.0-64.0 64.0-128.0 128.0-256.0 256.0-512.0 512.0-1,024.0 1,024.0-2,000.0

Amoreiras

Amoreiras ranked as the 20th most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of correct identifications, the number of non identifications, and of doubts in the correct recognitions.

Amoreiras is a district of the city, known for its three towers which are well visible in the cityscape. The day-time picture of *Amoreiras* was recognized by all participants, but its night version was slightly less recognizable. The main reason for this result seems to be the fact that the three towers that characterize this area are more visible during the day. The features that allowed for the recognition of this element in the day and night-time interviews almost did not coincide. The day-time picture elicited clues related mostly with the towers, its shape, colour, materials and the architect who designed them. The night-time photograph, on the other hand, prompted clues related almost exclusively to what exists in the lower area of the buildings.

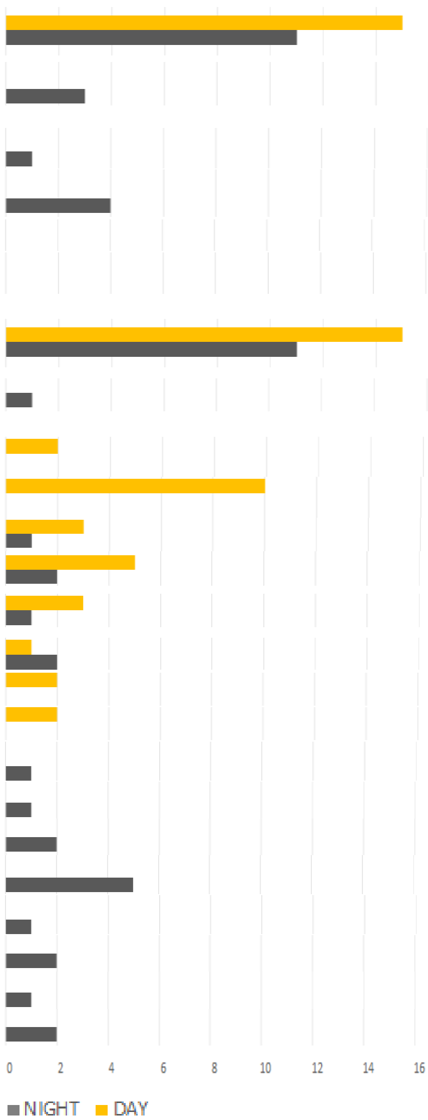
Observing the edges detected in the images and its luminance patterns, it can be confirmed that the towers are almost undetectable at night.

LISBON

AMOREIRAS Rank **#20**

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**11**
	But unsure	0	3
	But not as the primary object portrayed	0	1
	Not identified	**0**	**4**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	Amoreiras	15	11
	Rua Ferreira Borges	0	1
Recognizable features	Buildings designed by Taveira	2	0
	3 towers	10	0
	Shape of the towers	3	1
	Architectonic style	5	2
	Colours	3	1
	Rua Ferreira Borges	1	2
	Different	2	0
	Glass	2	0
	Triangles	0	1
	Arches	0	1
	Golf course	0	2
	Tower's bottom?	0	5
	Campo d'Ourique	0	1
	Aqueduto	0	2
	Wall	0	1
	Circular windows	0	2
	(continues)		

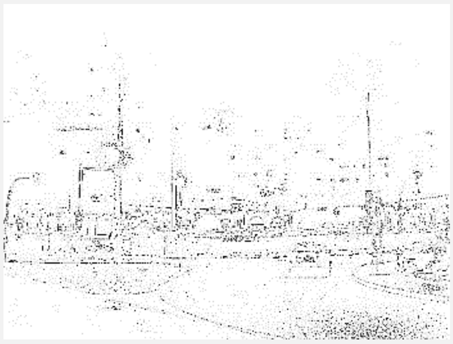


Recognizable features	Tall buildings	0	1	
	Unusual shapes on the bottom	0	1	

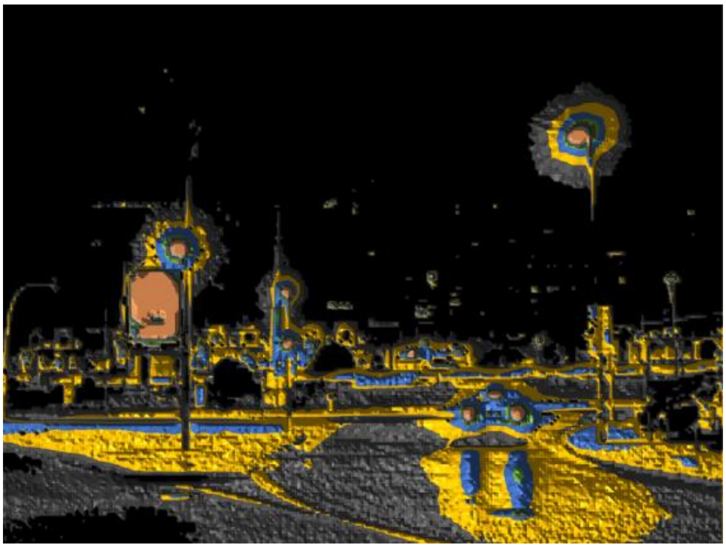
LISBON

AMOREIRAS Rank # **20**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns



■0.1-0.3 ■0.3-0.5 ■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-256.0 ■256.0-512.0 ■512.0-1,024.0 ■1,024.0-2,000.0

Campo Grande

Campo Grande is an area in the city centre which encompasses a large park with the same name. It was ranked as the 22nd most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of correct identifications and the number of non identifications.

The day-time picture elicited better recognition than its night-time version. The main clues that seem to be missing in the descriptions of the participants who examined the night-time picture are the road behind the statues (which is more visible in the day picture) and the restaurant *Churrasqueira*. Interestingly, the restaurant that the participants were referring to, is located in front of the area depicted and thus not in sight. Perhaps the day time picture prompted a better localization of the exact place where the photograph was taken and allowed for the creation a sort of mental map of the area, where the restaurant is a main local landmark.

Another recognizable feature which was only referred by one person in the night-time picture against five in the day-time version, were the dense trees that make the existence of the park perceptible. At night the large treetops are almost invisible, and that may also have contributed to hamper recognition.

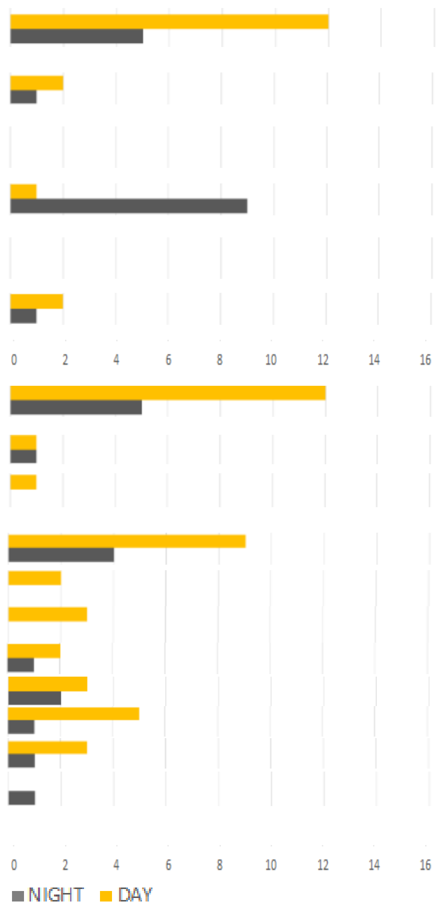
The images produced by the edge detector show well defined shapes of trees in the day-time photograph and poorly defined shapes in the night-time version. The analysis of luminance patterns reveals that the most prominent elements of the night-time image are two statues and the pavement.

LISBON

CAMPO GRANDE Rank #22

The analysis of responses

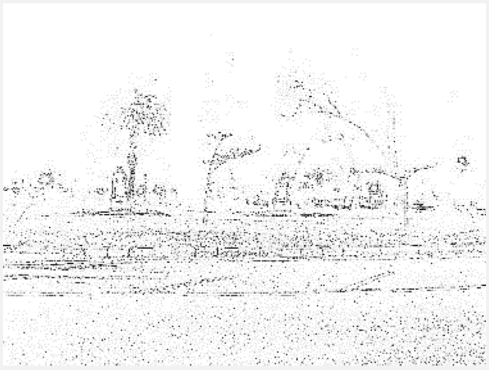
		DAY	NIGHT
Recognition	**Correctly identified**	**12**	**5**
	But unsure	2	1
	But not as the primary object portrayed	0	0
	Not identified	**1**	**9**
	But recognizes the area	0	0
	Misidentified	**2**	**1**
Primary element recognized	Campo Grande	12	5
	Belém	1	1
	Estrela	1	0
Recognizable features	Two statues	9	4
	Road	2	0
	Churrasqueira	3	0
	Garden	2	1
	Palm trees	3	2
	Dense trees	5	1
	Bus stop	3	1
	Parking	0	1



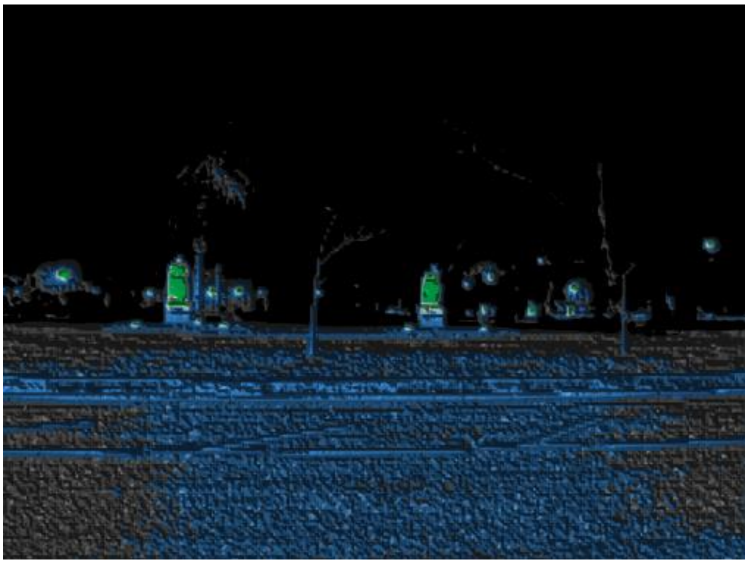
LISBON

CAMPO GRANDE Rank # **22**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns



■ 0.25-0.5 ■ 0.5-1 ■ 1-2 ■ 2-4 ■ 4-8 ■ 8-16 ■ 16-32

Rua do Ouro

Rua do Ouro is one of the main streets of the historic centre of Lisbon. It ranked as the 30th most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of non identifications. At night only, there were a few participants who were not able to identify this street, and yet the majority pointed its correct location, in *Baixa Pombalina* district. However, this street was also often confused with Rua da Prata, a similar street which runs parallel to it.

The confusion between the two streets was evident in both sets of interviews, and persisted when the individuals were confronted with the other version of the picture (either day or night-time) at the end of the interviews, and even when comparing the photograph of one street against the other. There were a total of eleven participants declaring they could not distinguish between the two streets when examining the picture of *Rua do Ouro*, and a total of eight participants when observing *Rua da Prata*. Most of the positive recognitions were possible because some individuals noticed the direction of the traffic, which runs differently in each street.

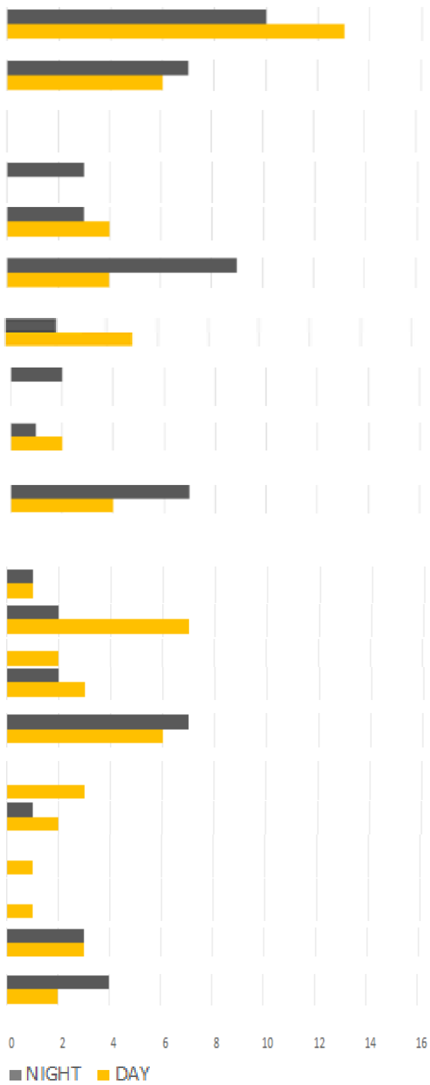
Figure 55. Rua da Prata on the left and Rua do Ouro on the right.

LISBON

RUA DO OURO Rank # 30

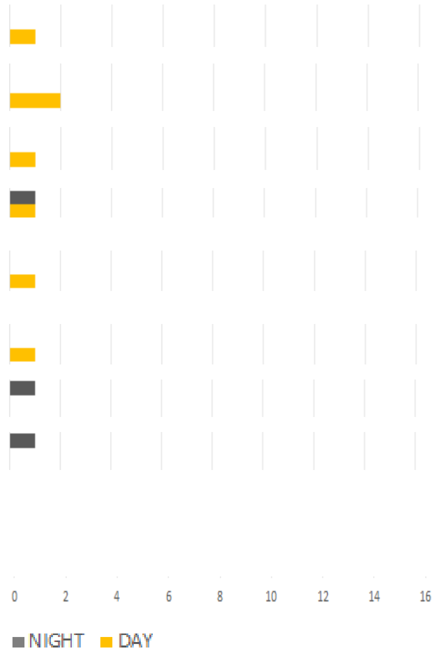
The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**11**	**10**
	But unsure	6	8
	But not as the primary object portrayed	2	0
	Not identified	**0**	**3**
	But recognizes the area	0	2
	Misidentified	**0**	**2**
Primary element recognized	Rua do Ouro	5	2
	Rua da Prata	0	2
	Baixa Pombalina	2	1
	Could not distinguish between Rua do Ouro and Rua da Prata	4	8
Recognizable features	Heavy traffic	1	1
	Traffic direction	7	2
	Sidewalks	2	0
	Stores	3	2
	The architecture of the buildings	6	7
	The river	3	0
	Wide street	2	1
	Configuration	1	0
	Straight street	1	0
	Baixa Pombalina	3	3
	Cobblestone pavement design	2	4



(continues)

Recognizable features	Narrow street	1	0
	Fuji store	2	0
	Elevador de santa justa	1	0
	Street lamps	1	1
	Looks exactly the same as Rua da Prata	1	0
	Is different from Rua da Prata	1	0
	Balconies	0	1
	It is not a pedestrian street	0	1



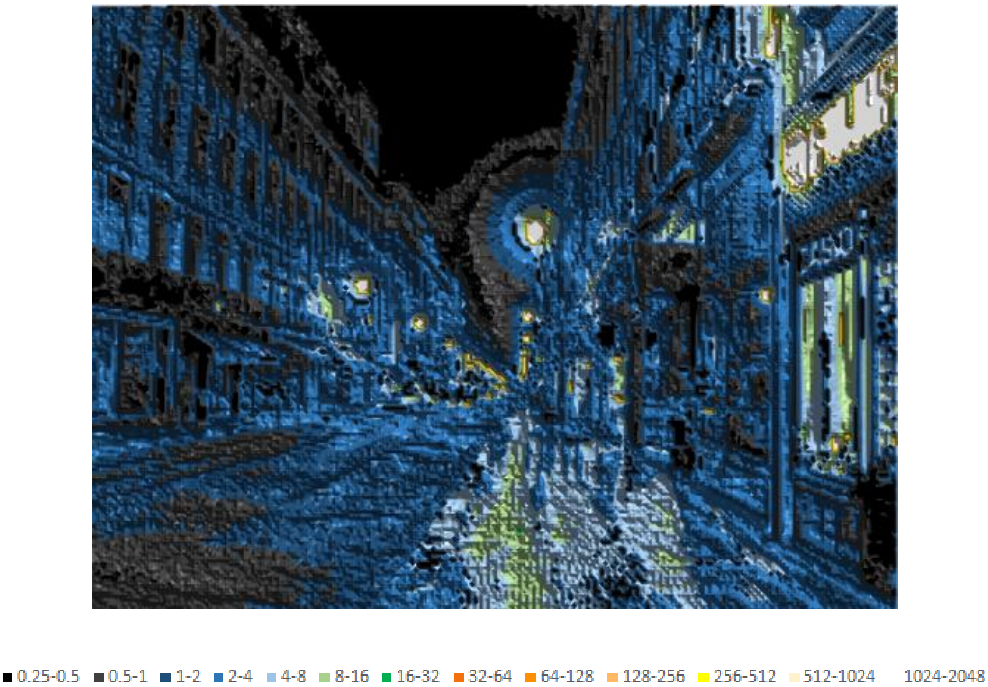
LISBON

RUA DO OURO Rank # **30**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns



Estação de Santa Apolónia

Estação de Santa Apolónia ranked as the 31st most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of correct identifications and the number of non identifications. The night-time photograph of the building was always recognized, but its day-time version had slightly less positive identifications.

The clues for recognition described by the participants revealed that the colour of the building became less clear for the individuals confronted with the night-time picture. The number of responses stating that the building had green colour, or either green or blue were larger than for those who were certain it was blue. However, this fact did not seem to hamper the recognition of the building.

The clock, the CP[183] symbol and the taxis were slightly more often remarked upon in the night-time photograph. The luminance map shows that in this picture, the areas of higher luminance were the clock and the entrance of the station. Perhaps the enhanced visibility of these elements allowed for a better recognition of the night-time picture.

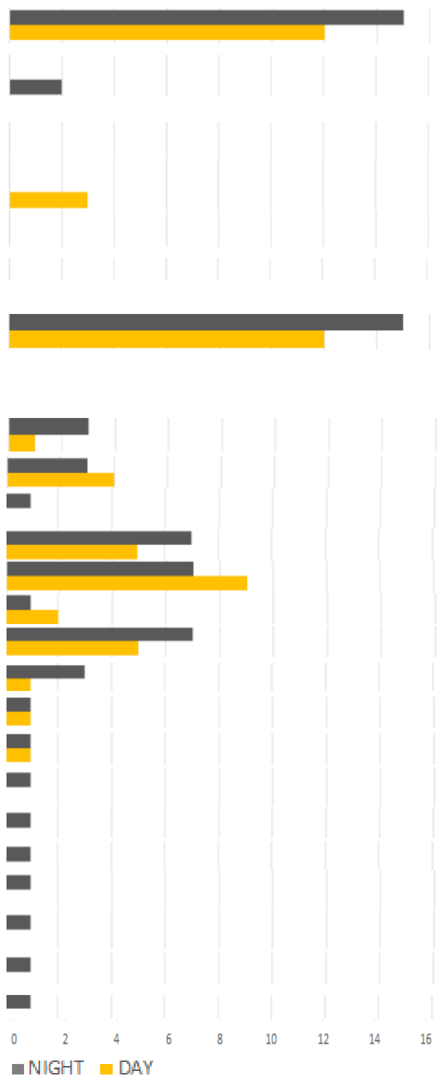
[183] CP stands for “comboios de Portugal”, the Portuguese National rail.

LISBON

ESTAÇÃO DE SANTA APOLÓNIA Rank # 31

The analysis of responses

		DAY	NIGHT
Recognition	**Correctly identified**	**12**	**15**
	But unsure	0	2
	But not as the primary object portrayed	0	0
	Not identified	**3**	**0**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	Estação de Santa Apolónia	12	15
Recognizabl e features	Green colour	1	3
	Blue colour	4	3
	Green or blue colour	0	1
	CP symbol	5	7
	Architectural style	9	7
	Entrance	2	1
	Taxis	3	5
	Clock	1	3
	Windows	1	1
	Avenue	1	1
	Symmetrical	0	1
	Rectilinear building	0	1
	Strong light	0	1
	Big	0	1
	Ancient	0	1
	Supermarket	0	1
	The Square	0	1



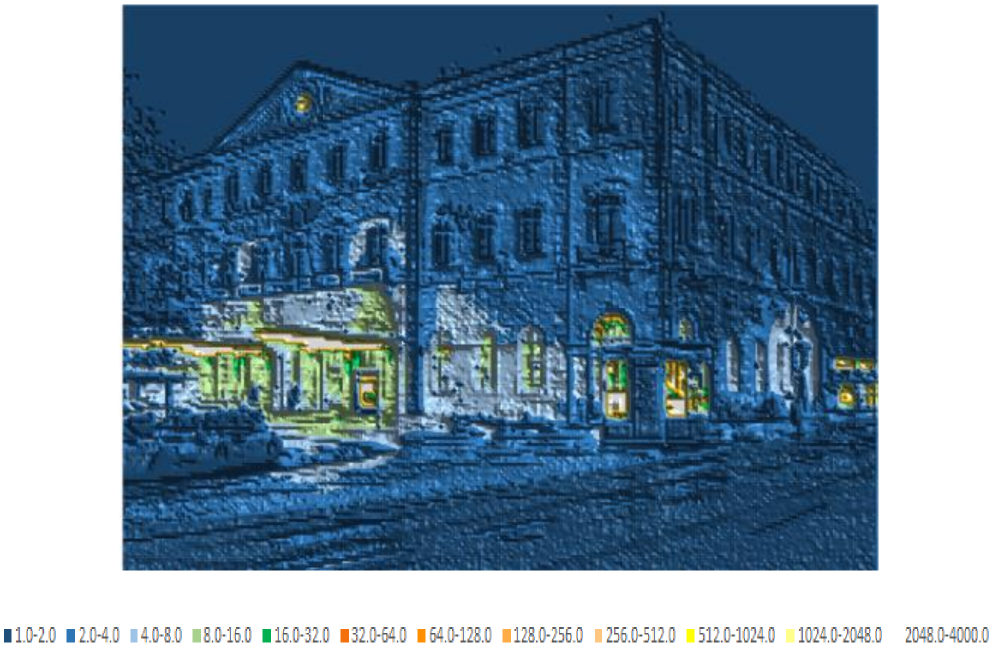
LISBON

ESTAÇÃO DE SANTA APOLÓNIA Rank # 31

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns



Jardim da Estrela

Jardim da Estrela is a garden located in the centre of the city, in front of *Basilica da Estrela*. It ranked as the 36th most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of correct identifications and the number of non identifications.

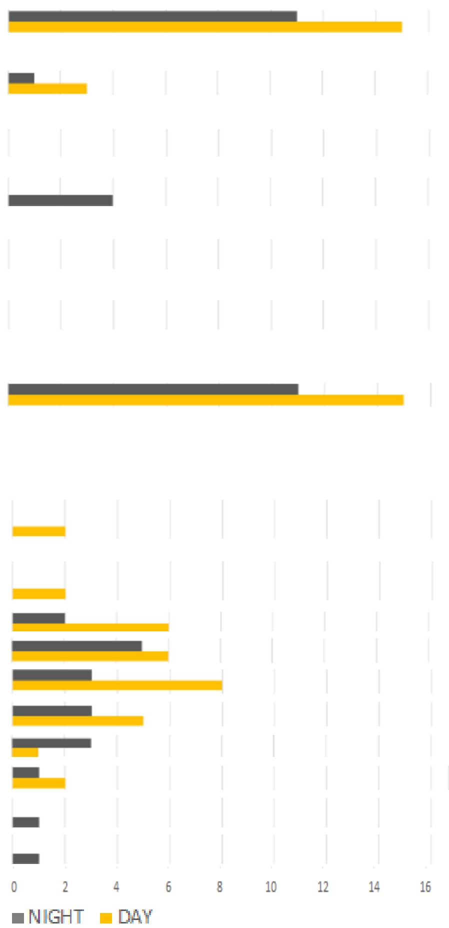
The clues described by the participants in both sets of interviews suggests that the recognition of the green colour and the trees could have been the main factors for the difference in results. The areas of higher luminance of the night-time image are the lamps situated at the entrance of the garden and the pavement. The tree tops are in almost complete darkness.

LISBON

JARDIM DA ESTRELA Rank # **36**

The analysis of responses

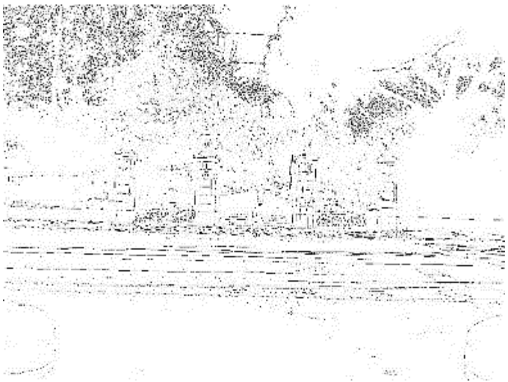
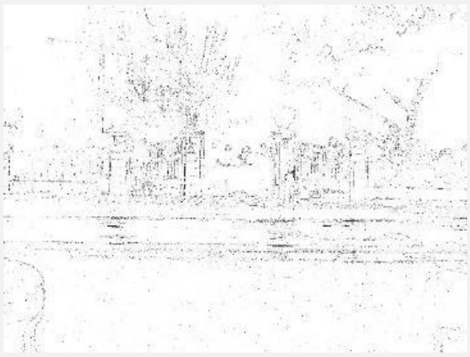
		DAY	NIGHT
Recognition	**Correctly identified**	**15**	**11**
	But unsure	3	1
	But not as the primary object portrayed	0	0
	Not identified	**0**	**4**
	But recognizes the area	0	0
	Misidentified	**0**	**0**
Primary element recognized	Jardim da Estrela	15	11
Recognizable features	The stone of Basilica da Estrela	2	0
	It is in front of Basilica da Estrela	2	0
	The entrance	6	2
	The gates	6	5
	Trees/garden	8	3
	Tram tracks	5	3
	The fence	1	3
	Columns with lanterns	2	1
	Wall	0	1
	Cobblestone pavement	0	1



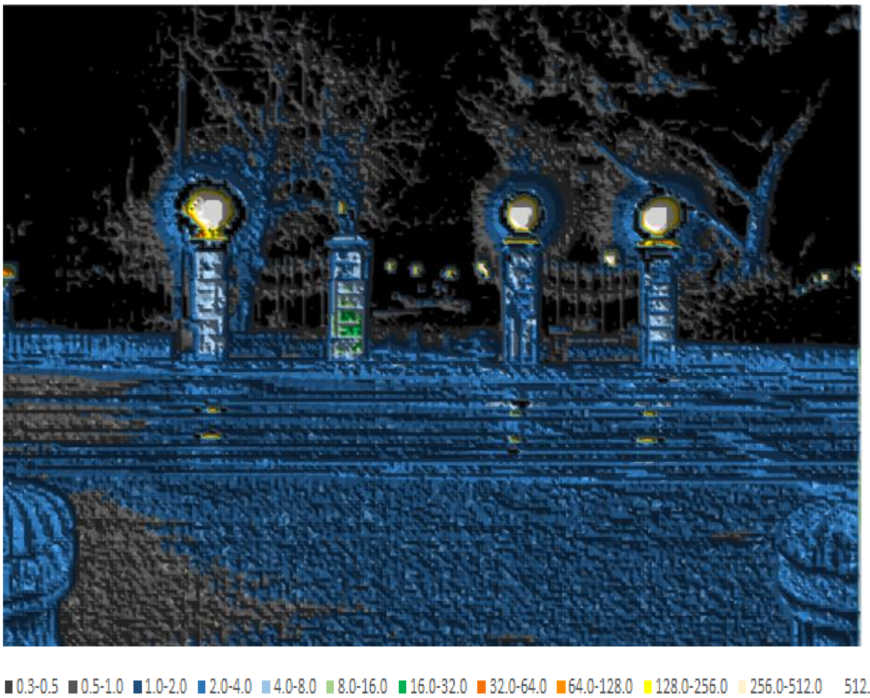
LISBON

JARDIM DA ESTRELA Rank # 36

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns



Praça Martim Moniz

Praça Martim Moniz is a modern square, located in the historic centre of Lisbon. It ranked as the 42nd most recognizable element of Lisbon in the verbal interviews. The statistically relevant differences between the day and night-time photographic interviews for this element regard the number of correct identifications and of non identifications. There was only one correct recognition by the persons who observed the day-time image of the square, and six by those who examined its night-time version.

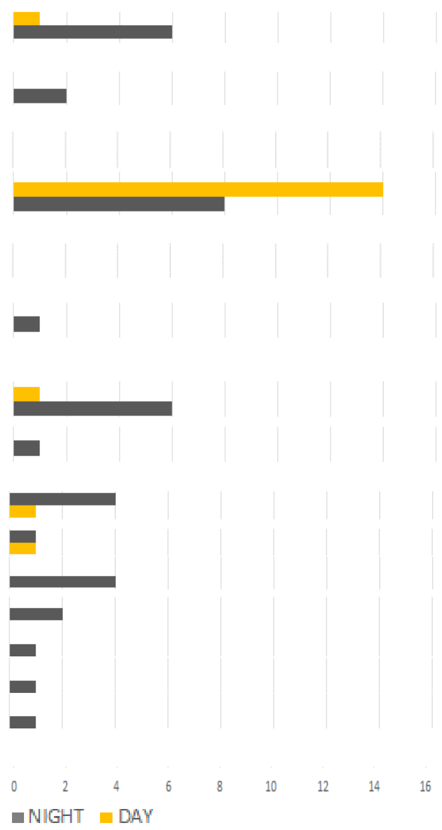
Because there was only one person who recognized this element when looking at the day-time picture, the comparison of recognizable features probably does not convey any significant data. However, all subjects who viewed the pictures at night pointed the hotel and the centre of the square as the main clues for recognition. The edge detection and the luminance map both indicate that these were the most prominent features in the night-time picture.

LISBON

PRAÇA MARTIM MONIZ Rank # **42**

The analysis of responses

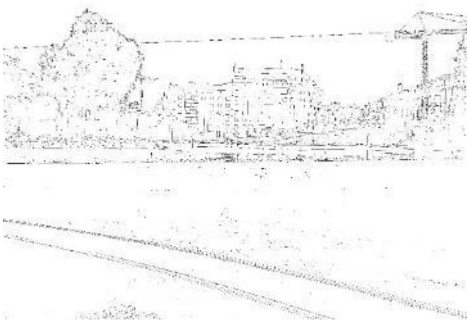
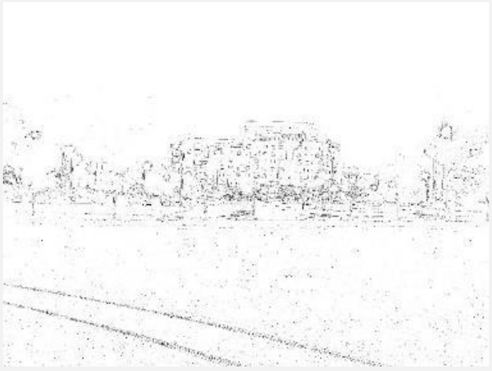
		DAY	NIGHT
Recognition	**Correctly identified**	**1**	**6**
	But unsure	0	2
	But not as the primary object portrayed	0	0
	Not identified	**14**	**8**
	But recognizes the area	0	0
	Misidentified	**0**	**1**
Primary element recognized	Martim Moniz	1	6
	Príncipe Real	0	1
Recognizable features	Hotel	1	4
	Big space	1	1
	Central square	0	4
	Subterranean parking	0	2
	Tram tracks	0	1
	Garden	0	1
	Ugly	0	1



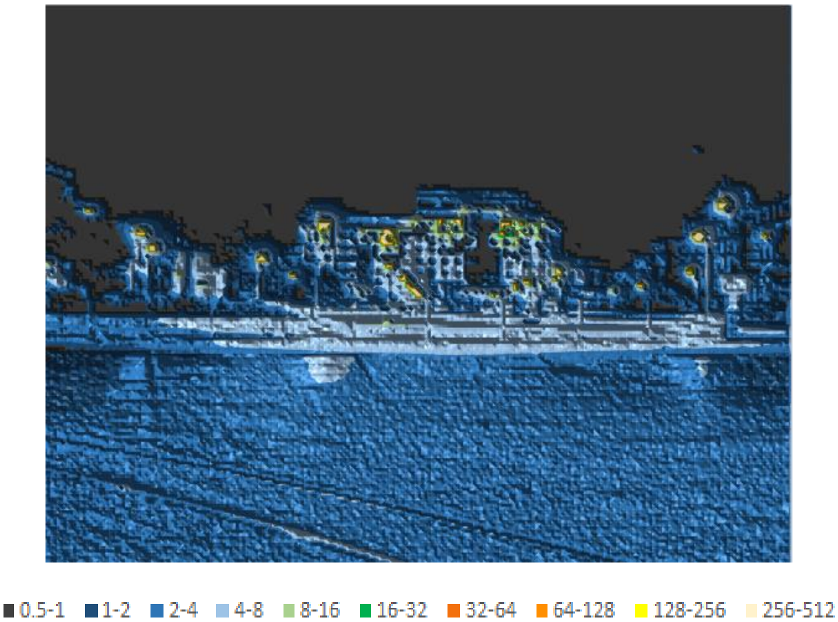
LISBON

PRAÇA MARTIM MONIZ Rank # **42**

The analysis of the photographs

	DAY	NIGHT
Edge detection		

Luminance patterns



Conclusions for the photographic interviews in Lisbon

The comparison of responses resulting from the observation of day and night-time photographs revealed three main aspects in which responses diverged the most. These were the ability to recognize a given element, misidentifying the target for another known landmark, and expressing doubts on having correctly identified the target.

The ability to recognize a given element was reduced with some significance for seven elements. Four of these elements were better recognized when participants observed its image photographed under daylight, and other three elements were better recognized under artificial lighting.

The relevant differences in the number of misidentifications was only found for one element. There were two elements that elicited correct identifications with doubts, of which one regarded the examination of the night-time version of the element, and the observation of the day-time picture of the other element.

Divergent results	**Photographs**	
	Day	Night
Element not identified	Bairro Alto Estação de Santa Apolónia Martim Moniz	Amoreiras Campo Grande Rua do Ouro Jardim da Estrela
Misidentified elements	Bairro Alto	
Correctly identified but with doubts	Avenida da República	Amoreiras

Table 28. Summary table for the results of the photographic interviews in Lisbon.

These results indicate that the image of some of the most prominent urban elements of Lisbon can be slightly less recognizable at night. This was the case of *Amoreiras*, where its characteristic three towers were almost undetectable in the night-time picture for lack of luminance contrast. In *Campo Grande* and *Jardim da Estrela*, the tree tops and green colour that characterize these green areas were almost imperceptible at night, and thus they were also less recognizable then.

However, there were also almost the same number of different distinctive elements which were less recognizable in the day-time photographs. It was the case of *Bairro Alto*, where the participants seem to have recognized its night-time picture better due to the satisfied expectation of seeing a greater number of people depicted there. The presentation of an empty street in the day-time seems to have led to non identifications and misidentifications with other similar districts.

Estação de Santa Apolónia was probably better recognized at night due to the better visibility of marks such as the railway symbol. *Avenida da República* elicited less doubts at night probably due to the identification of a distant lit landmark which was only prominent in the night-time picture.

For the walking interviews

As previously described, in this set of interviews the participants were asked to walk from *Largo de Camões* to *Praça do Comércio*. As in the interviews that took place in London, they were free to select which ever route they preferred and take as much time as they needed, but could not look at any maps or devices for orientation purposes and were unaware of the nature of the study. For both sets of interviews all participants declared having average to good knowledge of the area.

The wayfinding process

In Lisbon, the participants, of both sets of interviews, were quick in finding a strategy to arrive at the destination, many times not even pausing before starting to walk towards it. Although most explained which strategy they had in mind, some weren't able to do so, as they knew the area so well. They stipulated a strategy, quickly explained their thoughts and walked towards the destination with no hesitation or great change of plans.

Moreover, the fact that most participants had a good knowledge of the area reflected on their strategies for selecting a route to arrive at the destination. For example, at night, many individuals imagined some of the streets ahead on route as dark, narrow or deserted, probably recalling past experiences, and consequentially revised their plan in order to avoid them. In the day-time a number of participants recalled a number of stores associated with dear memories and choose routes to walk past those subjective landmarks. There was also the case of those who decided to follow unusual paths, as to explore the streets they were less familiar with, but that looked like would lead in the direction of the destination point.

THE PREFERENCES FOR ROUTE SELECTION	DAY	NIGHT
The most direct route	3	0
The shortest/quickest route	3	4
Most pleasant route	4	1
Best known route	1	4
The route which is less crowded	1	0
The most populated route	0	3
The safest route	0	3
The route less well known (exploring)	2	0
Does not express a preference	1	0

Table 29. The subjective preferences for path selection as declared by the participants in the interviews that took place in Lisbon.

The preferences expressed by the participants at the beginning and during the task were different between the two sets of interviews. During the day the main strategy was that of choosing the most pleasant or the most direct or shortest route, and some individuals declared they were following the routes they were less familiar with in order to explore them. However, at night most participants were instead concerned with finding the shortest way, with choosing a route which was well known to them, safe and populated.

The fact that there were different preferences may partially explain the differences in route choice between the day and night-time. Additionally the intermediate landmarks evoked before starting the walking task and those remarked while travelling also diverged between the two sets of interviews.

LANDMARKS EVOKED AT THE STARTING POINT	DAY	NIGHT
Rua do Alecrim	5	0
Rossio	4	0
Cais do Sodré	3	0
Mártires Church	1	0
Largo de Camões	1	0
Baixa Pombalina	1	0
Bairro alto	1	0
Rua Victor Cordon	1	0
Soutwest direction	1	0
Governo Civil building	0	1
Café A Brasileira	0	1
Rua da Conceição	0	1
Rua Augusta	0	1
Livraria Bertrand	0	1
Rua do Ouro	1	4
Tagus river	4	1
Rua Nova do Almada	1	1
Rua Garrett	3	7
Largo do Chiado	7	2
Descent	5	2
Two churches	2	1
Armazéns do Chiado	5	7
Teatro de São Carlos	2	1
No mental map	1	3

Table 30. The subjective preferences for path selection as declared by the participants in Lisbon.

The most conspicuous difference in the intermediate landmarks evoked before beginning the task was the absence of *Rua do Alecrim* in the night-time interviews, coinciding with the fact that no one took that route then, contrarily to day-time. The same was true for Cais do Sodré, a square located at the bottom of that street, and for Rossio, which is located north of the destination point (out of route). *Rua do Ouro* emerged stronger in the night-time descriptions and was also used more often then. The river was less mentioned at night probably because it was not visible.

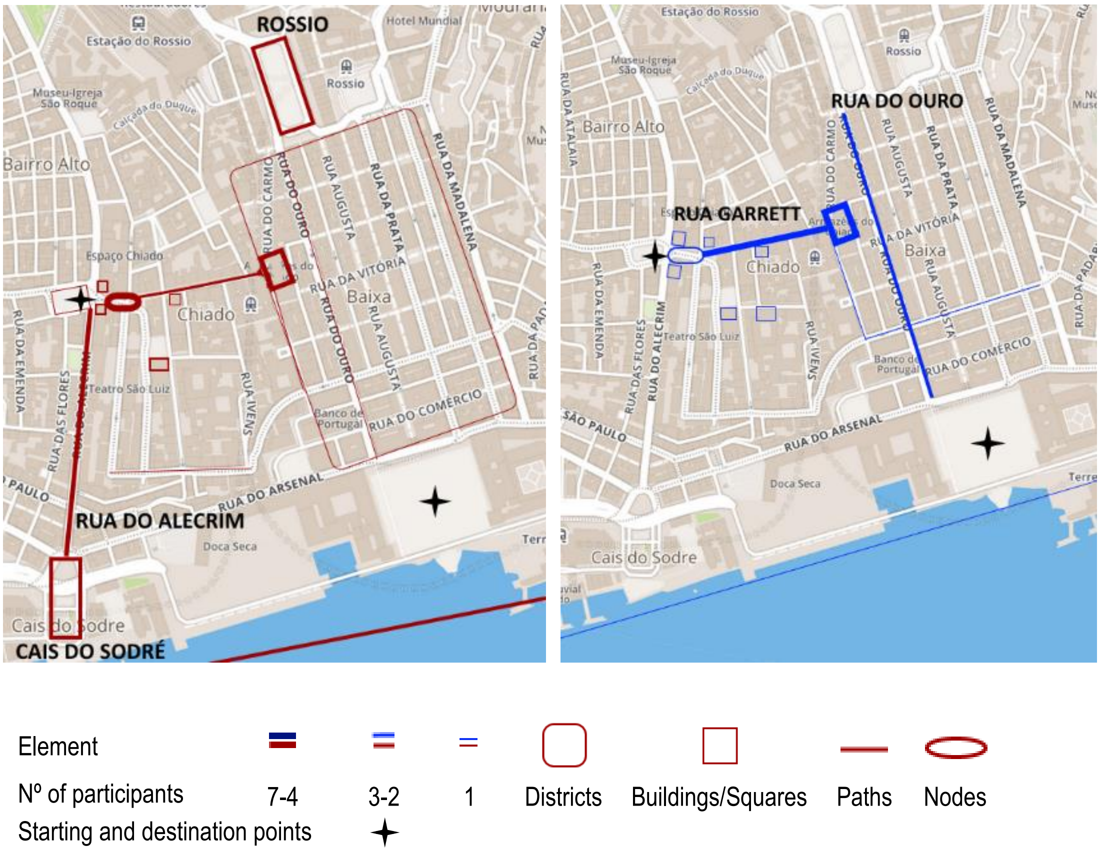


Figure 56. The day-time mental map at the beginning of the interviews (on the left), and its night-time version (on the right).

Probably because the preferences for route selection were different for each set of interviews, its participants thought of different intermediate landmarks and indeed used slightly different routes. Thus, the landmarks remarked as guidance aids diverged accordingly.

Although there were many common elements there were also a great number of landmarks which were mentioned either in the day or in the night-time interviews alone. This seems to be, mainly, the result of the differences in the routes travelled between the two sets of interviews. There are however, elements which are located in the routes travelled by a large number of participants in both day and night-time but that were only mentioned in one of the versions of the interviews. Those that were only mentioned at night include the underground station, *livraria Bertrand*, *A Brasileira* and the statue *Fernando Pessoa*. The elements which were only remarked in the day-time are located in places that were infrequently travelled or not travelled at all at night. These include *São Carlos* Theatre, and a number of elements towards that direction.

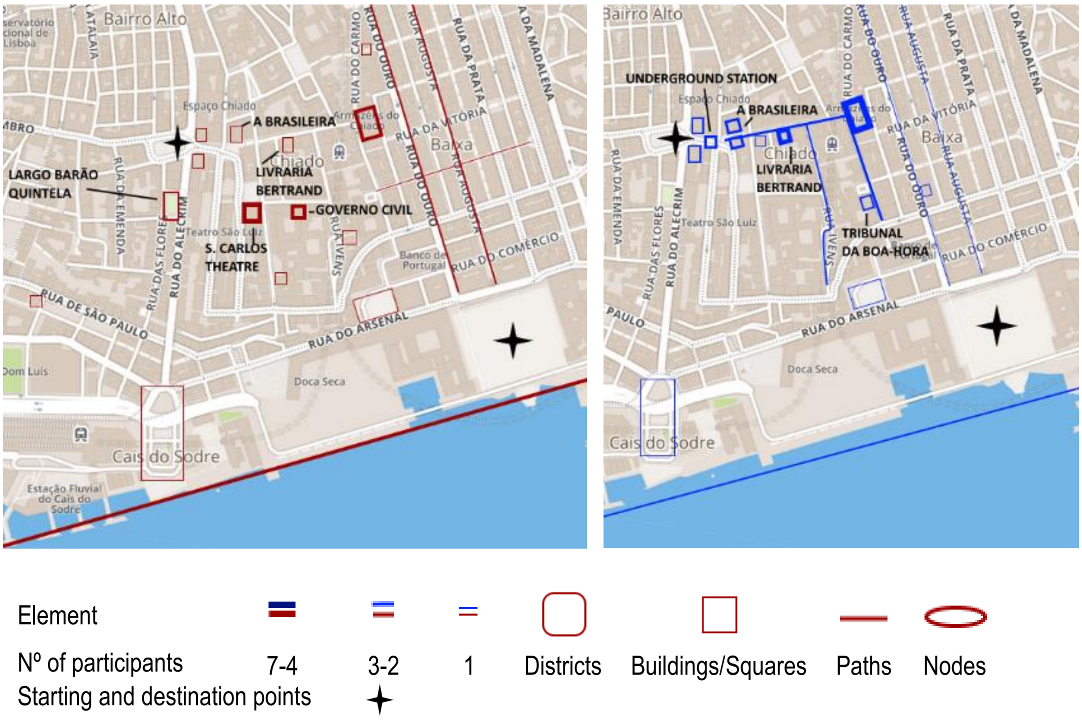


Figure 57. The elements mentioned during the interview in the day-time (on the left), and at night (on the right).

The streets at night which were most travelled were only mentioned in that set of interviews. This was the case of *Rua Garrett* and *Rua Nova do Almada*.

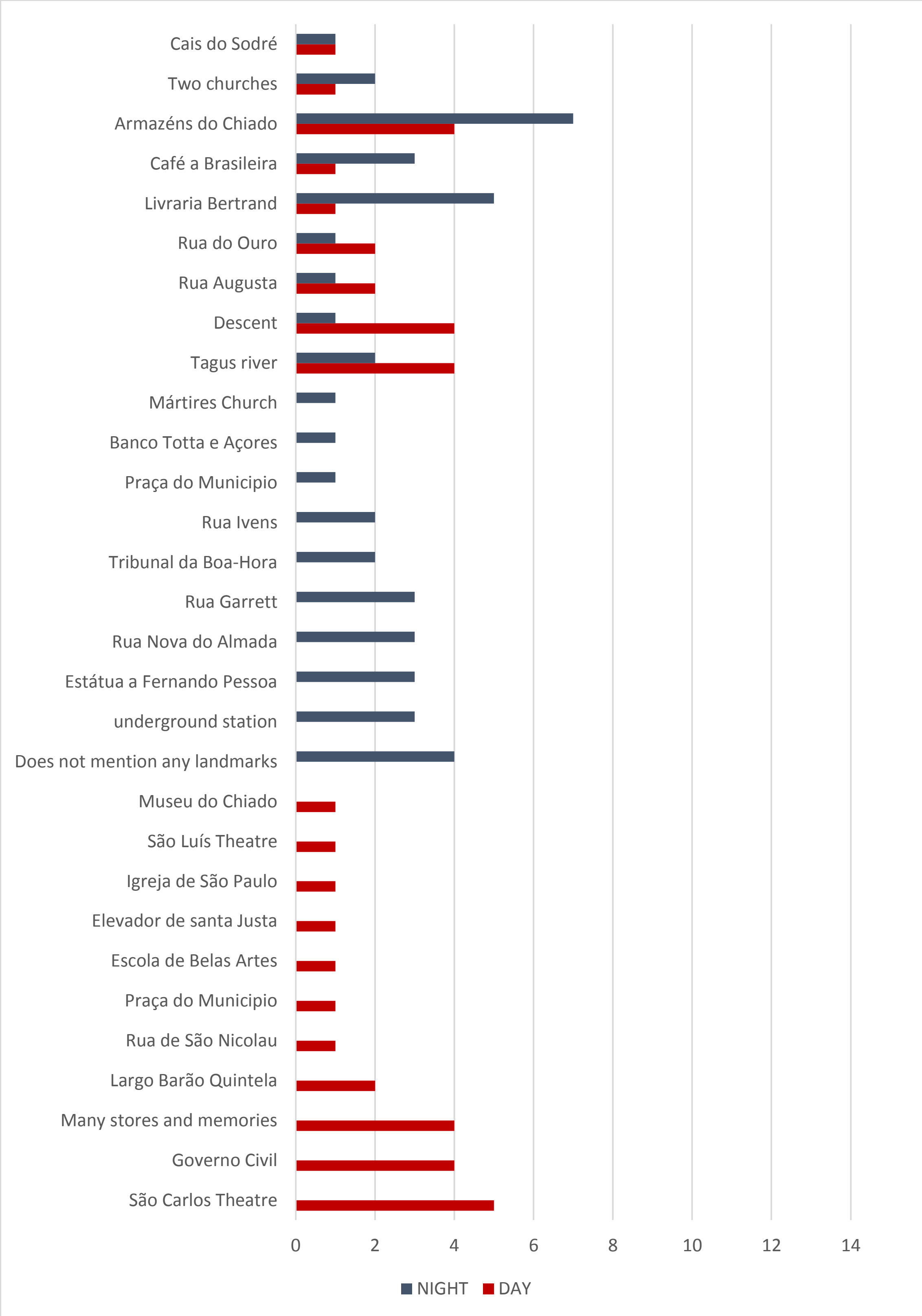
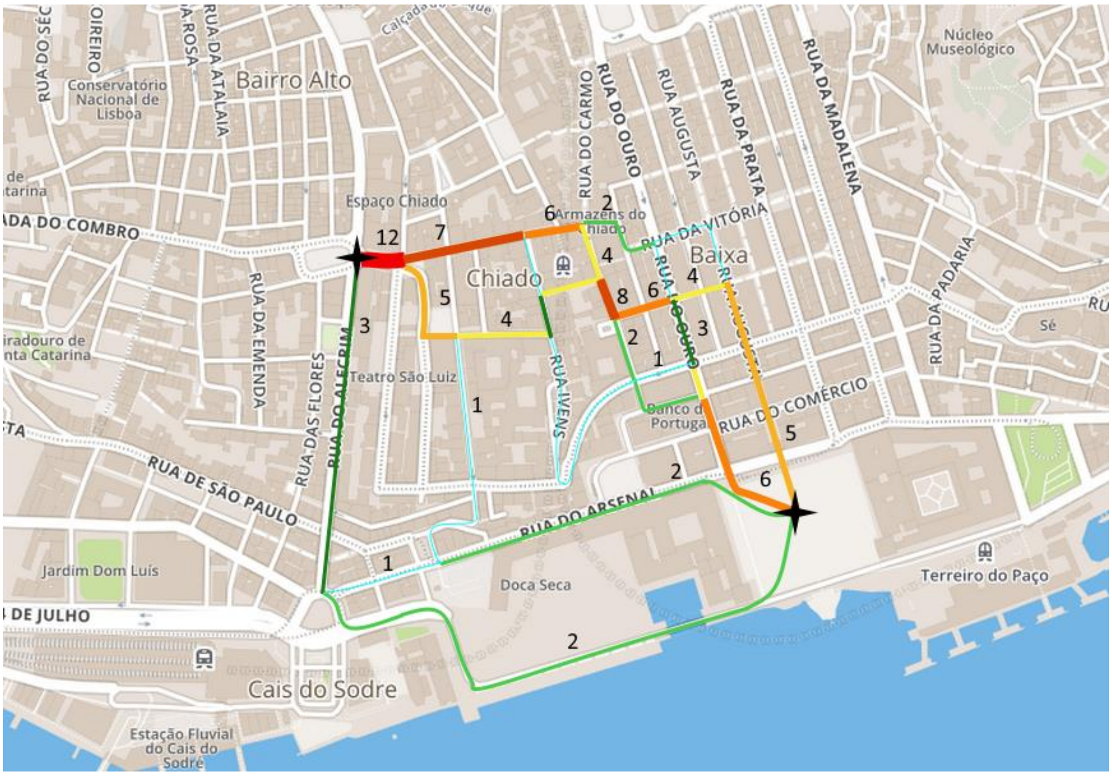


Figure 58. Landmarks mentioned during the walking interviews in Lisbon.

The differences in route choice between the day-time and night-time interviews

There is one main visible difference when comparing the routes travelled by the participants in the two sets of interviews. At night there was a common main route that almost all participants took, whereas in the day-time there was a greater dispersion through distinct paths.



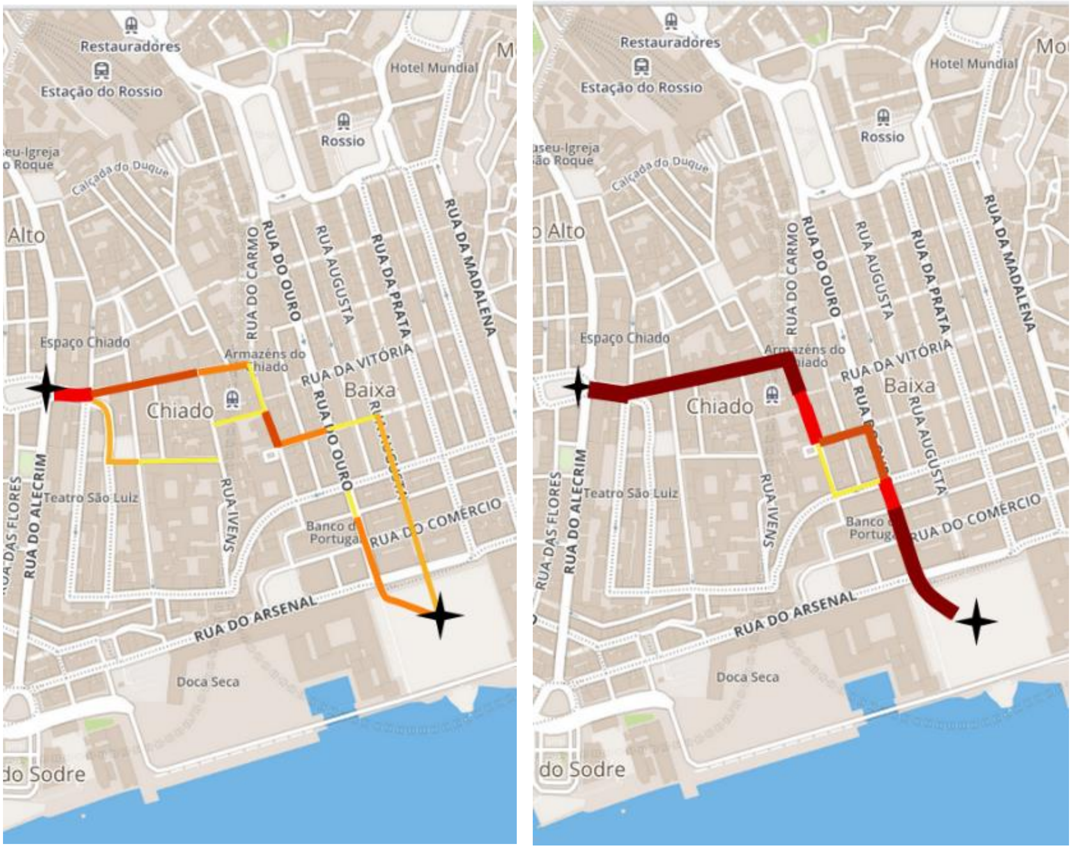
PATH	NUMBER OF PARTICIPANTS	PERCENTAGE (%)
	15-13	>80
	12-10	>60
	9-7	>40
	6	40
	5	33
	4	27
	3	20
	2	13
	1	7

Figure 59. The map representing the total results for the day-time walking interviews that took place in Lisbon.

PATH	NUMBER OF PARTICIPANTS	PERCENTAGE (%)
	15-13	>80
	12-10	>60
	9-7	>40
	6	40
	5	33
	4	27
	3	20
	2	13
	1	7

Figure 60. The map representing the total results for the night-time walking interviews that took place in Lisbon.

The first differences started to be drawn at the first intersection. At night all participants selected the same route, heading east, but in the day-time three individuals headed south towards the river. However, the most important divergence happened at the beginning of *Rua Garrett*, where in the day-time the participants were divided between the two possible routes. At night only two people chose to diverge from the most travelled route. These differences are clearer when comparing the maps of the routes travelled by four or more participants for both sets of interviews.



PATH	NUMBER OF PARTICIPANTS	PERCENTAGE (%)
	15-13	>80
	12-10	>60
	9-7	>40
	6	40
	5	33
	4	27
	3	20
	2	13
	1	7

Figure 61. The routes taken by four or more participants. On the left in the day, and on the right on the night-time interviews.

Examining the descriptions provided by the participants, it seems that the reasons for the divergence in route choice is mainly due to the preferences and strategies stablished before starting the task. These appear to be different at night mainly due to the fear of crime. This could be related both to the perceived and recalled lighting conditions ahead. Looking closely at each node where decisions diverged most should provide a better insight to the role of artificial lighting.

Four nodes were examined in Lisbon, and these are represented in a map on the following illustration.

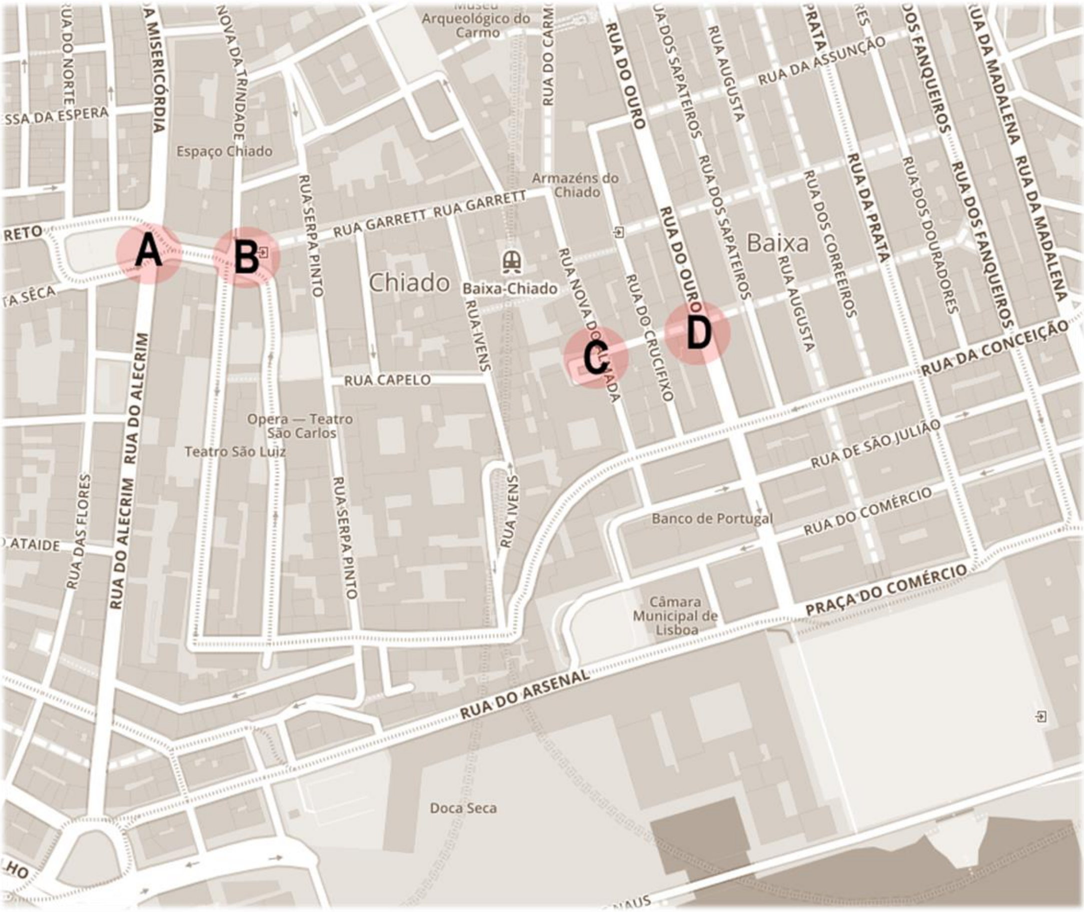


Figure 62. The location of the nodes which presented greater differences in route choice between the two sets of interviews.

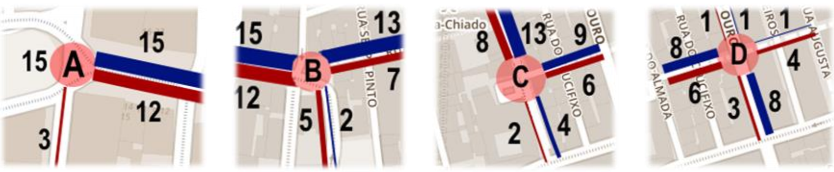


Figure 63. The number of participants travelling from the selected nodes during the day (red) and at night (blue).

Node A, B and D are those that presented greater differences between the day and night-time selection of routes. Although in node C there were not great differences between the two sets of interviews, it was still found interesting to examine what factors made the results similar.

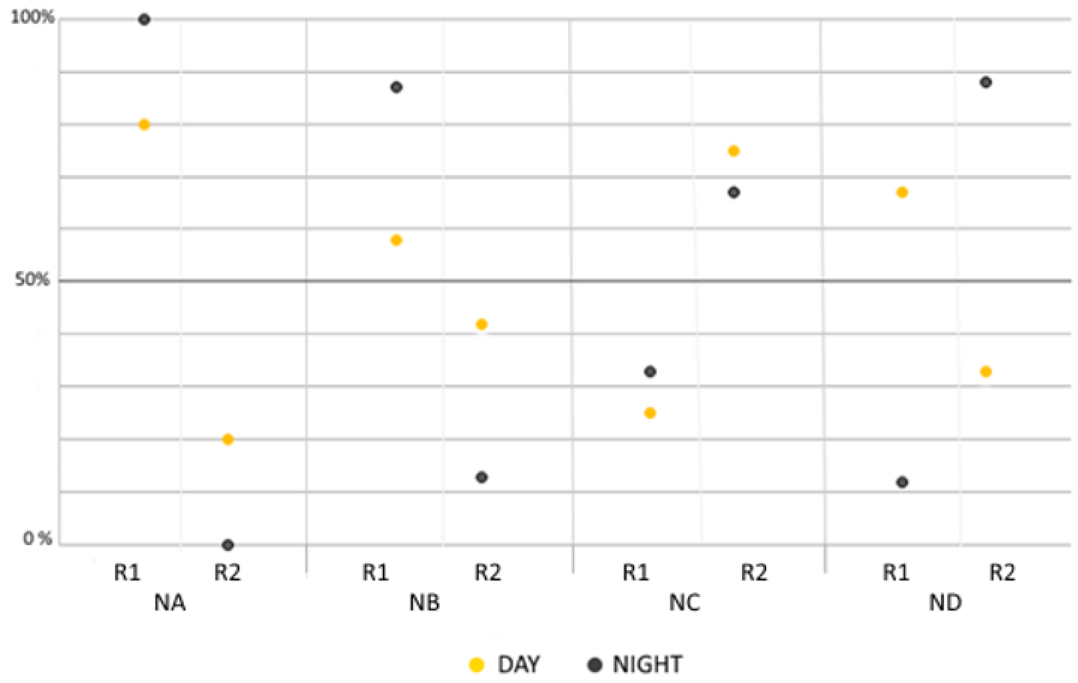


Figure 64.The distribution of the participants at each node, in Lisbon, during the day and night-time as a percentage.

As previously explained in the chapter regarding London, the next pages will present a detailed description of each node, covering those attributes that were thought to be critical to decision making, based on the overall explanations of the participants. These were the description of the routes coming out of each node, its liveliness, lighting conditions, and the analysis of the choices made by the participants.

The description of the routes consisted of the same parameters as those elaborated for London as was the method used to collect the data. The street gradient was remarked by a great number of participants as an important clue, as they all were aware that the destination point was located at a lower level from the starting point. For a very small amount of individuals it could also have acted as a potential discouraging factor if a street was considered too steep (as declared by two participants in the day-time).

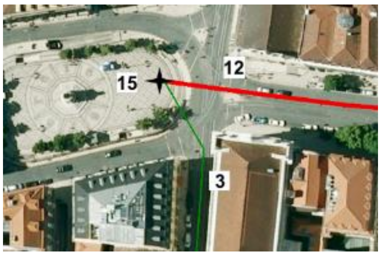
The description of the lighting equipment and measurements for each street is applicable for the night-time only. As in London, the lighting equipment refers to the description of the characteristics of the public street lighting equipment alone. This data was obtained from the city of Lisbon in Portugal. There was mainly one light source for public lighting in use for that area of Lisbon, which were lamps of high pressure sodium installed in suspended lanterns with no reflectors.

The section “measurements” conveys information on the survey performed, in the field, at each street that derives from the nodes in question, in a similar fashion to those performed in London.

The tables with detailed information for each relevant route coming out of a node also provide similar information to those for London. However, the field regarding the level of knowledge of the participants was supressed as everyone declared a similar good level of knowledge of the area.

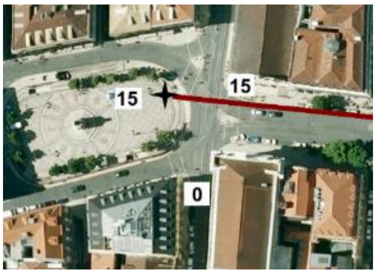
Node A

At the departure point, which was designated as node A, there were four possible paths. Two of these paths distanced the individuals from the destination point, while the other two would lead them in the right direction. It was observed that the participants only took the latter two, in both sets of interviews. These will be designated as route 1 and 2, or *R1* and *R2*, and correspond respectively to *Largo do Chiado* and *Rua do Alecrim*.



Route 1: *Largo do Chiado*

Route 2: *Rua do Alecrim*



Route 1: *Largo do Chiado*

Route 2: *Rua do Alecrim*

Figure 65. The possible routes from *node A* and the routes selected in the day-time and night-time interviews.

Rua do Alecrim is a steep street, with very few shops which close early, it usually has a high volume of cars, and it leads south, descending towards the river. At the beginning of that street there is a traffic sign indicating *Praça do Comércio*, the destination point, in that direction. *Largo do Chiado* is a flat small square which precedes *Rua Garrett* and is punctuated by two churches and a famous café. It usually gathers a large number of people and street performers.

The main difference in results was that while in the day-time a few participants (three in fifteen), took route 2, which is, *Rua do Alecrim*, in the night-time no one chose that path. The persons who chose *R2* declared they thought it was either the easiest or the most direct path towards the destination point. They also remarked that they could see the river and would head towards it. One of the participants was only familiar with the area by traveling it by car, and thus followed the traffic sign. At night most participants justified choosing route 1 by feeling safer, following the path with more people or the most pleasant one.

The reason for subjects to avoid *R2* at night seems to be mostly related to safety concerns. The number of people and businesses open were lower on that route, and there were no visible landmarks there, whereas the river had been the main attraction for the day-time participants to go in that direction. Additionally, the lighting analysis reveals that the average luminance was lower in *R2* than in *R1* and that there were no large and well defined areas of high luminance contrast visible at any of the routes.

Because at other nodes some subjects stated that they avoided streets that looked dark ahead, it was evaluated if the visible area at the end of the route had lower average luminance than its context. In route 2 the area at the end of the route was darker than its context by a ratio of around 1:2, but on route 1 it was brighter by a ratio of about 7:1.

On route 2, the average luminance for the area at the end of the street was estimated at about 2cd/m^2, and its context as having an average luminance of 3 cd/m^2.The area at the end of *Largo do Chiado* had an average luminance of 27 cd/m^2, against 4 cd/m^2 for the rest of the scene.

So, the perceived brightness of the area ahead, at the end of the routes, could have dissuaded the participants from taking route 2 while attracting them towards route 1.

Figure 66. The area of the image (in red) analysed for average luminance on route 1.

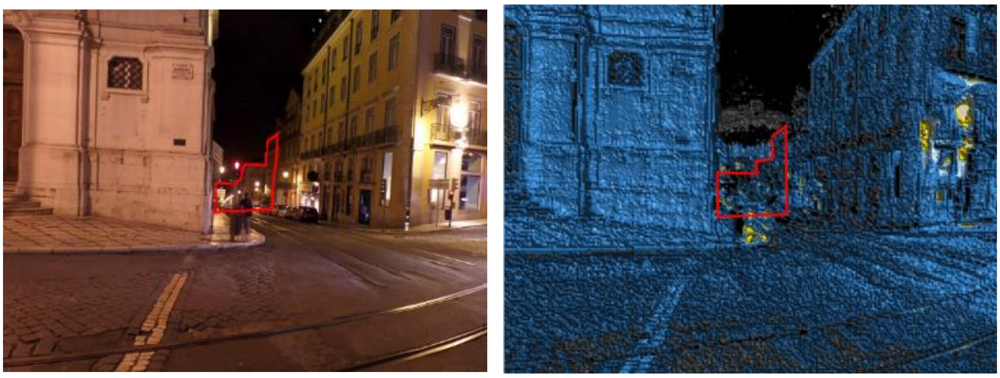
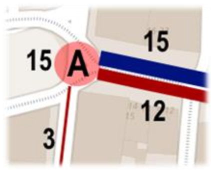


Figure 67. The area of the image (in red) analysed for average luminance on route 2.

	A few participants selected R2 during the day but no one went that way at night.
Summary of results	The main reason seems to be related to safety concerns
	The area at the end of the streets was darker for R2 and brighter than its context in R1

LISBON

NODE A



		DAY		NIGHT	
		R1	**R2**	**R1**	**R2**
Route description	Number of global landmarks visible at the route	2	1	2	**0**
	Number of subjective landmarks	0	0	0	0
	Street gradient	Flat	Descent 5^0	-	-
	Route direction	E	SWW	-	-
Liveliness	Average number of people in the street	>10	5-10	>10	0
	Number of businesses open	6	9	2	5
Street lighting equipment	Light sources			HPS	HPS
	CT			2000	2000
	CRI			25	25
Lighting	L_{av} (cd/m^2)			5.5	3.3
	E_v (lux)			13	27.4
	E_h (lux)			25/25.3/19.8	11/17/27
Route choice	Number of participants	12/15	3/15	15/15	0/15
	Percentage (%)	80	20	100	0

LISBON

Largo do Chiado

NODE A

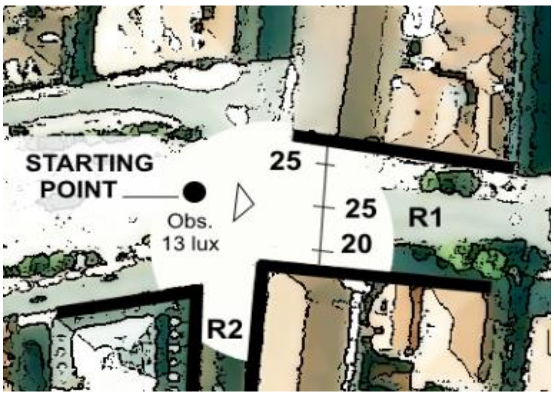
R1


Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
It is the quickest or most direct route to get to the destination point by foot.	8		3	
Pleasantness, shops and memories	3		2	
Heading towards *Rossio.*	1		0	
Would prefer the other route but this is safest at night	0		3	
A route well known to the participant	0		5	
There are more people in the street	0		1	
Avoiding cars	0		1	

Luminance map (cd/m²)

0.25-0.5 | 0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512 | 512-1024

Illuminance measurements (lux)



LISBON

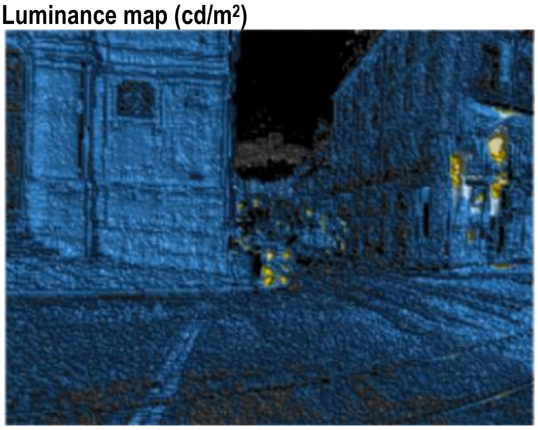
NODE A

Rua do Alecrim

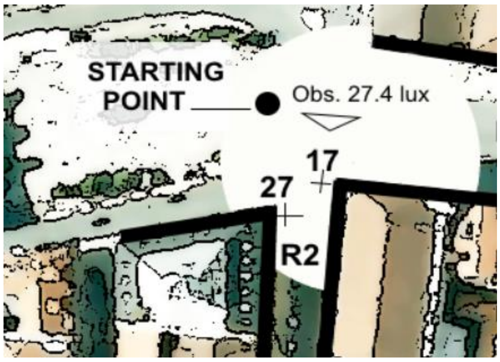
R2

Route choice explanation	DAY Nº	DAY ☆	NIGHT Nº	NIGHT ☆
Quickest or most direct route that heads to the river.	2	The river	-	-
Following the sign indicating the destination point in that direction	1	A sign, The river	-	-

Luminance map (cd/m²)



Illuminance measurements (lux)



0.25-0.5 | 0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512

Node B

Node B is located at the top of *Rua Garrett* and enabled the participants to take two possible routes: either straight ahead through *Rua Garrett (R1),* or by turning right through *Rua Paiva de Andrade.*

Route 1: *Rua Garrett*

Route 2: *Rua Paiva de Andrade*

Route 1: *Rua Garrett*

Route 2: *Rua Paiva de Andrade*

Figure 68. The possible routes from *node B* and the routes selected in the day-time and night-time interviews.

Rua Garrett descends towards the west and a famous department store (*Armazéns do Chiado*) is visible at the end of the slope. On the background on the top of a hill, the castle *São Jorge* is also observable. The street is partly pedestrianized and comprises a large number of stores, some which are considered landmarks, such as Café *A Brasileira* with the statue of *Fernando Pessoa* in front, and *Bertrand* bookstore. Great part of the commerce is open until mid-night, and it attracts a large number of shoppers, tourists and street performers during the day and night hours.

Rua Paiva de Andrade is mostly flat, with a very light descent, and it leads south. The river is visible at the end of the street and it leads towards an important theatre, *Teatro de São Carlos* which is also partly visible especially during the day.

In the day-time twelve participants stood at the node, and they distributed almost evenly through the two routes. At night-time only, two out of fifteen individuals selected route 2, while everyone else decided to go straight ahead on route 1.

The reasons provided by participants for taking *R1* in the day-time were mostly related to pleasantness, whereas at night they were related with getting quick and safely to the destination. Either because they knew that route better, because they felt it was more populated or brighter, or because they preferred to travel by streets with less vehicles.

The main attraction for choosing the alternative route in the day was *São Carlos* Theatre, and it was also considered a pleasant route. The two individuals that took that route at night had different reasons to do so, but both seemed to be following the strategy they had established previously at the departure point: following the tram line and going towards the theatre.

As in the previous intersection the main reason for the differences in results seem to be related to the fear of crime at night. In this case route 2 was less populated and seemed to be perceived or remembered as darker ahead than the other option. Another aspect is that there are no visible landmarks in that direction at night, whereas on route 1 the lit sign of Armazéns do Chiado is well visible from the distance, as well as a wall of the castle.

Figure 69. *Armazéns do Chiado* and the castle walls at night. *Bertrand* bookshop on the right side.

The average luminance of the two routes is very similar, however when examining the average luminance of the area at the end of each street it was found that there were differences.

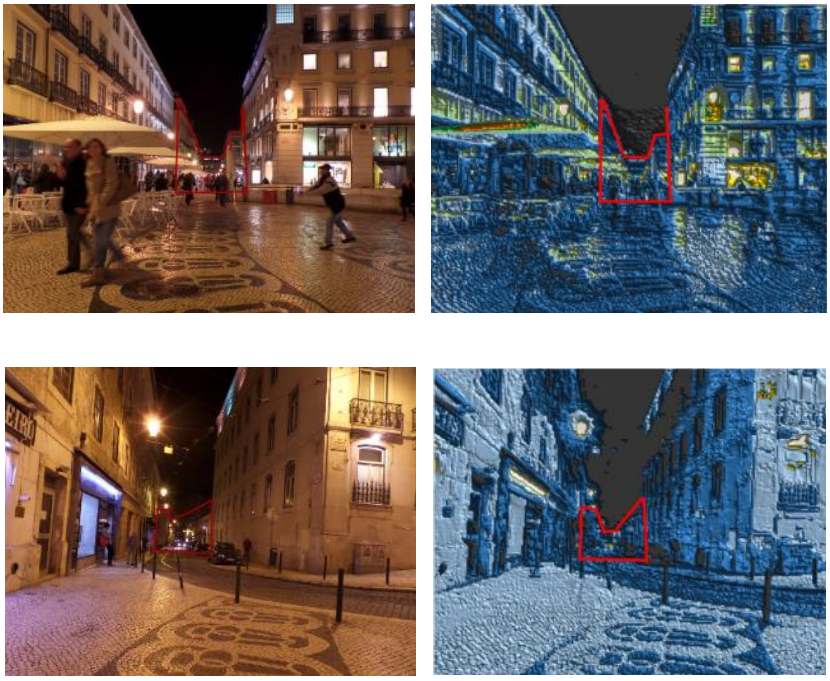


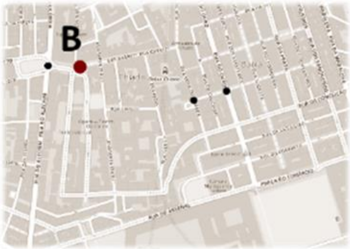
Figure 70. The area of the image (in red) analysed for average luminance in route 1 (top) and 2 (bottom) for node B.

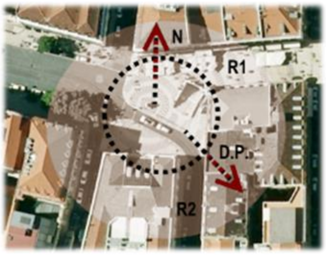
Since a number of participants justified avoiding *R2* because it looked darker ahead, the average luminance of the visible area at the end of the street was analysed and compared against the average luminance of the rest of the image. The ratio for R1 was 1.2:1 (13:11 cd/m^2), making the end of that route practically as bright as the rest of the scene. However, the average luminance at the end of R2 was almost half of the average luminance from the rest of the image with a ratio of around 1:2, (5.5:11 cd/m^2), making it possibly less attractive for that reason.

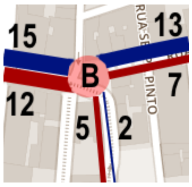
Summary of results	There was a clear preference for *R1* at night only.
	The participants distributed evenly between the two routes in the day-time.
	The participants declared avoiding R2 for safety reasons at night only.
	The L average contrast between the end of R2 and its context shows it may have been perceived as dark ahead, but that is not the case in R1.
	There are two landmarks visible at R1 both day and night.
	The landmark at R2 is not visible at night.

LISBON

NODE B







		DAY R1	DAY R2	NIGHT R1	NIGHT R2
Route description	Number of global landmarks visible at the route	4	2	4	**0**
	Number of subjective landmarks				
	Street gradient	Descent 4^0	Descent 2^0		
	Route direction	S	W		
Liveliness	Average number of people in the street	>10	5-10	0	>10
	Number of businesses open	>10	3	>10	0-1
Street lighting equipment	Light sources			HPS	HPS
	CT			2000	2000
	CRI			25	25
Lighting	L_{av} (cd/m^2)			11.4	11.5
	E_v (lux)			28	27.5
	E_h (lux)			24/22/15	17/21/16
	L_c of selected object			-	-
Route choice	Number of participants	7/12	5/12	13/15	2/15
	Percentage (%)	58	42	87	13

LISBON

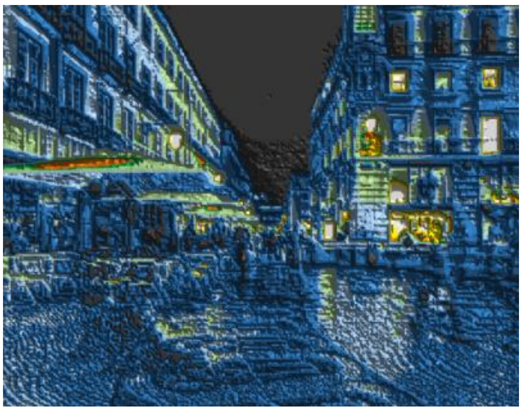
NODE B

Rua Garrett

R1

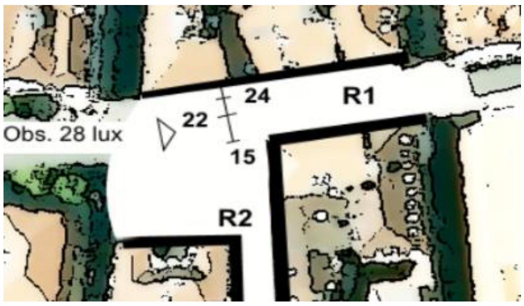
Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
Pleasantness, pedestrianized street, memories	5	*Armazéns do Chiado*	0	
The quickest and shortest way to get to the destination	1		4	
The street descends and the destination point is at a lower level.	1		0	
It looks safer. Not sure if the streets in the other direction are sufficiently lit.	0		1	
It's safer to take this route because there are more people on the streets.	0		2	
I am avoiding dark streets. Passing by reference points such as *Fernando Pessoa* statue, *Mártires* church and *Bertrand* bookshop.	0		1	Pessoa statue, Mártires church, Bertrand bookshop
It's the quickest way and I am avoiding streets with traffic	0		2	
Going through shops I know well	0		3	

Luminance map (cd/m²)



■ 0.5-1 ■ 1-2 ■ 2-4 ■ 4-8 ■ 8-16 ■ 16-32 ■ 32-64 ■ 64-128 ■ 128-256 ■ 256-512 512-1024

Illuminance measurements (lux)



LISBON

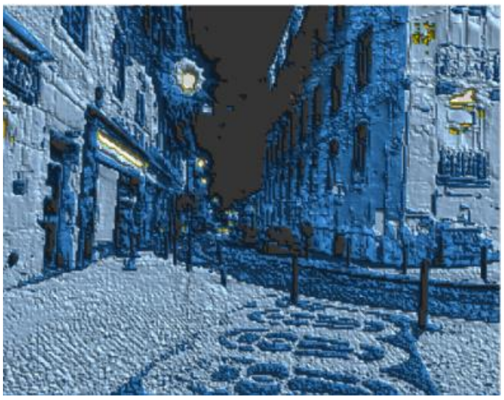
Rua Paiva de Andrade

NODE B

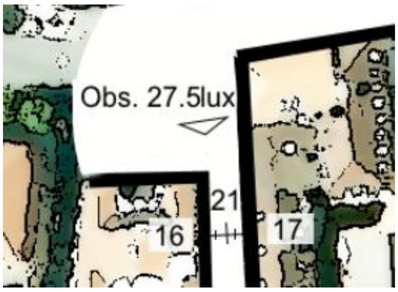
R2

Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
Pleasant route towards *São Carlos* theatre. It may be the shortest path.	3	S. Carlos Theatre	0	-
I am exploring this way which I know less well.	1	-	0	-
The destination point is by the river so I am going towards it and the Theatre. It is the simplest way.	1	S. Carlos Theatre	0	-
Following the tram line. It is the shortest path and it is pleasant.	0	-	1	-
My reference point to arrive at the destination is *São Carlos* Theatre.	0		1	S. Carlos Theatre

Luminance map (cd/m²)



Illuminance measurements (lux)



0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512 | 512-1024 | 1024-2048

Node C

Node C is located at the intersection of *rua Nova do Almada* with *rua de São Nicolau* and enabled the participants to take two possible routes: either straight ahead through *rua Nova do Almada (R1),* or by turning left at *rua de São Nicolau (R2).* Both streets descend: route 1 towards the south and route 2 towards the east.

Route 1: *Rua Nova do Almada*

Route 2: *Rua de São Nicolau*

Route 1: *Rua de São Nicolau*

Route 2: *Rua Nova do Almada*

Figure 71. The possible routes from *node C* and the routes selected in the day-time and night-time interviews.

There is one landmark at the intersection, *Tribunal da Boa-Hora* which is an old court house where a number of televised court cases took place in the past. A few participants mentioned that they stopped or turned at the intersection because they had noticed the court house. Both streets have a visible floodlit façade.

In the day-time only two out of eight persons who stood at the intersection chose route 1, the remaining turned left following route 2. In the night-time interviews four in thirteen participants went straight ahead through route 1 and nine decided to take route 2.

The justifications provided by the participants show that the fear of crime may have again partly conditioned route choice. The decision, in day-time, of continuing straight ahead through R1 was that of quickly arriving at the destination, to walk through streets with better lighting or towards a lit façade. Turning to R2 seemed to be related in both sets of interviews to selecting the most pleasant route or to reach another street visible from that intersection. A number of people who turned to *R2* declared that they preferred walking through populated, main streets at night.

In both routes there are visible areas of some luminance contrast, which at route 1 corresponds to the façade of the building at the end of the street, which is the lateral façade of a former church, and in route 2 to a façade of a building located on the left side of the street. At route 1 the ratio of the average luminance of the façade against the rest of the scene was estimated at around 5:1[184], and on the other route, the façade of the building presented a similar contrast ratio of 4:1[185].

[184] Estimated L_c = 58:12.5 cd/m^2

[185] Estimated L_c = 56:14 cd/m^2

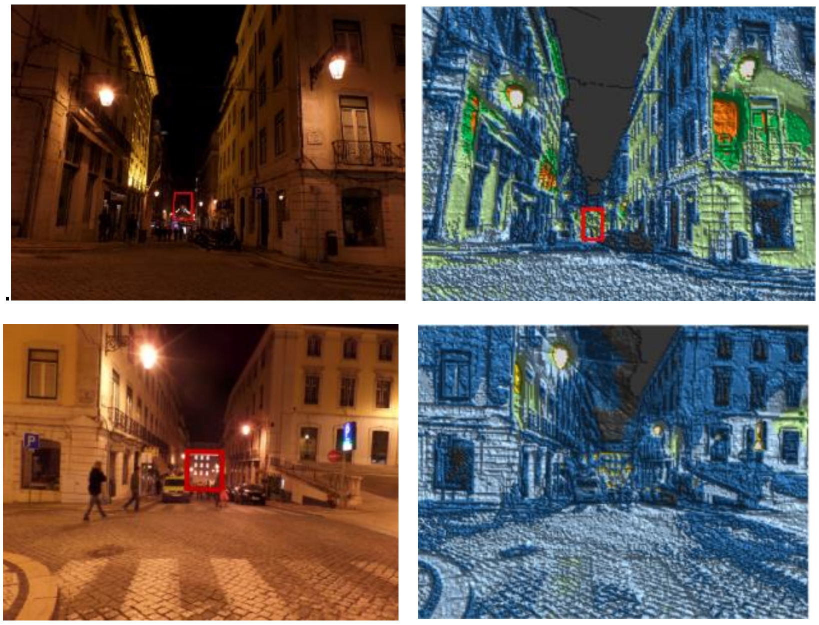


Figure 72. The area of the image (in red) analysed for average luminance in route 1 (top) and 2 (bottom) for node C.

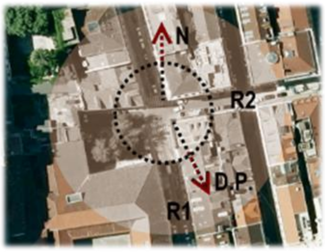
Since it was previously observed, in other nodes, that the luminance contrast at the end of the street could have an effect on the perception of safety, the luminance contrast for the end of the routes was also examined. Both areas at the end of the streets had higher luminance than its context. Route 1 with a ratio of around 5:1 (58:12.5 cd/m^2) and route 2 with 2:1 (23:15 cd/m^2).

Most of the lighting conditions were similar for both routes, which might explain the fact that the distribution of the participants was similar on both sets of interviews. The higher luminance contrast of focal points against its context in one of the routes did not seem to affect decisions.

Summary of results	All conditions are similar between the two routes at night.
	The average luminance of *R1* and *R2* are similar.
	Both routes have one potential focal point. The focal point on *R1* has higher luminance than the one on *R2*.
	The area at the end of both streets has an average luminance higher than that of its context. This is particularly true for *R1* where the area has higher contrast than that on *R2*.
	Route 2 was the most travelled both in day and night-time interviews
	The distribution of the participants was similar between day and night-time.

LISBON

NODE C



		DAY		NIGHT	
		R1	**R2**	**R1**	**R2**
Route description	Number of global landmarks visible at the route	1	1	**1**	1
	Number of subjective landmarks				
	Street gradient	Descent 5^0	Descent 4^0		
	Route direction	SSE	ENE		
Liveliness	Average number of people in the street	>10	>10	5-10	3-5
	Number of businesses open	9	7	3	**0**
Street lighting equipment	Light sources			HPS	HPS
	CT			2000	2000
	CRI			25	25
Lighting	L_{av} (cd/m²)			13	15
	E_v (lux)			48	51
	E_h (lux)			36/60/37	47/21/21
	L_c of selected object			5:1	4:1
Route choice	Number of participants	2/8	6/8	4/13	9/13
	Percentage (%)	25	75	31	69

LISBON

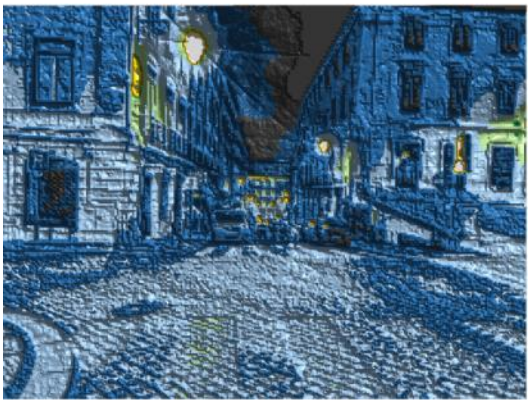
NODE C

Rua Nova do Almada

R1


Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
I see Tribunal da Boa-Hora and go straight ahead towards the City Hall because it is quicker this way.	2	-	0	
Towards *Rua da Conceição* where the tram goes by because it may have more people and be better lit.	0	-	3	
Towards *Igreja de São Julião* façade.	0	Igreja de S. Julião	1	

Luminance map (cd/m²)



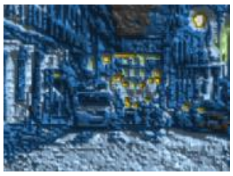
Area of luminance contrast

Object: *The lateral façade of S. Julião* church

L_{av} of the object 58 cd/m²

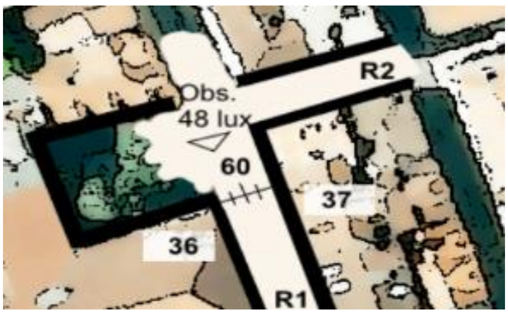
L_{av} of the context 12.5 cd/m²

Images:




■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-256.0 ■256.0-512.0 ■512.0-1,024.0 ■1,024.0-2,048.0 2,048.0-2,200.0

Illuminance measurements (lux)



LISBON

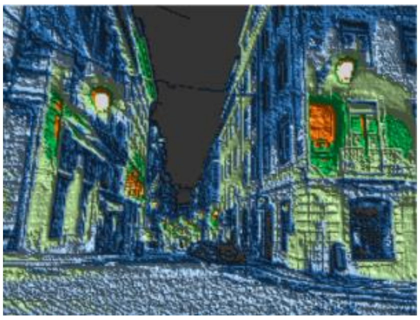
NODE C

Rua de S. Nicolau

R2

Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
Pleasantness, more people on the street, less traffic, pedestrianized, there is more light and colour.	2		0	
I turn here where *Tribunal da Boa-Hora* is, towards *Rua Augusta*.There are several shops which I like on route 2.	1	Tribunal da Boa-Hora	0	
Towards *Rua Augusta* or *Rua do Ouro.*	3	Rua do Ouro/Rua Augusta	0	
I recognize *Tribunal da Boa-Hora,* turning to head to *rua do Ouro*.	0	Tribunal da Boa Hora/ Rua do Ouro	4	
The street has more people, is more pleasant, and I prefer to walk through main streets	0		3	
I could turn left in any street from this road, but I will turn here because it is simpler and pleasant.	0		2	

Luminance map (cd/m^2)



Area of luminance contrast

Object: The façade of the building on the left side of the street

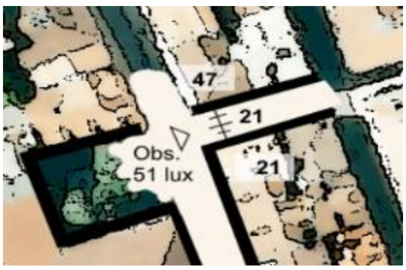
L_{av} of the object 56 cd/m^2

L_{av} of the context 14 cd/m^2

Images:

0.5-1 | 1-2 | 2-4 | 4-8 | 8-16 | 16-32 | 32-64 | 64-128 | 128-256 | 256-512 | 512-1024 | 1024-2048

Illuminance measurements (lux)

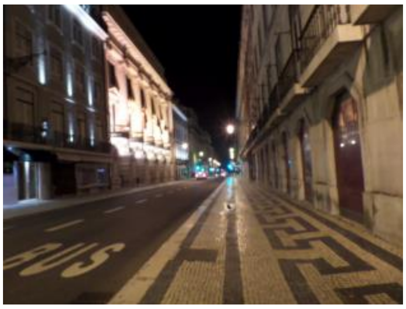


Node D

Node D consists of the intersection of *rua do Ouro* with rua de *São Nicolau* and allows choosing four different paths, two of which would distance the individuals from the destination point, corresponding to the streets where they had arrived from. The participants either went west to *rua de São Nicolau* (*R1*) or south, through *rua do Ouro* (*R2*). The terrain is mostly flat in all directions from the node.

Route 1:

Route 2: Rua do Ouro



Route 1: Rua de São Nicolau

Route 2: Rua do Ouro

Figure 73. The possible routes from *node D* and the routes selected in the day-time and night-time interviews.

Route 1 has no visible landmarks and leads to *Rua Augusta*, a busy, pedestrianized street which leads to a monumental entrance of the square designated as the destination point. From the node looking towards route 2 it is possible to view the river and the façade of a bank. A great number of individuals recognized or remembered stores there during the day. The river becomes undetectable at night and the façade of that bank is lit, making it highly conspicuous. Route 2 leads directly towards the destination whereas route 1 runs parallel to the square where the participants were asked to walk to. Both streets have similar liveliness.

In the day-time seven participants stood at the node, six arriving from *rua de São Nicolau* and one coming from *Rua do Ouro*. They distributed almost evenly through the two routes: three persons went through *Rua do Ouro* (*R2*), including the one who was already coming from that street; and four followed *Rua de São Nicolau* (*R1*). At night there were nine participants at the intersection, again only one of which had arrived there from *Rua do Ouro*. All individuals followed route 2 with the exception of one who went through route 1. This participant had arrived to de node from *Rua de São Nicolau (R1)*, thus choosing to go straight ahead.

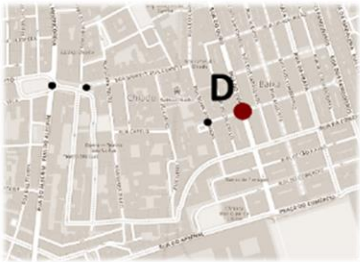
The justifications provided by the participants show that in the day-time interviews, those who went straight ahead through *R1* were looking for the most pleasant route and were heading towards *Rua Augusta.* Those who turned on *R2* did so because they could see the river from the node and decided to take the most direct route. At night all who turned on *R2* were selecting the quickest route or were attracted by the lit façade of the bank.

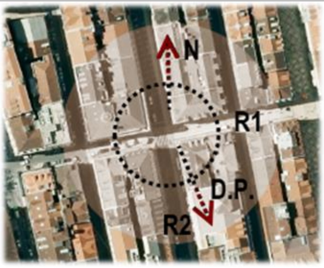
Although *R1* has a much higher average luminance than *R2*, there was a clear preference for *R2* at night. This could be due to the lit façade of the bank which attracts attention and acts as a focal point. The luminance contrast of the area of the façade against its background was estimated at around 22:1 (101:4.6 cd/m^2), making it highly visible.

Summary of 3results	There was a preference for route 2 in the night-time interviews
	Route 1 has a much higher average luminance than route 2.
	Route 2 has a high luminance contrast area which seems to act as a focal and attraction point.

LISBON

NODE D





		DAY		NIGHT	
		R1	R2	R1	R2
Route description	Number of global landmarks visible at the route	0	2	0	1
	Number of subjective landmarks				
	Street gradient	Flat	Slight descent		
	Route direction	NE	SE		
Liveliness	Average number of people in the street	5-10	>10	0-5	0-5
	Number of businesses open	4	7	0	0
Street lighting equipment	Light sources			HPS	HPS
	CT			2000	2000
	CRI			25	25
Lighting	L_{av} (cd/m^2)			28.2	11
	E_v (lux)			43	20.5
	E_h (lux)			91.5/12/43.3	14.3/20/11
	L_c of selected object			-	22:1
Route choice	Number of participants	4/6	2/6	1/8	7/8
	Percentage (%)	67	33	12	88

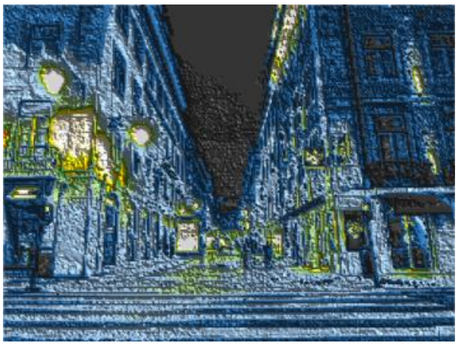
LISBON

NODE D

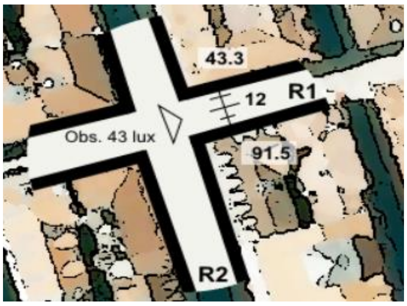
Rua de S.Nicolau **R1**

Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
Going in the direction of rua Augusta, which is more pleasant and lively. It has a number of shops, and no cars.	4		0	
I rather go through pedestrianized, wide streets.	0		1	

Luminance map (cd/m²)



Illuminance measurements (lux)



■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-256.0 ■256.0-512.0 512.0-1,000.0

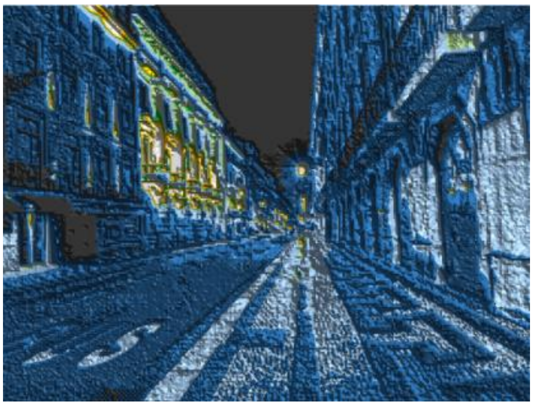
LISBON

NODE D

Rua do Ouro **R2**

Route choice explanation	DAY Nº	DAY ✡	NIGHT Nº	NIGHT ✡
The destination is right at the end of this street. I can see the river from here.	3	The river	0	
Most direct and quickest way.	0		5	
Towards the destination in direction of the river and I can see the façade of Totta Bank.	0		3	*Totta* Bank façade

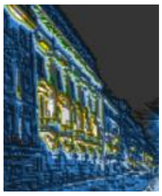
Luminance map (cd/m²)



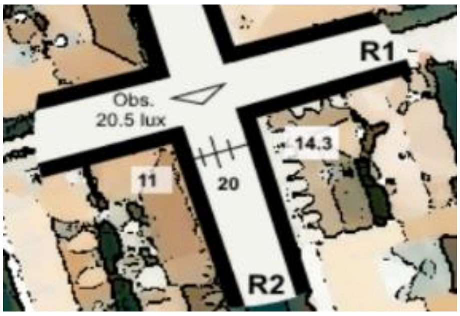
■0.5-1.0 ■1.0-2.0 ■2.0-4.0 ■4.0-8.0 ■8.0-16.0 ■16.0-32.0 ■32.0-64.0 ■64.0-128.0 ■128.0-256.0 ■256.0-512.0 512.0-1,000.0

Area of luminance contrast

Object:	*Totta Bank* façade
L_{av} of the object	101 cd/m^2
L_{av} of the context	4.6 cd/m^2
Images:	



Illuminance measurements (lux)



Conclusions for the walking interviews in Lisbon

In Lisbon, as in London, it was also observed that most participants, of both day and night time interviews, constructed a strategy previous to starting walking, and based on the use of a mental map composed of a number of anchor points. But more importantly, they also had strong preferences for route selection at the starting point. These preferences were different for those who performed the task in the day and those who did it at night. However, the perceived environmental conditions also seem to have influenced the selection of paths during the interview.

The main preferences in day-time interviews were related to taking the most direct, shortest or quickest path or the most pleasant route. Some persons also declared that they were exploring new routes or following those streets which were less crowded. At night the participants expressed preferences based on safety concerns. As a result there was a higher coincidence of route choice among the individuals who took the task at night than among those who performed it in the day.

After analysing a selected number of intersections it was also observed, as in London, that route choice seemed to be affect by the presence, or the absence of reference points. They also seemed to have been attracted by focal points, especially at node D. The most interesting observation, however, was that the participants seem to have avoided those streets that looked darker ahead than the alternative route. This observation will be further explored ahead when comparing the results of the interviews held in both cities.

THE COMPARISON OF RESULTS BETWEEN LONDON AND LISBON

For the photographic interviews

For the walking interviews

THE COMPARISON OF RESULTS BETWEEN LONDON AND LISBON

For the photographic interviews

The comparison of results of the photographic interviews suggest that the main elements of Lisbon can be better recognized at night than the main elements of London. There was a better recognition of the pictures of the elements presented to the participants in Lisbon than of those presented in London. Overall, in London there were twelve photographs whose day-time version was better recognized than the night-time one (see Table 17 on page 169). There were also four elements whose night-time picture elicited a better recognition than its day-time version. However, in Lisbon, there were five elements better recognized when photographed under artificial lighting and also five different elements which, on the contrary, were better recognized when photographed under day lighting (see Table 28 on page 274).

Number of divergent results in London	**Photographs**	
	Day	Night
Element not identified	2	5
The element identified was not the primary target of the photograph	2	4
Misidentified elements	-	2
Correctly identified but with doubts	-	2
Number of divergent results in Lisbon		
Element not identified	3	4
Misidentified elements	1	-
Correctly identified but with doubts	1	1

Table 31. The number of divergent results between the day and night-time photographs in London and in Lisbon

The photographic interviews held in London produced a greater variety and stronger results than the interviews that took place in Lisbon. The results of Lisbon reinforce some of the conclusions taken from the results in London, but do not add anything new.

The interviews that took place in London suggested that the main factors that influenced the perception of the most distinctive elements of the city were the expectations of observers and the perception of contrast.

In London there were two different situations related to the influence of expectations on the recognition of a place. The expectation to see a larger number of people at places which are usually crowded, seems to have hampered the identification of Covent Garden and Soho, when the spaces were presented with less persons. This was confirmed in Lisbon, where the photograph of a district famous for its night-life, was less recognized when presented emptied. This suggests that the image that the inhabitants have of a place may be associated with a temporal dimension. That is, if the population of a city only uses an environment at a certain time of the day, and thus is used to seeing it with a certain occupation, they may be less likely to recognize it when observing it with more or less occupants.

The same was found true regarding buildings which have a very different physical appearance at night due to the way they are lit. The National Theatre was found to have a stronger image at night, when it is lit with bright colours, than in the day, and to contribute for a better recognition of other elements in the surroundings. On the opposite side, Harrods was slightly less identified in its night-time depiction for those who were unfamiliar with its characteristic night-time appearance.

The second aspect found regarding expectations was the phenomena where a number of individuals pointed objects in a picture that were not there, after having misidentified a place. This was only found in one case in London, with the night-time picture of The Natural History Museum.

The effect of luminance contrast on the perception of objects was found to have an effect both in the interviews that took place in London and in Lisbon. For example, when the contrast of the façade of a building against its background was almost null, and its shape undistinguishable, the participants were less able to recognize it. This was the case with The Gherkin, in London and *Amoreiras*, in Lisbon. On other occasions, certain elements became recognizable due to the existence of elements with high luminance contrast against its background. This revealed to be particularly important to identify distant landmarks, which in turn would allow to locate and recognize a certain place at night. It was the case with some of the parks in London such as Regent’s Park and St. James’s Park, and also with *Avenida da República* in Lisbon.

There were a total of four elements whose image was less recognizable at night in Lisbon, against eleven in London. Thus, it was investigated if the lighting conditions in Lisbon could have supported a better recognition of its elements.

Looking at the results in both London and Lisbon, it can be observed that a total of five elements which were less recognizable at night were parks or gardens (three in London and two in Lisbon). All photographs of parks that were presented to the participants elicited poor results at night with the exception of Regent Park in London and *Parque Eduardo VII*, in Lisbon. This is probably justified by the fact that the trees and vegetation are not lit at night, making recognition only possible through the identification of distant landmarks, which enabled the geographical positioning of the place where the photograph was taken from.

An analysis of the luminance measurements that were taken at the various scenes that were more closely examined in Lisbon and in London, suggest that the average luminance is higher on the images of Lisbon, than in London, even at places expected to have high luminance, as in Oxford Circus. Combining this information with the edges detected on the images could have partly previewed which scenes and elements were more likely to be recognized. However, it does not seem as if an average higher luminance of a scene is in itself a condition to allow for a better perception of an environment. The average luminance does not inform on how uniformly lit the scenes were, and if the elements of interest were visible or not.

London		**Lisbon**	
Photograph	**L_{av} (cd/m²)**	**Photograph**	**L_{av} (cd/m²)**
The Millennium Bridge	0.2	Campo Grande	0.7
Tate Modern	0.4	Praça Martim Moniz	3
The British Museum	0.5	Jardim da Estrela	6
St. James's Park	0.6	Bairro Alto	11.2
Centre Point	3.5	Amoreiras	22
The Westminster Bridge	4	Estação de Santa Apolónia	30
Oxford Circus	4.1	Rua do Ouro	31
Harrods	25.4	Avenida da República	46.5

Table 32. The average luminance (L_{av}) of the selected scenes captured in London and in Lisbon for the photographic interviews.

For example, *Amoreiras* has a very high average luminance mostly due to the amount of lighting on the foreground. Yet, the characteristic three towers, on the distance, do not have sufficient luminance contrast against the background to be detected.

The perception of the luminance contrast of objects against their background, or at least the perception of their shapes, can be examined by looking at the edges detected in the images, which can found on Annex 2. Observing the differences between the edges detected in the day and night-time pictures both in Lisbon and in London, it looks as if the main edges that are visible in the day pictures are more often still perceptible in the night-time pictures of Lisbon than those of London.

THE COMPARISON OF RESULTS BETWEEN LONDON AND LISBON

For the walking interviews

The samples

An important difference between the interviews that took place in London and in Lisbon was the characteristics of the samples. These differed mostly on the level of knowledge declared and demonstrated by the participants in each city.

In London some of the participants had poor knowledge of the area whereas in Lisbon every participant had a good to average knowledge of the environment where the task took place. Moreover, the individuals who were interviewed in Lisbon had lived there longer on average than the participants of London, and they were also older in age. Thus, unsurprisingly, it was later noticed that those who declared having a good knowledge of London did not seem to have as good knowledge of that particular area where the task took place, as the participants in Lisbon did.

This imbalance was not deliberate, it was a product of the characteristics of the population found willing to voluntarily participate in this stage of the study, which partially replicated the characteristics of the wider population of London and Lisbon. However, the lack of knowledge of the participants in London was welcomed. It was speculated that these individuals would, probably, be more affected by the environmental conditions, for example lighting, as they would not be biased by past experiences, and that this fact could lead to more interesting results. At least they might have been more prone to explore and search the environment for clues.[186] However, in Lisbon no participants with poor knowledge of the area were found, resulting in different behaviours.

[186] According to Golledge 1999, if a destination is known but it is not directly connected by a path to the origin, the traveller might have to search and explore, among other efforts in order to succeed in his task.

	London		Lisbon	
	Day	Night	Day	Night
Knowledge	50% Poor, 50% Average or good		100% Good	
Average number of years living in the city	6 y	5 y	48 y	38 y
Average age	34 y	33 y	57 y	39 y
Gender	46% F, 54% M	40% F, 60% M	46% F, 54% M	

Table 33. The characteristics of the sample of population in London and in Lisbon.

The wayfinding process

The analysis of responses showed that, in London, the participants of both sets of interviews established similar preferences, and that before starting the task, they described cognitive maps with largely coinciding reference points. Yet, the routes selected at night were not equal to those adopted in the day. The actual landmarks which guided the participants also differed, even in the sections of routes which were common between the day and night-time interviews. This indicated that the dissimilarities in their behaviours could have been a result of differences in the night-time environment, such as lighting.

In Lisbon, however, the participants of the two sets of interviews expressed different preferences, and thought of different reference points, before starting the task. Then, they followed slightly different routes. Here, it was not as clear if the dissimilarities in behaviour between the two sets of interviews could be attributed to the differences in environmental conditions alone. The familiarity of the participants with the characteristics of that part of the city also seemed to weigh in the selection of routes. Specifically, because they were able to preview what they would find ahead, the routes which did not match preferences were discarded in advance. This was particularly true at night, when most preferences were related to safety concerns, pre conditioning route selection.

Even if the memory of past experiences played an important role, the participants also took decisions while travelling, particularly at intersections. There, it was found that they would tend to avoid streets that looked dark and unpopulated ahead, revealing that their behaviour could have been, at least partly, influenced by the lighting conditions.

The preferences for route selection in Lisbon	**Day**	**Night**
The most direct route	3	0
The shortest/quickest route	3	**4**
Most pleasant route	4	1
Best known route	1	**4**
The route which is less crowded	1	0
The most populated route	0	**3**
The safest route	0	**3**
The route less well known (exploring)	2	0
Did not express a preference	1	0

Table 34. The preferences for route selection in Lisbon. In bold are those preferences which could be related directly or indirectly to safety concerns.

The results

The results of the interviews revealed that there was a difference in the selection of routes between the day and night-time interviews in both cities. At the intersections where decisions diverged the most, the difference between the percentage of subjects following a given route in the day and that same route at night varied between 6% and 58% in London, and between 6% and 55% in Lisbon. It should be noted, however, that the actual number of people at the nodes was not always equal for the day and night-time, as subjects distributed differently in space. Thus, for example, the same number of individuals stood at nodes *A*, *C* and *E*, in London at both day and night-time. Whereas in Lisbon, this situation only occurred at node *A*. In London, at night there were three less individuals at node B and two more at node *D* than in the day. In Lisbon, at night there were three, five and two more people at respectively nodes *B*, *C* and *D* than in the day.

Results

		London				**Lisbon**			
		Number of subjects				Number of subjects			
Node		Night		Day		Night		Day	
A	R1	3/15	20%	0/15	0%	15/15	100%	12/15	80%
	R2	2/15	13%	1/15	7%	0/15	0%	3/15	20%
	R3	0/15	0%	1/15	7%				
	R4	10/15	67%	13/15	87%				
B	R1	1/10	10%	6/13	46%	13/15	87%	7/12	58%
	R2	9/10	90%	7/13	54%	2/15	13%	5/12	42%
C	R1	3/5	60%	5/5	100%	4/13	31%	2/8	25%
	R2	2/5	40%	0/5	0%	9/13	69%	6/8	75%
D	R1	1/6	17%	2/4	50%	1/8	12%	4/6	67%
	R2	5/6	83%	1/4	25%	7/8	88%	2/6	33%
	R3	0/6	0%	1/4	25%				
E	R1	3/5	60%	5/5	100%				
	R2	2/5	40%	0/5	0%				

Table 35. The distribution of the participants at key intersections in both day and night-time, at the cities of London and Lisbon.

Although the task was set in an uncontrolled environment, with a great number of variants, the examination of several parameters and the responses of the participants suggested that the lighting conditions may have been the main cause of the differences in behaviour for both cities.

The influence of lighting

Examining the lighting conditions and the responses of subjects (the combination of verbal remarks and patterns of movement) at the nine selected nodes in London and Lisbon, it was found that there were three main aspects which seem to have affected the selection of routes at night. These were *the ability to detect and identify landmarks*, the existence of areas with high luminance contrast against its context (*areas of focal attention*) and *the perception of brightness ahead*.

The influence of these features was evaluated by examining and comparing luminance ratios[187] of the scenes with which the subjects were confronted with when at the intersections of interest. Specifically it consisted on comparing the average luminance (L_{av}) of a target area against the average luminance of its immediate and wider background, and with the adaptation state of the observer (given by the average luminance of the whole scene and complemented by the vertical illuminance (E_v) measured at the height of an observer).

L_{av} of the context against L_{av} of an object	The effect of the luminance contrast ratio
1:1	Not noticeable
1:3	Just noticeable
1:5	Low drama
1:10	High drama

Table 36. The effects of luminance contrast ratios as defined by CIBSE & ILE[188]

The ratios were considered as likely to produce an effect on the observer based on the classification on the effect of contrast ratio provided by the ILE guidelines (CIBSE & ILE, n.d.). These establish the ratios of the L_{av} of the surrounds against the L_{av} of an urban object as *not noticeable* for ratios of 1:1, *just noticeable* for 1:3, *low drama* for 1:5 and *high drama* for a ratio of 1:10. The contrast ratios and its potential effect were then compared with the variation in the percentage of subjects travelling through

[187] These were estimated from a number of measurements in the field, using *Imagelum* (by Peter Raynham, 2000)

[188] *Ibid.*

the routes where the conditions were observed. The results suggested that the lighting conditions had an effect on the behaviour of the subjects (see Table 38).

In the table below, the ability to detect and identify a landmark was considered **increased** by lighting when the ratio of the average luminance of its façade against the immediate background was found equal or above to 3, and **decreased** when below this value. This ratio would mean that the landmark is above the *just noticeable* effect for positive detections. Likewise, it considers that an object will barely be noticed or not detected at all, if the contrast was estimated below that value.

City		**London**					**Lisbon**				**Total**
Nodes		A	B	C	D	E	A	B	C	D	
The ability to detect and identify landmarks	Increased	R1	-	-	-	R2	-	-	-	R2	3
	Reduced	-	-	-	R1 R2	-	R2	R2	-	R2	5
Existence of an area of high luminance contrast	On landmarks	-	-	-	-	-	-	-	-	R2	1
	On other objects	-	R2	R1 R2	-	-	-	-	-	-	3
The perception of brightness ahead	Above L_{av} of the rest of the scene	R4 R2	R2	R1 R2	-	-	R1		R1	R1	8
	Below L_{av} of the rest of the scene	-	-	-	R1 R3	-	-	R2	-	-	3

Table 37. Main factors acting on the selection of routes at night.

Similarly, a random area or a landmark was considered to have such high luminance contrast to be likely to attract the attention and eventually the movement of people, if the ratio between its average luminance and its wider context was estimated as 10 or above. This would correspond to the *high drama* effect. In this case the wider context was more valued than its immediate background, because, the recognition of the shape of the target was found less relevant than for landmarks, whose shape perception is important for it to be likely to produce an effect on wayfinding as they need to be not only detected but also recognized. However, for any surface to attract attention, it needs only to be salient against all other surfaces.

The perception of brightness ahead was estimated considering the $L_{av.}$ of the furthest visible area of a street, against the $L_{av.}$ of its wider background. It was considered above the luminance of the context for ratios equal or above 3, and below for ratios equal or below 0.3. This corresponds to values above or below the *just noticeable* classification for ratios of 3:1 or 1:3. Thus, ratios between the values of 0.4 to 2.9 were considered neutral. However, the perception of the brightness of the area ahead of a street seemed to be mainly related to the comparison with the other streets, rather than with the perceived ratios in that street alone. For example, in London node D, *R2* had an area ahead with L_{av} ratio of 0.7:1 against its context, which could be considered neutral and thus unlikely to attract attention (see Table 45 and Table 46).

London

			Results at night			Number of factors	
			Nº. subjects	%	Variation night v/s day	Attraction	Dissuasion
Node	A	R1	3/15	20	+20%	1	0
		R2	2/15	13	+6%	1	0
		R3	0/15	0	-7%	0	0
		R4	10/15	67	-10%	1	0
	B	R1	1/10	10	-36%	0	0
		R2	9/10	90	+36%	2	0
	C	R1	3/5	60	-40%	2	0
		R2	2/5	40	+40%	2	0
	D	R1	1/6	17	-33%	0	2
		R2	5/6	83	+58%	0	1
		R3	0/6	0	-25%	0	1
	E	R1	3/5	60	-40%	0	0
		R2	2/5	40	+40%	1	0

Lisbon

Node	A	R1	15/15	100	+20%	1	0
		R2	0/15	0	-20%	0	1
	B	R1	13/15	87	+29%	0	0
		R2	2/15	13	-29%	0	1
	C	R1	4/13	31	+6%	1	0
		R2	9/13	69	-6%	0	0
	D	R1	1/8	12	-55%	0	0
		R2	7/8	88	+55%	3	1

Table 38. The distribution of subjects at specific nodes and the variation at night, in percentage, for both London and Lisbon.

However, given that the alternative routes presented lower ratios, of 0.4:1 and 0.1:1, *R2* might have been perceived as brighter ahead by comparison, than if it had been presented along with streets with higher luminance ratios ahead. This subject will be further discussed on page 336.

Some factors seem to have attracted subjects and others to have discouraged them from taking a route. The increased ability to detect and identify landmarks, the existence of an area of focal attention and the perception of higher luminance levels ahead were all **persuasive** aspects. On the contrary, the decreased ability to identify landmarks and the perception of darker areas ahead were all **dissuasive** factors.

They occurred either isolated or combined. When combined, the disparities between the behaviour of the participants in the day and night-time seem to have been accentuated, particularly if the alternative routes presented contrasting lighting conditions (see Table 38). For example, in Lisbon at node *A*, it was found that route 2 had both a landmark which was undetectable at night (the river) and had a neutral luminance contrast ahead (0.7:1). Simultaneously, the alternative route exhibited high luminance contrast ahead (6.5:1). As a result there were less 20% individuals taking route 2 at night. In fact, no one selected it. In the same city a similar situation occurred at node *B*. At node *D*, route 2, the combination of the existence of a focal point, which was coincidently also a landmark, with high spatial brightness ahead was observed. The fact that the river was no longer visible did not seem to weight much on the results, which yielded in an increase of 55% participants selecting this route at night.

In London, it was observed that from node A, route 1 showed both a landmark with increased visibility and a high luminance contrast ahead, resulting in an increase of 20% participants taking that route at night, even though it lead in the wrong direction. At node B a combination of the existence of a focal area of attention with, again, a high luminance contrast ahead caused an increase of 36% in the selection of that route at night. Moreover, all subjects except one went in that direction at night only. The above described observations are summarized on Table 45 and Table 50.

The suggested importance of these factors on the behaviour of the participants will be closely analysed in the next pages.

The ability to detect and identify landmarks

Detecting a landmark, as any other object, requires it to be visible, that is, to have some sort of contrast against its background. Its identification is dependent on the recognition of its main characteristics, as for example its shape and eventually its context[189], which obviously cannot be achieved without the landmark being visible in the first place.

Thus, it was investigated if the landmarks at the nodes where the behaviour of the subjects was most divergent between the day and night-time interviews, were conspicuous and recognizable. For that purpose the luminance contrast of their visible surfaces against their immediate and wider background was evaluated. These values were estimated by using the previously described method of approximate field measurements using a digital camera[190]. The images used were collected from the node in question and a mask was applied to select the target of the luminance analysis. The immediate background of the object was considered to be an area closely surrounding the landmark[191] and the wider background the entire context of the object, limited by the size of the photograph that was captured by the camera. Additionally, it was also observed if the main features[192] of the landmark were fully visible. Finally, these assessments were compared with the remarks that the participants produced during the interviews, which are fully described in the chapters on the results of the walking interviews in London and Lisbon.

[189] (Christophe & Winter, 2007)

[190] Described in the chapter Methodology and analysis.

[191] An area corresponding to twelve pixels counted from the edges of the target, in the *Excel* file generated by *ImageLum*, for all cases.

[192] The main features were obtained by either comparing the day-time with the night-time image of the object or obtained through the descriptions of the participants in the previous stages of the study.

Figure 74. The photograph used to analyse the luminance contrast for the façade of *Totta* Bank in Lisbon. From left to right: The landmark highlighted, the immediate context of the landmark and the wider context of the landmark.

Based on the descriptions of subjects during the interviews, certain landmarks were found important to provide orientation clues during the day. However, results suggest that their visibility was sometimes modified at night. There were at least eight situations in which the ability of detecting and identifying global landmarks changed at night. Half were observed in London and the other half in Lisbon. In London two of these consisted of an increase and the other two in a decrease in the capacity to discern a landmark. In Lisbon, all examined cases, except one, had a landmark which became inconspicuous at night.

City		London					Lisbon				Total
Nodes		A	B	C	D	E	A	B	C	D	
The ability to detect and identify landmarks	Increased	R1		-	-	R2	-	-	-	R2	3
	Reduced	-	-	-	R1 R2	-	R2	R2	-	R2	5

Table 39. The location and visibility of landmarks in London and Lisbon as seen from the selected nodes at night.

In London the distribution of subjects at the nodes seems to have been mainly affected by the visibility of landmarks at nodes *A R1*, *D R1,* and *E R2*. These correspond respectively to an increased saliency of the Covent Garden underground sign, to the river not having been detected from The Strand, and to the positive recognitions of the National Gallery. The inability to detect Nelson's column from The Strand (node *D R2*), may have also contributed for dissimilarities in route choice between day and night-time interviews, as some subjects were less able to anticipate the location of Trafalgar Square at night only.

Landmark Location: **London**	Underground sign *NA R1*	The National Gallery *NE R2*	Nelson's column *ND R2*	The river Thames *ND R1*
L contrast against immediate background	128/3.5 = 36.6	11.4/3=3.8	0.3/0	0/0
L contrast against wider background	128/4.57 = 28	11.4/5.9 = 1.9	-	-
L contrast effect[193]	High drama	Just noticeable	Not noticeable	Not noticeable
Visibility of the main features	Yes	Yes	-	-
Percentage of subjects taking the route at night	20%	40%	83%	17%
Variation night v/s day	+20%	+40%	+58%	-33%

Table 40. The luminance contrast of the landmarks against the background and visibility of its main features in London.

The luminance contrast of the underground sign was very high against both its immediate and wider background, which made it conspicuous, even if set against a complex background[194]. The effect of the luminance contrast of the National Gallery was estimated as *Just noticeable*, according to the classification by (Institution of Lighting Engineers, 1995). However, this element was mentioned by almost all participants who stood at the node, and additionally, those who followed its direction, justified the decision with the detection of the National Gallery as a landmark. On the other hand its main features[195] were well recognizable, such as the columns and the dome.

As it can be observed in the images below, Nelson's column was not noticeable with a luminance contrast against its immediate background close to null.

[193] According to the classification in ILE 2005

[194] The research by (Davoudian, 2011) suggests that the visual saliency of a target is reduced when the density of the background light pattern is increased.

[195] The results of the photographic interviews showed that the National Gallery was 100% recognized in both its day and night-time version. The features which were more often mentioned as the main clues for its recognition were the stairs, the columns, and the dome.

Figure 75. From left to right: The underground sign, the National Gallery and Nelson's column, captured respectively from nodes A, E and D. Note that Nelson's column is barely visible at the top right end of the picture.

As it can be observed on Table 40, the distribution of subjects at the nodes seems to have been mainly affected by the visibility of landmarks at nodes *A R1*, and *E R2*, but not as much at node *D R2*. However, the lack of visibility of Nelson's column did not affect as much the behaviour of the subjects who stood at node *D* as the lack of visibility of the river did, which seems to have diverted people from *R1* towards *R2*. Additionally, *R2* may have appeared brighter ahead than the alternative routes (with a higher luminance contrast between the area ahead against its background), as it will be discussed ahead. The fact that Nelson's column was unnoticed would impact the selection of path further ahead, at node *E*, perhaps such or more than the increased visibility of The National Gallery. The explanation is that it was an essential marker of the location of Trafalgar Square for those approaching it from The Strand.

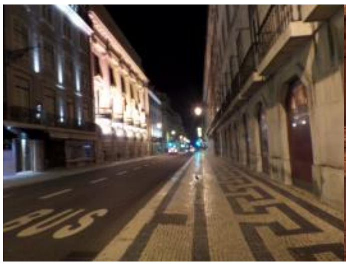
In Lisbon, the main landmarks that might have influenced wayfinding were located at nodes *A R2*, *B R2* and *D R2.* These correspond respectively to the river Tagus, *São Carlos* Theatre and the façade of bank *Totta e Açores*. The first two landmarks were inconspicuous at night, with ratios close to null and the façade of the bank had such a high luminance contrast it became an area of focal attention.

Landmark	Bank Totta façade	The river Tagus	The river Tagus	S. Carlos Theatre
Location: **Lisbon**	*Node D R2*	*Node D R2*	*Node A R2*	*Node B R2*
L contrast against immediate background	104/6.8=15.3	0	0	1.6/3.5=0.5
L contrast against wider background	104/4.6=22.6	-	-	1.6/11.4=0.1
Contrast effect[196]	(above) High drama	Not noticeable	Not noticeable	Not noticeable
Visibility of the main features	Yes	-	-	-
Percentage of subjects taking the route at night	88%	88%	0%	13%
Variation night v/s day	+55%	+55%	-20%	-29%

Table 41. The luminance contrast of the landmarks against the background and visibility of its main features in Lisbon.

As it can be observed in Table 41, above, the average luminance contrast of the façade of bank *Totta* against its immediate and wider background is very high. The fact that a major landmark, the river, was not detectable, did not seem to make a difference for the attraction towards that street. The other examined landmarks had an inexistent or close to null luminance contrast, as it was the case of the river and S. Carlos Theatre, coinciding with a decrease in the number of people travelling through those routes at night (see Figure 76).

[196] *Ibid.*



Node *D R2*

Node *A R2*

Node *B R2*

The river from Node A R2

The corner of S. Carlos Theatre from node *B R2*

Figure 76. The visibility of the river (top left and middle) and Totta Bank (top left) and of S. Carlos Theatre (top right) from different nodes in Lisbon at night.

<u>Existence of an area of focal attention</u>

The existence of random areas of high luminance contrast, or the increased saliency of minor landmarks, hardly recognized under daylight, appear to have caused an effect on the movement of subjects. Generally, it was observed that a greater number of participants followed in their direction at night, comparing with the day-time results. There were a total of four places in which large areas of high luminance contrast may have attracted the movement of people, three in London and the other one in Lisbon.

In London, these occurred at nodes *B R2* and *C R1* and *R2*. In Lisbon, there was only one focal point of attention detected at node *C R2*. This was the façade of bank *Totta e Açores*.

City		**London**					**Lisbon**				**Total**
Nodes		A	B	C	D	E	A	B	C	D	
Existence of an area of high luminance contrast	On landmarks	-	-	-	-	-	-	-	-	R2	1
	On other objects	-	R2	R1 R2	-	-	-	-	-	-	5

Table 42. The location of areas of high luminance contrast in London and Lisbon as seen from the selected nodes.

In London, at night, all participants except one turned towards route 2 at Node *B*, even though in the day-time the subjects had distributed almost evenly between the two routes (see Table 35). Even though there could have been other reasons for the disparity in behaviours, such as a coinciding different strategy from the day-time participants, there was also an area of high luminance contrast which could have acted as an attraction. This was the area of a restaurant with an average luminance as high as 59 cd/m^2, set against a background with an average luminance of 2.3 cd/m^2.

From node C there was one visible area of high luminance contrast at each route. These were located at random areas of the façades of the buildings at the street, and are designated in Table 43 as the façades of buildings 1 and 2. During the day all subjects followed route 1, but at night the participants distributed almost evenly through the two possible routes, which presented similar lighting conditions.

Focal point	Restaurant area	The façades of buildings 1	The façades of buildings 2
Location: **London**	*Node B R2*	*Node C R1*	*Node C R2*
L contrast against immediate background	59/6.3=9.4	12/0.49=24	8.1/1.7=4.8
L contrast against wider background	59/2.3=25.7	12/1.2 = 10	8.1/0.6=13.5
L contrast effect[197]	(above) High drama	High drama	(above) High drama
Percentage of subjects taking the route at night	90%	60%	40%
Variation night v/s day	+36%	-40%	+40%

Table 43. The location and values of areas of high luminance contrast in London.

Node B route 2 Node C route 1 Node C route 2

Figure 77. The areas of high luminance contrast in London.

In Lisbon, although three different facades were tested for possibly acting as focal areas of attention, only the previously described façade of bank *Totta* seems to have acted as such. The other two facades that were surveyed were not mentioned by any of the participants and its luminance contrast did not seem to be sufficient to make them attract the attention or the movement of the subjects.

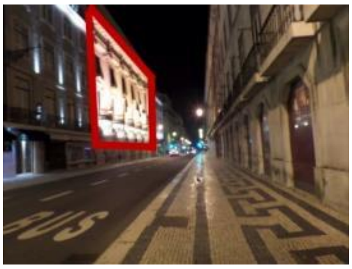
197 According to the classification in ILE 2005

Focal point	The façade of building 1	The façade of building 2	Bank *Totta* façade
Location: **Lisbon**	*Node C R1*	*Node C R2*	*Node D R1*
L contrast against immediate background	-	-	104/6.8=15.3
L contrast against wider background	58/12.5=4.6	56/14=4	104/4.6=22.6
L contrast effect[198]	Just noticeable to low drama	Just noticeable to low drama	High drama
Percentage of subjects taking the route at night	31%	69%	88%
Variation night v/s day	+6%	-6%	+55%

Table 44. The location and values of the areas analysed for potential high luminance contrast in Lisbon.

Node C route 1

Node C route 2



Node D route 2

Figure 78. The regions analysed as potential areas of high luminance contrast in Lisbon.

[198] According to the classification in ILE 2005

<u>The perception of brightness ahead</u>

The possible influence of the perception of brightness ahead was noticed in both cities. In London a number of subjects declared that they were attracted by the brightness ahead associating it with the existence of a main road which could aid way finding. In Lisbon, a total of five subjects declared that they were avoiding streets that appeared dark ahead for safety concerns during the task. This last observation also happened in London, although less frequently, where only one subject declared favouring one route over others because they looked too dark.

In fact, in London there seems to have existed almost no cases of streets which looked darker ahead, with the exception of those coming out of *node D*. However, this intersection is located at The Strand, a road which has such high levels of light[199], that by contrast, probably, all areas ahead would look darker. Yet, most followed the path which looked less dark ahead. In Lisbon, there were two intersections (nodes A and B) where there was an evident contrast between the appearances of brightness ahead at the available routes. Although it is not possible to isolate one single reason to justify the behaviour of the subjects, they seem to have avoided those routes that looked darker ahead, in a percentage of 100 % subjects at node A and 87% subjects at node B. Of these, respectively 20% and 31% justified their choice based on safety concerns.

As the analysis of data progressed, the issue of the perceived brightness ahead seemed to gain importance, particularly in Lisbon. Thus, it was hypothesized that the perception of the average luminance of the area at the end of a route against the average luminance of its context, could have had an effect on the behaviour of the subjects. Specifically, it could either have attracted or repelled the participants from taking a route. To test this hypothesis, the ratio between the average L of the visible end of a route and the average L of its context was calculated, for each route coming out of the previously selected nodes in both cities. These were then compared with the results for the number of subjects who selected those routes at night. The method to calculate the ratio consisted of using a photograph of the route, taken from the

[199] Measured average horizontal illuminance near the node of around 30 lux and average luminance of the images, as captured from the intersection, estimated at around 13 cd/m^2.

intersection, and calculating the average luminance of the selected areas through the previously described method of approximate field measurements using a digital camera[200].

The area that could have been perceived by subjects as the end of the street was isolated by roughly selecting the furthest area of the image using linear perspective. Distant landmarks were fully included, when existent, but transient features, such as vehicles were ignored. As it can be observed in the images below, at node *D R3*, the objects on the foreground were subtracted from the area considered as the back of the street. The sky was also partly eliminated, but the church Saint Mary le Strand and the surrounding vegetation, although almost invisible, were included in the selection as landmarks.

Figure 79. On the left the original image, in the middle linear perspective over the image. On the right the selection of the area of the street ahead. Note that this image was capture with high exposure time.

Figure 80. Detail of the selection of the area at the end of the street for *NDR3.* On the left the detail of the original image, in the middle the selection area, on the right the final selection after cropping the foreground objects and including relevant landmarks.

At all examined cases, except one, there was an increase, at night, in the number of subjects following a route at night, when it exhibited the higher luminance ratio between the area at the end of the street and its context, in relation to the other

[200] Described in the chapter Methodology and analysis

options. This suggests that there is a relation between the perception of the amount of light ahead and route selection. In both London and Lisbon, there seems to have existed a preference for the path that presented a higher ratio of luminance ahead against its context.

London

			Ratio			Results		
			L_{av} ahead (cd/m^2)/ L_{av} context (cd/m^2)			Nº. subjects	%	Variation night vs. day
Node	A	R1	8/4.5	=	1.8	3/15	20	+20%
		R2	96.3/7.3	=	13.2	2/15	13	+6%
		R3	24.9/18.1	=	1.4	0/15	0	-7%
		R4	48.9/3.3	=	14.8	10/15	67	-10%
	B	R1	30.7/14.2	=	2,2	1/10	10	-36%
		R2	56.3/9.5	=	**5.9**	**9/10**	**90**	**+36%**
	C	R1	29.8/2.8	=	10.6	3/5	60	-40%
		R2	19.3/1.2	=	**16.1**	2/5	40	**+40%**
	D	R1	4/11	=	0,4	1/6	17	-33%
		R2	10.5/15.6	=	**0.7**	**5/6**	**83**	**+58%**
		R3	1.4/9.5	=	0.1	0/6	0	-25%
	E	R1	19.9/21.3	=	0.9	3/5	60	-40%
		R2	11.4/6	=	**1.9**	2/5	40	**+40%**

Lisbon

			Ratio			Results		
			L_{av} ahead (cd/m^2)/ L_{av} context (cd/m^2)			Nº. subjects	%	Variation night vs. day
Node	A	R1	27.3 /4.2	=	**6.5**	**15/15**	**100**	**+20%**
		R2	2.2/3.3	=	0.7	0/15	0	-20%
	B	R1	13.2/11.3	=	**1,2**	**13/15**	**87**	**+29%**
		R2	5.5/11.3	=	0,5	2/15	13	-29%
	C	R1	58/12.5	=	4.6	4/13	31	+6%
		R2	22.9/15	=	1.5	9/13	69	-6%
	D	R1	76.5/30	=	2.6	1/8	12	-55%
		R2	50.9/11.1	=	4.6	**7/8**	**88**	**+55%**

Table 45. Analysis of selected nodes in London and Lisbon on luminance ratios and route choice. The ratio between the average luminance of the area at the end of a route and its context, and the differences in the selections by participants at night. The results which seem to have a relation with the average luminance ratios are highlighted.

However, this relation was not always confirmed by the few subjects who spontaneously[201] made an appraisal of the appearance of spatial brightness ahead, as described on Table 46. In Lisbon a total of five subjects (three at *Node A R2* and two at *Node B R2*) perceived a street that, could be classified as neutral[202] as dark ahead. However, the contrary was observed in London (at *Node D R2*), where a ratio that would be classified as neutral was perceived as being bright by one subject. These small samples seem to indicate that the subjective perception of brighter or darker routes ahead seem to be better related to the comparison between the lighting conditions on the other available choices of travel, than by the ratios established by literature.

			London				Lisbon		
		The perception of brightness ahead		L_{av} contrast of area ahead against its context		The perception of brightness ahead		L_{av} contrast of area ahead against its context	
Node		Bright	Dark	Criteria	Ratio	Bright	Dark	Critera	Ratio
A	R1	-	-	Neutral	1.8	-	-	Above	6.5
	R2	-	-	Above	13.2	-	3	Neutral	0.7
	R3	-	-	Neutral	1.4				
	R4	-	-	Above	14.8				
B	R1	1	-	Neutral	2.2	-	-	Neutral	1.2
	R2	-	-	Above	5.9	-	2	Neutral	0.5
C	R1	1		Above	10.6	-	-	Above	4.6
	R2			Above	16.1	-	-	Neutral	1.5
D	R1	-	1	Neutral	0.4	-	-	Neutral	2.6
	R2	1	-	Neutral	0.7	-	-	Above	4.6
	R3	-	1	Below	0.1				
E	R1			Neutral	0.9				
	R2			Neutral	1.9				

Table 46. The comparison of the perception of the amount of light ahead by some participants and the estimated ratio from the measurements in the field.

However, there were also two cases in which the comparison between available routes did not match the subjective appreciation of the few participants who

[201] The participants were not asked to describe the appearance of the route ahead, or the quantity of light. All remarks related to the appearance of brightness ahead were spontaneous.

[202] According to the previously described effects of luminance contrast by (Institution of Lighting Engineers, 1995)

mentioned their thoughts on this particular matter. This was, in fact, observed in two cases, remarked by only two different subjects, in London at *NB R1* and *NC R1*. There routes which were slightly darker ahead than the alternative, were perceived as brighter, contrary to what it would be expected. This may be meaningless, given the insignificant number of subjects who made such an appraisal. However, it could also result of different sensations of lightness, related to the luminance of the immediate surroundings of the area under evaluation.

Thus, to evaluate if the luminance of the immediate background could be affecting the perception of brightness ahead, the ratio between the area at the end of a street against its immediate context[203] was also estimated additionally to the ratio against the wider context. By adding this information it becomes clearer why, in London at node B, the area ahead at route 1 could have looked brighter than at route 2. The luminance ratio of the immediate context of the area of interest at R1 is around 6:1 (31:5 cd/m^2), whereas at R2 the same ratio is around 0.8:1 (56/70 cd/m^2).

At Node C, this evaluation does not clarify why the one subject found *R1* to be brighter ahead than the alternative, since the area ahead on *R2* presents a higher luminance ratio for both the evaluation of the luminance contrast against the wider and the immediate context (see Table 47).

[203] The area corresponding to the immediate context was calculated as twelve pixels (or *Excel* cells) surrounding the target.

London

Node			Ratio: L_{av} ahead (cd/m²)/ L_{av} context (cd/m²)			L_{av} ahead/ immediate background (cd/m²)			Results: Variation night vs. day
	A	R1	8/4.5	=	1.8	8/2.8	=	2.8	+20%
		R2	96.3/7.3	=	13.2	96.3/17.6	=	5.4	+6%
		R3	24.9/18.1	=	1.4	24.9/12.5	=	2	-7%
		R4	48.9/3.3	=	14.8	48.9/16.7	=	2.9	-10%
	B	R1	30.7/14.2	=	2,2	30.7/5	=	6.1	-36%
		R2	**56.3/9.5**	**=**	**5.9**	**56.3/69.7**	=	**0.8**	**+36%**
	C	R1	29.8/2.8	=	10,6	29.8/10	=	3	-40%
		R2	**19.3/1.2**	**=**	**16.1**	**19.3/4.3**	**=**	**4.5**	**+40%**
	D	R1	4/11	=	0,4	4/15.7	=	0.25	-33%
		R2	10.5/15.6	=	0.7	10.5/8	=	1.3	**+58%**
		R3	1.4/9.5	=	0.1	1.4/45	=	0.03	-25%
	E	R1	19.9/21.3	=	0.9	19.9/13	=	1.5	-40%
		R2	11.4/6	=	**1.9**	11.4/5.4	=	2.1	**+40%**

Lisbon

Node			Ratio: L_{av} ahead (cd/m²)/ L_{av} context (cd/m²)			L_{av} ahead/ immediate background (cd/m²)			Results: Variation night vs. day
	A	R1	27.3 /4.2	=	6.5	27.3/7	=	3.9	**+20%**
		R2	2.2/3.3	=	0.7	2.2/5	=	0.4	-20%
	B	R1	13.2/11.3	=	1,2	13.2/13	=	1	**+29%**
		R2	5.5/11.3	=	0,5	5.5/8	=	0.7	-29%
	C	R1	58/12.5	=	4.6	58/17	=	3.4	+6%
		R2	22.9/15	=	1.5	22.9/19	=	1.2	**-6%**
	D	R1	76.5/30	=	2.6	76.5/44.8	=	1.7	-55%
		R2	50.9/11.1	=	4.6	50.9/11.6	=	4.4	**+55%**

Table 47. The ratios of luminance contrast for the luminance at the end of a route against is wider and immediate context in London and in Lisbon.

The evaluation of the subjective appraisal of brightness ahead could probably only have been accomplished by asking the participants to specifically report which path looked darker or brighter ahead and whether that sensation was influencing their selection. Given that subjects were only asked to broadly describe their choice of route without any specific questions on the influence of lighting, only a few participants referred directly to this aspect. Thus, it can only be speculated that the perception of brightness ahead may have an effect on the movement of people, based on the correlation between the field measurements and the variation in the movement of people between the day and the night-time.

The adaptation state of the observer

The classification of the effect of the contrast ratios, based on the CIBSE guidelines, allowed the detection of a probable relation between the behaviour of the subjects and certain lighting conditions. However, it was found to be over simplistic for such complex scenes, as it does not account for eventual subjective appreciations of lightness, depending on the luminance and number of the objects surrounding the target (Purves & Lotto, 2003), as well as the perception of the contrast of its boundaries. It also did not consider that the subjective knowledge of the observer and that the adaptation of their visual system also can influence perception (Boyce, 2014). This problem was particularly apparent on the analysis of the probable effect of the L_{av} ratios on the perception of brightness ahead, as subjects seem to be more influenced by the comparison of the ratios on the alternative routes than by the effect of the ratio in one route alone.

To have a more complete evaluation of the scenes, the adaptation state of the observers was also examined. A possible evaluation of the adaptation state of the visual system on a complex scene when the eye has many fixation points could be the average luminance of the whole scene[204]. The analysis of the Vertical illuminance at the approximate height of the observer, should also contribute to having an idea of the state of adaptation, even though the two measurements cannot be directly compared.

Two different cameras were used to photograph London and in Lisbon, but the images were calibrated using the luminance measurements made by the same luminance meter. However, the resulting images had slightly different dimensions. Thus, it is unclear if a reliable comparison can be made for the average luminance of the scenes photographed in London and in Lisbon (the average of the values of L_{av} is slightly higher in Lisbon with 12.4 cd/m^2 against 10.2 cd/m^2 in London).

[204] (Boyce, 2014) p.60

The examination of the illuminance values, measured with the same equipment, in both cities, placed at the constant height[205] of the eye of the observer, is probably more reliable. The results suggest that in Lisbon there was on average a higher quantity of light at the intersections than in London. The average vertical illuminance was measured at around 13 lux in London and 32.5 lux in Lisbon.

London

			The adaptation state of the observer		Results		
			L_{av} (cd/m²)	E_v (lux)	N. participants	%	Variation night vs. day
Node	A	R1	4.6	7	3/15	20	+20%
		R2	11.4	15	2/15	13	+6%
		R3	18.2	15	0/15	0	-7%
		R4	4.8	6.5	10/15	67	-10%
	B	R1	14.5	4	1/10	10	-36%
		R2	11.4	4.5	**9/10**	**90**	**+36%**
	C	R1	3.6	1.7	3/5	60	-40%
		R2	1.6	1	2/5	40	**+40%**
	D	R1	10.4	17	1/6	17	-33%
		R2	15.5	19	**5/6**	**83**	**+58%**
		R3	11.5	21.4	0/6	0	-25%
	E	R1	18.5	28	3/5	60	-40%
		R2	6.6	28	2/5	40	**+40%**

Lisbon

			The adaptation state of the observer		Results		
			L_{av} (cd/m²)	E_v (lux)	N. participants	%	Variation night vs. day
Node	A	R1	5.5	13	**15/15**	**100**	**+20%**
		R2	3.3	27.4	0/15	0	-20%
	B	R1	11.4	28	**13/15**	**87**	**+29%**
		R2	11.5	27.5	2/15	13	-29%
	C	R1	13	48	4/13	31	+6%
		R2	15	51	**9/13**	**69**	**-6%**
	D	R1	28.2	43	1/8	12	-55%
		R2	11	20.5	**7/8**	**88**	**+55%**

Table 48. The adaptation state of the observer. Measurements for the average luminance of the scenes and the vertical illuminance at the height of an observer.

[205] At 1.60 metres

The eventual higher amount of light to which the observers in in Lisbon were adapted to, could have, generally, made them appreciate the spaces ahead as darker, than the observers in London, when looking at scenes lit with the same amount of light.

All observations seem to have been made under photopic vision (above 3 or 5 cd/m^2)[206], meaning that the environments should have been observed with fine resolution of detail and with good colour resolution (depending on the colour rendering index of the light sources, which were generally lower in Lisbon, with HPS lighting, than in London).

[206] (The Society of Light and Lighting, 2009) explains the functioning of the photopic vision for adaptation luminances above 3 cd/m^2, and (Boyce, 2014) when higher than 5 cd/m^2.

<u>The horizontal illuminance</u>

The horizontal illuminance was measured at each route, three metres from each intersection. The measurements were taken from three spots: at each side of the street and in its middle, around twenty centimetres above the ground. This information did not seem to add much to the previous discussion.

London

			Horizontal Illuminance measurements (lux)			Results		
			Side 1	Middle	Side 2	Nº. subjects	%	Variation night vs. day
Node	A	R1	5	3	180	3/15	20	+20%
		R2	5.3	7.7	26	2/15	13	+6%
		R3	8.4	22	190	0/15	0	-7%
		R4	10	9.4	11	10/15	67	-10%
	B	R1	67	3	117	1/10	10	-36%
		R2	1.5	2.1	3	9/10	90	+36%
	C	R1	24	3	1.4	3/5	60	-40%
		R2	1	2	3.2	2/5	40	+40%
	D	R1	30	29	30	1/6	17	-33%
		R2	31	14	13	5/6	83	+58%
		R3	76	16	20.7	0/6	0	-25%
	E	R1	16.5	18.5	22.5	3/5	60	-40%
		R2	16.5	n.a.	6.2	2/5	40	+40%

Lisbon

			Horizontal Illuminance measurements (lux)			Results		
			Side 1	Middle	Side 2	Nº. subjects	%	Variation night vs. day
Node	A	R1	25	25.3	19.8	15/15	100	+20%
		R2	11	17	27	0/15	0	-20%
	B	R1	24	22	15	13/15	87	+29%
		R2	17	21	16	2/15	13	-29%
	C	R1	36	60	37	4/13	31	+6%
		R2	47	21	21	9/13	69	-6%
	D	R1	91.5	12	43.3	1/8	12	-55%
		R2	14.3	20	11	7/8	88	+55%

Table 49. The illuminance measurements taken in the different routes of Lisbon and of London.

On hindsight, after finding that the perception of brightness ahead could have influenced the movement of the subjects, it was found that it would have been useful to have taken additional measurements further ahead at each street in order to appreciate if horizontal illuminance was higher or lower ahead. This would have allowed to better evaluate if there was relation between the quantity of light in a given street and the movement of the subjects. The measurements were not accomplished at a later stage because years after the completion of the interviews, the lighting conditions might not have been the same as those originally observed by the subjects. On the other hand, the luminance measurements seemed more adequate to better appreciate the perception of the lit environment.

It is however possible to understand that in London, from Node C, in route 1, the horizontal illuminance was probably higher ahead than on the alternative route. Route 1 leads to The Strand, which had some of the higher horizontal illuminance values of the area (see horizontal illuminance measurements for *NDR2* and *NDR3* on Table 49). However, this does not seem to have had a great effect on results, and actually there was a slight decrease in the number of participants heading towards The Strand from Node C, at night.

A comparison on the average horizontal illuminance measurements in London and Lisbon shows similar values at both cities. However, when ignoring the measurements captured on the side of the streets, and comparing the average amount of light measured in the middle of the streets, it was found that on average Lisbon has more than double the amount of lighting arriving at the pavement level than London. The average horizontal illuminance measured in the middle of the streets of Lisbon was around 25 lux, against 11 lux in London.

Conclusions

The level of knowledge of the participants in Lisbon and London was different. Although a greater homogeneity of samples would probably allowed for stronger results, it can be argued that this difference provided clues that would have been missed otherwise. Mainly, the strategies employed at night by the participants of Lisbon, who had a good level of knowledge of the area, and the participants in London, who had a lower average knowledge of the area where the task took place, produced different types of results.

In Lisbon the participants were able to anticipate the environmental conditions and adjust their navigation plan as to avoid potentially unpleasant situations ahead. The decisions seem to have been subjected to confirmation, in the field, through the appraisal of the appearance of brightness ahead at intersections. In London, by contrast, most subjects were unable to anticipate the environment ahead. Thus, the decisions were not connected as tightly to a plan, and seem to have actually been made mostly in the field. Often, the participants wandered through the streets, attracted by the brightest path, hoping it would contain clues to complete the task in hand.

These aspects were later confirmed by the examination of the ratios of average luminance between the end of a street and its context. These suggest that there is a strong relation between the perception of spatial brightness ahead and the selection of a route during a wayfinding task. Additionally, the increased conspicuity of landmarks and the existence of high luminance contrast areas, or focal points, also seem to attract attention and the movement of people. Undetected landmarks, particularly distant landmarks, may also trigger the opposite behaviour, as people may become less able to evaluate distances and directions[207]. This could eventually deviate them from taking the most efficient route towards the destination or hamper wayfinding.

[207] Considering the results and that according to several authors, as for example: (Golledge, 1999), (Lynch, 1960) (Sadeghian & Kantardzic 2008), visual references and landmarks in particular are important for efficient navigation, to organize large scale spaces, and to provide references with which to calibrate distances and directions

Overall the results suggest that the different combinations of these factors allied to the feeling of safety could be key to influencing the process of wayfinding in an urban environment at night. Moreover, that the daytime pedestrian movement patterns in a city can be modified at night and as it can be observed in the next table, that people may be driven to take the less direct or even the wrong direction, at night, when certain lighting conditions occur (see the results in London on Table 50, for example in Node A, R1 and R2).

			Adaptation (cd/ m^2)	Perception of brightness ahead (L_{av} ahead / L_{av} wider context)	Focal area (L_{av} focal point /L_{av} wider context)	Visibility of Landmarks (L_{av} landmark/L_{av} immediate background)	Route direction: Most direct	Route direction: Wrong direction	Variation night vs. day
Node	A	R1	4,6	1,8	-	36,6			**+20%**
		R2	11,4	13,2	-	-			**+6%**
		R3	18,2	1,4	-	-			-7%
		R4	4,8	14,8	-	-			-10%
	B	R1	14,5	2,2	-	-			-36%
		R2	11,4	5,9	25,7	-			+36%
	C	R1	3,6	10,6	10	-			-40%
		R2	1,6	16,1	13,5	-			+40%
	D	R1	10,4	0,4	-	0			-33%
		R2	15,5	0,7	-	0			+58%
		R3	11,5	0,1	-	-			-25%
	E	R1	18,5	0,9	-	-			-40%
		R2	6,6	1,9	-	3,8			**+40%**

Table 50. Summary table for London.

			Adaptation	**Perception of brightness ahead**	**Focal area**	**Visibility of Landmarks**	**Route direction**		**Variation night vs. day**
			(cd/ m²)	(L_{av} ahead / L_{av} wider context)	(L_{av} focal point /L_{av} wider context)	(L_{av} landmark/L_{av} immediate background)	Most direct	Wrong direction	
Node	A	R1	5.5	6.5	-	-			**+20%**
		R2	3.3	0.7	-	0			-20%
	B	R1	11.4	1.2	-	-			**+29%**
		R2	11.5	0.5	-	0.5			-29%
	C	R1	13	4.6	-	-			+6%
		R2	15	1.5	-				**-6%**
	D	R1	28.2	2.6	-	-			-55%
		R2	11	4.6	22.6	15.3 and 0			**+55%**

Table 51. Summary table for Lisbon

Chapter 5 CONCLUSIONS

CONCLUSIONS

Summary

This study set out to examine the effects of artificial lighting on urban legibility and wayfinding by adapting the classic method devised by Kevin Lynch in the “Image of the City” to the night-time dimension. Assuming that the appearance of an environment changes at night, it was hypothesized that the image of the most distinctive elements of a city could also be modified, resulting eventually in changes in their salience and functional role as a component of a cognitive map. Given that these elements usually act as orientation markers, it was presumed that human wayfinding behaviour and that particularly the selection of routes during a wayfinding task could differ under natural and artificial lighting.

The general literature review on this matter showed that most studies in the area of legibility and wayfinding behaviour do not seem to address the night-time dimension. Additionally, many cities in the world still treat exterior lighting as a mere functional means to provide safety and enable outdoor activities after dark and do not have a strategic instrument to plan and rule their night-time image. Even though it was found that other cities have developed and some even implemented urban lighting masterplans, they rarely follow common objectives, and many do not include any concerns related to improve or preserve urban legibility at night. From the rare examples that do include such objectives even fewer refer to the possibility of providing or maintaining the visibility of orientation cues at night. These aspects show the importance that this research may have for bridging a gap on the research on wayfinding, providing an extension to the classic work of Kevin Lynch and present references for the future development of urban lighting masterplans.

There were a number of specific research questions that this study sought to answer. First, it was important to find if the adaptation of the method of analysis devised by Kevin Lynch was suited for the purposes of the research. That is, if it worked when adapted for the comparison and analysis of the day and night-time image of cities, and specifically for those of London and Lisbon.

As previously described, the methodology of the present study was only partially based on the original method, in order to address different research questions, to simplify a complex and lengthy technique and to include the previously absent night-time dimension. On the other hand, it tried to bridge some gaps and strengthen some of its weaknesses, by, for example, having a more consistent and balanced sample. It comprised three main stages which were fully described in the chapters on methodology and analysis. The first stage, entitled as verbal interviews was fundamental to extract the essence of the image of the city from its inhabitants, and particularly its most distinctive urban elements. The information distilled from these first sets of interviews were the basis for the following stages of the method: the photographic and walking interviews. The results of these last stages showed that the method was successful in detecting differences between the day and the night-time in the perception of urban elements and in the wayfinding behaviour of the participants in both cities. More importantly, it enabled the identification, with consistency in both cities, of probable causes for the disparities between the day and night-time results, most of which were related to lighting. Thus, it can be argued that the method worked for the purposes of this study and thus, that it could eventually be replicated in the future, perhaps in other cities with different lighting and urban characteristics.

Secondly, this research investigated if the perception of the most distinct urban elements of a city are modified at night and if the wayfinding behaviour of its inhabitants changes between the day and night-time. This inquire could be unfolded in four main questions:

1. Could the way by which a landmark is lit at night modify how accurately it could be identified?

2. Presuming that lighting affects the identifiability of landmarks by night, what is the effect on the ability of people to find their way to a specified destination?

3. Do people use the same routes when finding their way to a specified destination by day and by night?

4. Are there other factors influencing wayfinding, or route choice decisions at night which are mainly related to lighting?

Regarding the first question the results suggest that lighting can influence both the detection and the accurate identification of a landmark in a positive or a negative way. That is, they imply that lighting can either improve or reduce the recognisability of a landmark. This question was mainly addressed in the photographic interviews, where it was concluded that many of the urban objects that compose the image of London and Lisbon became either undetected, unrecognizable or were prone to be misidentified with other elements at night.

The main factors that were found to influence the detection and recognition of landmarks at night were, generally, luminance contrast, colour contrast and the expectations of the subjects regarding the element.

Regarding **luminance contrast** certain elements were found to become undetected or less identifiable at night, either due to the lack of perception of its shape, of its most important features or due to a modification in the saliency of the object, or in a change in the visual hierarchies of a set of landmarks at night.

The lack of perception of boundaries, thus the shape of objects, reduced, for example, the night-time recognisability of the Gherkin, in London and *Amoreiras*, in Lisbon. Most of the pictures of landmarks which were only partly lit at night, elicited misidentifications or an overall worst recognisability than when these elements were depicted under daylighting. Thus the British Museum and the Natural History Museum were often confused with other landmarks due to being only partly lit, and The Tate Modern, was only recognized at night due to its proximity to another more recognizable landmark.

A change in the saliency of objects in the night scene due to some being lit with higher average luminance than others was also observed, making some landmarks secondary to others at night only. For example, in the night-time picture of The Millennium Bridge, this landmark lost its saliency to St. Pauls Cathedral, perceived as the primary object depicted due to its high luminance contrast against its surroundings. However, the change in hierarchies also made certain landmarks more recognizable at night than in the day. This was especially important for the identification of some parks in London such as Regent’s Park and St. James’s Park, and also in *Avenida da República* in Lisbon. The detection of brightly lit distant landmarks (respectively Centre Point, Victoria Memorial and *Atrium Saldanha*) allowed for positioning the location of these places.

The existence of **coloured lighting** also seems to have had, mostly a positive, effect on the identification of landmarks. This was particularly evident with the increase of the recognisability of Waterloo Bridge. This element was more than twice better recognized at night due to the bright colours of The National Theatre, next to it, whose picture was in turn also better recognized in its night-time version. Centre Point in London was also better recognized at night due to the blue colour that lines the top of the building.

A third factor that seems to have conditioned the recognition of objects were the **expectations** and familiarity of the subjects with the landmarks. This aspect seems to have influenced results in two different ways. In one case, the expectation of seeing a certain feature next to a known landmark lead some participants to erroneously pointing objects which were not in the picture, by for example identifying Big Ben next to The Natural History Museum after confusing it with The Houses of Parliament. In other cases, some images of urban elements were less recognisable when presented in an unexpected or unfamiliar way to the observer. Such was the case of Harrods, in London, which was better recognized at night, but only to those who were familiar with its particular appearance under artificial lighting. On the other hand, in both London and Lisbon, the images of districts which are mostly visited at night had a worst recognition rate when presented under daylight.

Thus, this could mean that according to the familiarity of the subjects with both the day and the night-time appearance of a city there could potentially co-exist two images of a city. One for the day and another for the night-time. In fact, what the results of the interviews suggested was that the participants who had a good knowledge of the city in question were often prone to be misguided by their expectations, which were usually related to the memory of the element at a specific time of the day. For example, Soho, in London was slightly better recognized at night, because subjects probably visited that part of the city more often then. The same was found with a similar district in Lisbon: *Bairro Alto*.

In summary the results of the photographic interviews suggests that the main orientation references in a city could be transformed at night. Some of the landmarks that could aid wayfinding in the day could be undetected, others unrecognizable, and that potential new landmarks can also emerge. At the same time it also implies that the natural hierarchies among elements can be modified. That is, some elements that are naturally more salient due to their size or shape, can lose their visibility at night if its shape or size is not perceptible, while other objects, which were less conspicuous in the day can become the most visible element in a night scene.

Thus, if the identifiability of landmarks is modified at night, what is the effect on the ability of people to find their way to a specified destination? And, do people chose the same route in the day and the night-time? Does lighting influence route choice in any other way?

These questions were explored in the walking interviews. Here a number of subjects were asked to walk from an origin to a destination point. Half of the subjects were required to take the task at night and the other half in the day. As before the interviews took place in London and in Lisbon. The comparison of the results revealed that the subjects that completed the task at night followed different routes than those who had travelled in the day. The analysis of the intersections where the behaviours had been observed to diverge the most were further examined regarding its lighting conditions. This analysis suggested that the ability to detect landmarks could be affecting the choices of routes, as it had been previously suspected. However, additionally the results also suggested that the existence of a random areas of high luminance attracted the attention and eventually the movement of people, and that the perception of brightness ahead also had an impact on route selection. This last observation seemed to be linked at times with the feeling of safety. These aspects were found to have an important impact on wayfinding, as they could have lead some subjects through the less effective routes, or even towards the wrong direction relative to the destination point.

Theoretical Implications

The results presented in this study lead to the belief that lighting has an important role in the legibility of a city and on wayfinding tasks. It supports the assumptions of the studies by (Yuktadatta, 2002), and (Winter, et al., 2004), which found that people tend to refer to different landmarks at night. However, this study adds evidence that certain aspects of lighting are the main cause of the divergence. It also suggests in agreement to (Kang, 2004) that lighting may affect the movement of people, according to the perception of the quantity of light ahead.

The results of this study also indicates that the main components of cognitive maps can be transformed at night, and thus that they could become less functional for wayfinding tasks at night. For example, important landmarks can become undetectable, main paths of travel may be unattractive due to the fear of crime, random objects in space may become focal points of attention, thus transformed into new landmarks at night only; and distant landmarks may emerge as new orientation markers.

These aspects may have important implications for research on human wayfinding, which has traditionally been focussed in a single temporal dimension (day-time). For example, it raises the question if people have two different images or cognitive maps of a city that are used according to the time of travel? Looking at the results of the present study, it may be speculated that, generally, the inhabitants of a city may have a primary mental day-time image, mixed with night-time images of certain places to which they travel to with some frequency at night. For some people the night-time memory of a place may be stronger than its day-time image and vice-versa. For example, the usual places of socialization after work were better recognized at night in both Lisbon and London[208]. A possible way of better evaluating the hypothesis of the co-existence of several temporal images of a city, would be to repeat the experiment with workers who take the night-shift. These are probably most usually

[208] *Bairro Alto,* in Lisbon and Soho in London, were better recognized when depicted at night, in the photographic interviews.

exposed to the night-time environment, and should have developed a predominantly night-time image of the city.

The results of the present study may also be of particular interest to the research on the field of automatic landmarks detection, for navigation assistance. These studies[209], are interested in extracting the main qualities of landmarks in order to enhance the quality of route directions produced by navigation services. However, they often ignore the specific qualities of landmarks at night, which may be very different from the day-time, as the present study suggests.

In the field of lighting it raises the question if the simple luminance ratios given by the CIBSE[210] are completely adequate for evaluating the effects of these ratios on wayfinding or navigation tasks in complex outdoor environments. Particularly at intersections where the visual system is confronted with a large range of different stimuli, and is constantly in search of a target to guide direction. In these cases it could eventually by argued that a landmark may still be more than “just noticeable” even if the luminance ratio of its façade against the background is below 3:1. This was found to be the case of The National Gallery, in London, whose facade had a luminance contrast against the background of 2:1 and yet it was still sufficiently salient to be detected and to have an effect on the movement of people.

It also may add a new layer of analysis for the studies concerning the feeling of safety by pedestrians. Most research in this area is focussed mainly on illuminance[211], light spectrum (Knight, 2010), light sources (Boyce & Bruno, 1999), uniformity, glare and facial recognition issues. This study raises the question whether the perception of the amount of light ahead, or if the relative luminance contrast ratio of the visible facades ahead can also play a role in this complex issue.

[209] For example (Sadeghian & Kantardzic, 2008)

[210] (Institution of Lighting Engineers, 1995)

[211] For example (Boyce & Rea, 1990) (Boyce, et al., 2000)

Practical implications

The main findings of this study suggest that a city may be perceived differently by its inhabitants at night, which has an effect on the way that they read the city, orientate and travel within it. These findings could have important implications for urban planning, and particularly for the development of urban lighting masterplans both in existing and new cities.

If a city, its elements and spatial qualities may be visually transformed at night, with potential consequences on human behaviour, then artificial lighting should be subjected to some sort of planning or control. Thus, the first practical implication that could be drawn from the conclusions of this research is that there is a need for a planning instrument of the night-time image of the cities. This instrument is usually described as a lighting masterplan, and there are already a number of such strategies implemented or drawn for many cities around the world. However, as has been previously discussed in the literature review, the scope, understanding and the ability to implement such plans is still very limited. Furthermore, many are sometimes developed with little or no concern regarding the impact of lighting on urbanism or wayfinding. Instead, there is a greater focus on aesthetics, culture, safety or economic issues. Thus, the second main practical implication of the findings of this research is that lighting masterplans should incorporate in its objectives a strategy related to orchestrating the perception of urban elements and the movement of people, in the sense of creating a "lighting urbanism".

Specifically, what the study shows is the possibility of analysing the night-time image of a city, and the potential to shape its legibility and eventually the wayfinding behaviour or pedestrian movement of its inhabitants. In this regard the method developed by Kevin Lynch seems to provide an interesting basis on how to analyse a city to be artificially lit. Particularly because it identifies, classifies and characterizes the role of the main urban elements which impact on the legibility and wayfinding in a day lit city. However, this does not mean that the day-time image of a city should be simply replicated at night. Instead, what the present study suggests is that artificial lighting can be used to reshape the image of a city at night. This may be of special interest for those parts of a city which may have a confusing layout or lack or defining characteristics.

The results of this study suggest some ways to influence and eventually improve the image of a city at night. The first conclusion, which can be distilled from the results of the photographic interviews, is that those urban elements which are regarded as essential for the recognisability of the city in the daytime should also be made visible at night when appropriate. This may include the five types of elements described by Lynch. They should be lit in a way that does not distort the main features which make them identifiable in order not to compromise their recognisability, thus their function as landmarks. These elements may also have an important role for travelling in the city, especially at decision points such as intersections, to confirm the route or as attraction elements towards which people may travel to. As verified in the walking interviews, their visibility and recognisability may modify the routes chosen by people at night and eventually contribute to a modification in the urban night-time movement patterns.

Additionally, the conclusions also indicate that new landmarks can be created by colour or luminance contrast at night. These can be useful in order to improve orientation in certain places where the task may be made difficult due to the lack of references. The creation or enhancement of distant landmarks may be of special importance to provide geographic orientation towards which one can travel to or way from and to better identify his own location. It may also be relevant to create or enhance landmarks at intersections, especially if the area is poor on reference points.

Another aspect that this research underlines is the importance for lighting masterplans to orchestrate hierarchies among the urban elements. As it was found, that certain landmarks can became secondary to others at night, other elements can be made invisible or new ones can be created, transforming the natural hierarchies that exist during the day. The lighting masterplans can provide indications to emphasize the natural hierarchies of the urban landscape or modify it in order to improve the legibility of an area, by for example creating an order of hierarchies among the same type of urban elements such as groups of landmarks, nodes or paths.

This study also points to ways through which to eventually modify the movement of people, by for example creating areas of focal attention or by regulating the luminance contrasts and the amount of light perceived at the end of each street from a given intersection.

The above description of possibilities for shaping the night-time image of a city implies that all types of lighting will be strictly regulated by the lighting masterplan. This may not always be feasible in practical terms due to the number of different entities that intervene in the public spaces. Nevertheless, the conclusions of the present research may be of interest for the development of lighting masterplans in new or existing cities, and integrated with the urban design plan for an increased legibility of the city at night.

Lastly, the suggestions of this study might also be of interest for those who are working on writing new lighting recommendations or guidelines for exterior lighting in the urban environment.

Limitations of the study

Characteristics of the sample

This study was performed with several small samples, in similarity to the work of Kevin Lynch[212]. It had a total of one hundred and eighty participants, divided in small groups in two different cities and distributed in different tasks. The size of the sample felt small, especially in the photographic and walking interviews, where the subjects were divided in groups of fifteen for the day and night-time tasks, making it difficult to find significant differences and arrive at decisive conclusions. However, because the method was being replicated at two different cities, at times the results in one place would confirm the findings of the other. Yet, especially in the walking tasks, where the participants distributed wide in space, it was sometimes hard to evaluate the significance of the responses when analysing an effect at a certain intersection where very few subjects had travelled through. Thus, the study would have gained in having had a greater number of participants.

Another limitation regarding the nature of the samples was the fact that, in the verbal interviews that took place in London, half of the participants worked or studied at University College London. This aspect surfaced in the account of distinctive elements of London. For example, The UCL campus, the UCL hospital, the Bloomsbury area, and Russel Square, were all elements that probably would not have

[212] (Lynch, 1960)

appeared if the sample of subjects had been different. However, these were mentioned in small numbers, such that it is believed not to have had an important influence on the results of that stage and not to have affected the remaining stages of the study. The number of times that they were mentioned or sketched was so slim that they were not included as elements of the photographic interviews. It is believed that the resulting visual image of the city would not vary much had these subjects been removed from the sample.

Another aspect regarding the participants of the study was that they were not tested for colour vision deficiency. There may have been some participants who were colour blind and that was not taken into account and may have influenced results to some extent, particularly in the photographic interviews. The participants were also not tested or inquired about visual acuity.

The methods of analysis

The main limitation of the analysis of the data was the fact that colour contrast was not objectively measured. The luminance mapping of the images did not comprise the analysis of colour, and the selected edge detector (Sobel) did not detect colour contrast. There were also some limitations found with the method for the analysis of luminance patterns which has been previously described in the chapter methodology and analysis.

Recommendations for future research

The investigation of the effects of artificial lighting on the perception of the city and on wayfinding and urban spatial occupation is still very rare. The findings described in the present study suggest that there is an important impact but further research is needed to consolidate knowledge in this field.

As previously described at times it was found that the sample used in this study was too small, and thus it would be worth having the different stages of the present study replicated with a larger sample, in order to test if the main findings would be the same.

It would also be useful to further investigate the role of lighting on wayfinding. Particularly it would be important to research the role of focal areas of attention and of the perception of brightness ahead in the movement of people. This could be achieved better in a controlled environment, and by testing different luminance ratios and its influence on the qualitative assessment of the participants and on the actual choices of paths.

Conclusion

This study demonstrated that artificial lighting has an important role in urban legibility and it may affect orientation and wayfinding tasks. It suggested that people may choose different landmarks as orientation markers at night and that they tend to follow different routes to arrive at the same destination according with the lighting conditions.

These findings may have important implications for future research in different areas, for urban planning policy and urban lighting design, and hopefully for improving the nightscapes of our cities.

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ANNEXES

The photographs presented to the participants of the photographic interviews

The analysis of the edges of the photographs

ANNEX 1: THE PHOTOGRAPHS PRESENTED TO THE PARTICIPANTS

ANNEX 1A: the day-time photographs presented to the participants in London[213]

1. The river

2. Oxford Street

3. Hyde Park

4. Saint Paul's Cathedral

5. The London Eye

6. Oxford Circus

[213] Note that the original photographs are larger and that they were presented in random order to the participants.

7.Big Ben

8. Trafalgar Square

9. Tower Bridge

10. The Houses of Parliament

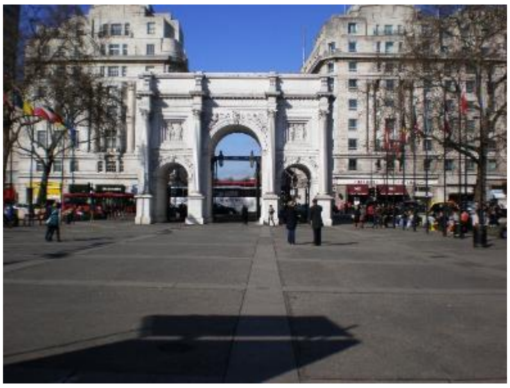
11. Buckingham Palace

12. The Tate Modern

13.The Gherkin

14. Covent Garden

15. Regent Street



16. Marble Arch

17. Regent's Park

18. Leicester Square

19. Piccadilly Circus

20. Soho

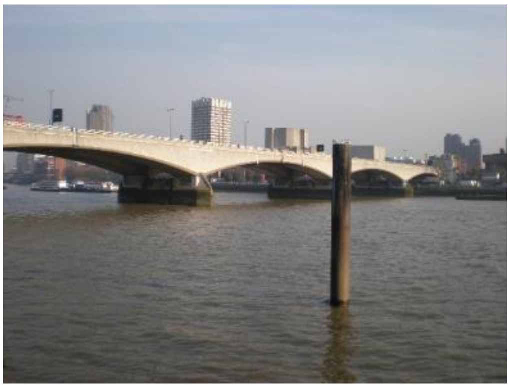
21. The City

22. The Millennium Bridge

23. Kensington

24. The Southbank

25.The Westminster Bridge



26. Waterloo Bridge

27. Kings Cross/ Saint Pancras Station

28. The British Museum

29. Saint James's Park

30. Harrods

31. Centre Point

32. The Natural history Museum

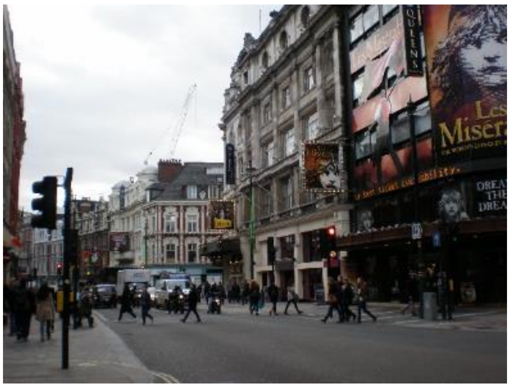
33. Green Park

34. The Strand

35. Piccadilly

36. Tower of London

37. Euston Station

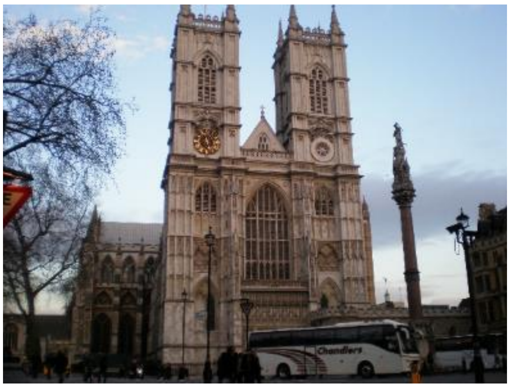


38. The West End

39. Tottenham Court Road

40. The Mall

41. The Globe Theatre



42. The Westminster Abbey

43. The National Theatre

44. Madame Tussauds

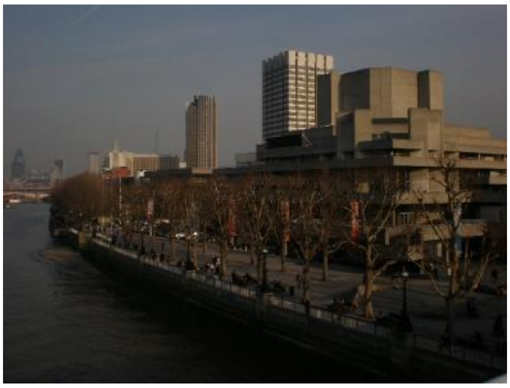
45. Victoria Station

46. Bond Street underground Station

47. China Town

48. Notting Hill

49. Westminster



50. The National Theatre

ANNEX 1B: The night-time photographs presented to the participants in London

1. The river

2. Oxford Street

3. Hyde Park

4. Saint Paul's Cathedral

5. London Eye

6. Oxford Circus

7.Big Ben

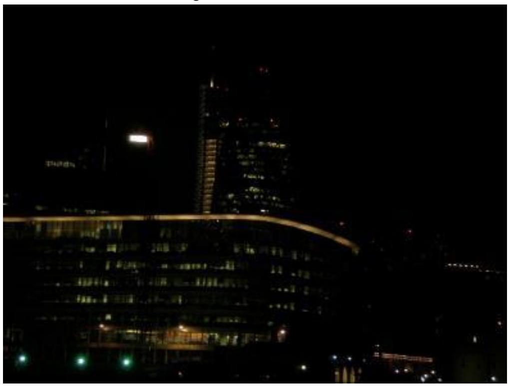
8. Trafalgar Square

9. Tower Bridge

10. The Houses of Parliament

11. Buckingham Palace

12. The Tate Modern

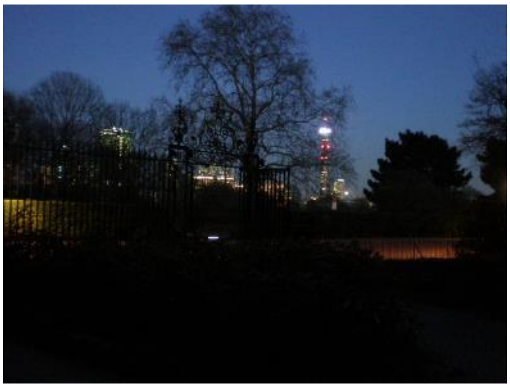


13.The Gherkin

14. Covent Garden

15. Regent Street

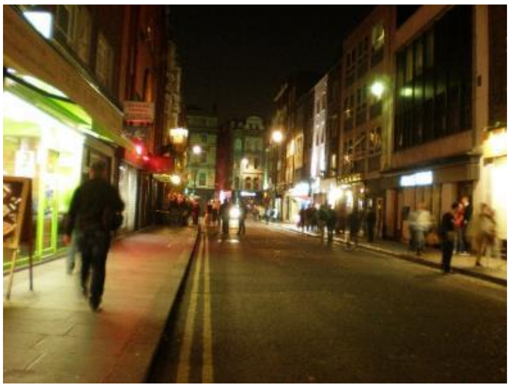
16. Marble Arch



17. Regent's Park

18. Leicester Square

19. Piccadilly Circus



20. Soho

21. The City

22. The Millennium Bridge

23. Kensington

24. The Southbank

25.The Westminster Bridge

26. Waterloo Bridge

27. Kings Cross/ Saint Pancras Station

28. The British Museum

29. Saint James's Park

30. Harrods

31. Centre Point

32. The Natural history Museum

33. Green Park

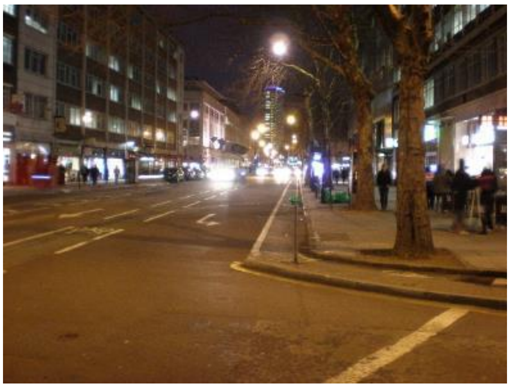
34. The Strand

35. Piccadilly

36. Tower of London

37. Euston Station

38. The West End



39. Tottenham Court Road

40. The Mall

41. The Globe Theatre

42. The Westminster Abbey

43. The National Theatre

44. Madame Tussauds

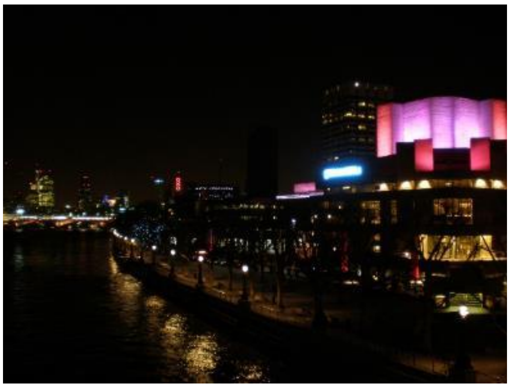
45. Victoria Station

46. Bond Street underground Station

47. China Town

48. Notting Hill

49. Westminster



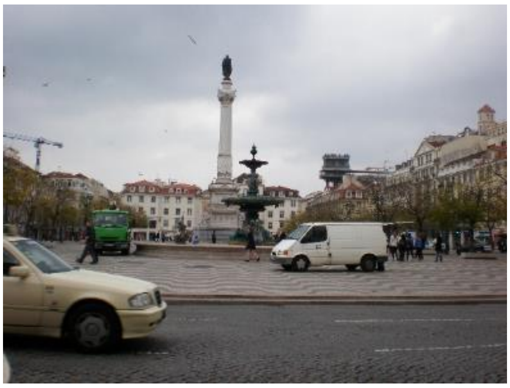
50. The National Theatre

ANNEX 1C: The day-time photographs presented to the participants in Lisbon

1. Rotunda Marquês de Pombal

2.Praça do Comércio

3.Avenida da Liberdade



4. Rossio

5. Castelo de São Jorge

6. Rio Tejo

7. Bairro Alto

8. Restauradores

9. Rua Augusta

10. Baixa Pombalina

11. Parque Eduardo VII

12. Praça Saldanha

13. Alfama

14. Chiado

15. Avenida Fontes Pereira de Melo

16. Jerónimos

17. Avenida da República

18. Ponte 25 de Abril

19. Torre de Belém

20. Amoreiras

21. Praça da Figueira

22. Campo Grande

23. Largo de Camões

24.Sé de Lisboa

25. Teatro D. Maria II

26. Arco da Rua Augusta

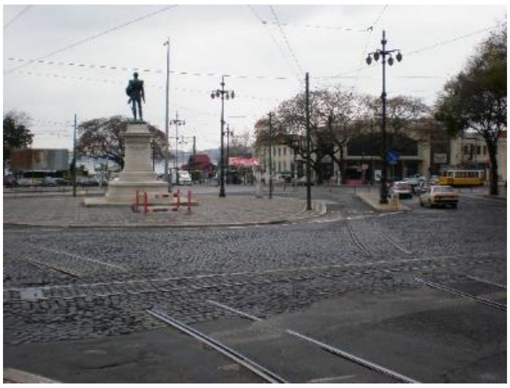
27. Belém

28. Estação do Rossio

29. Rua da Prata

30. Rua do Ouro

31. Estação de Santa Apolónia



32. Cais do Sodré

33. Principe Real

34. Centro Cultural de Belém

35. Elevador de Santa Justa

36. Jardim da Estrela

37. Largo do Rato

38. Mouraria

39. Campo Pequeno

40. Parque das Nações

41. Graça

42. Martim Moniz

43. Miradouro de s. Pedro de Alcântara

44. Miradouro da Graça

45. Padrão dos Descobrimentos

46. Rua Garrett

47. Assembleia da República

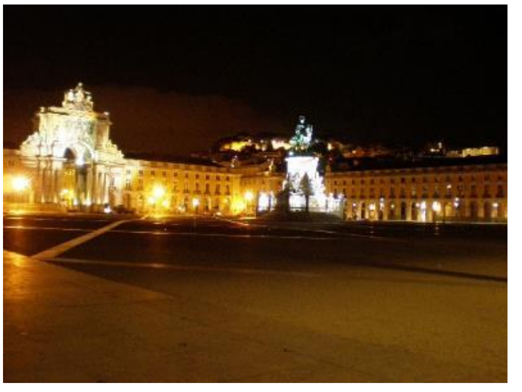
48. Avenida 24 de Julho

49. Estátua de D. José

50. Estátua Fernando Pessoa

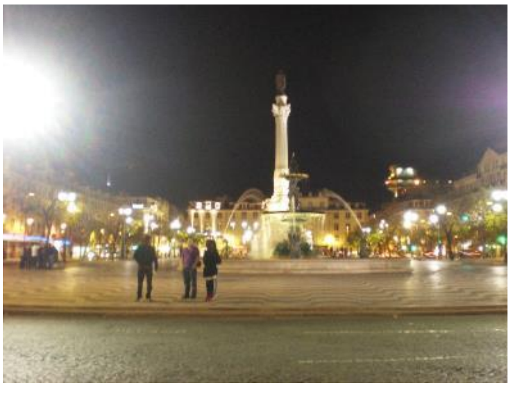
ANNEX 1D: The night-time photographs presented to the participants in Lisbon

1. Rotunda Marquês de Pombal



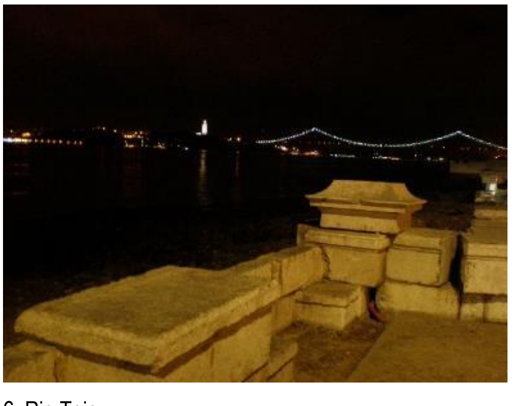
2.Praça do Comércio

3.Avenida da Liberdade



4. Rossio

5. Castelo de São Jorge



6. Rio Tejo

7. Bairro Alto

8. Restauradores

9. Rua Augusta

10. Baixa Pombalina

11. Parque Eduardo VII

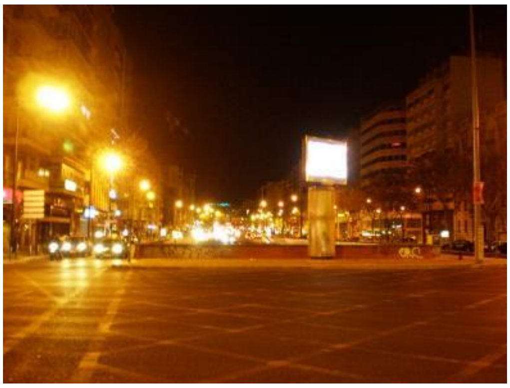
12. Praça Saldanha

13. Alfama

14. Chiado


15. Avenida Fontes Pereira de Melo


16. Jerónimos


17. Avenida da República


18. Ponte 25 de Abril


19. Torre de Belém


20. Amoreiras


21. Praça da Figueira


22. Campo Grande

23. Largo de Camões

24.Sé de Lisboa

25. Teatro D. Maria II

26. Arco da Rua Augusta

27. Belém

28. Estação do Rossio

29. Rua da Prata

30. Rua do Ouro

31. Estação de Santa Apolónia

32. Cais do Sodré

33. Principe Real

34. Centro Cultural de Belém

35. Elevador de Santa Justa

36. Jardim da Estrela

37. Largo do Rato

38. Mouraria

39. Campo Pequeno

40. Parque das Nações

41. Graça

42. Martim Moniz

43. Miradouro de s. Pedro de Alcântara

44. Miradouro da Graça

45. Padrão dos Descobrimentos

46. Rua Garrett

47. Assembleia da República

48. Avenida 24 de Julho

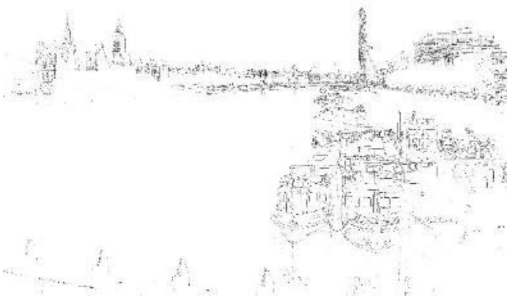
49. Estátua de D. José

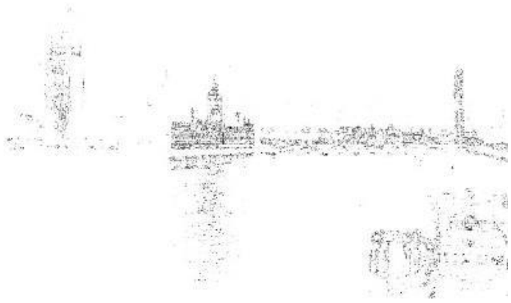
50. Estátua Fernando Pessoa

ANNEX 2: THE ANALYSIS OF THE EDGES OF THE PHOTOGRAPHS

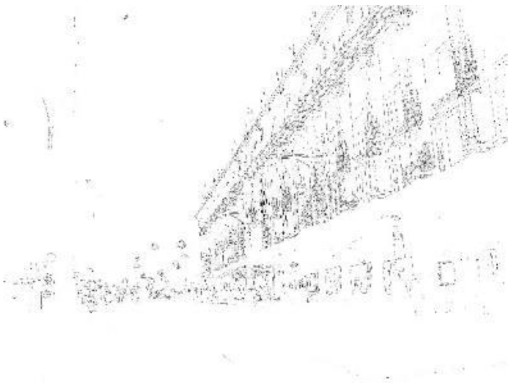
ANNEX 2A: The edge detection for the photographs in London

DAY **NIGHT**

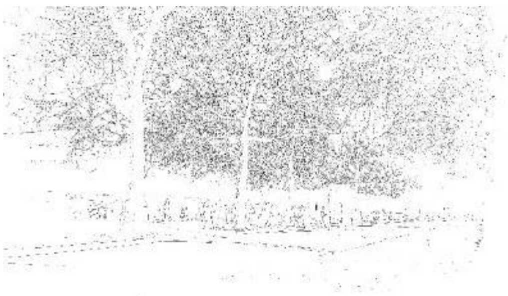




1. The river Thames

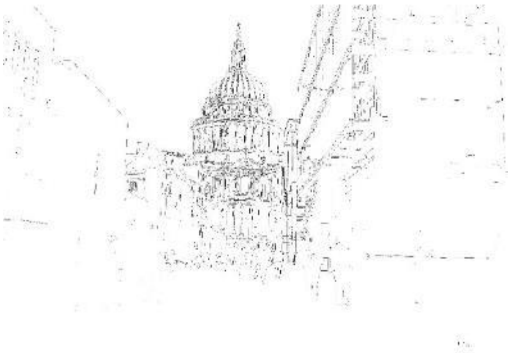


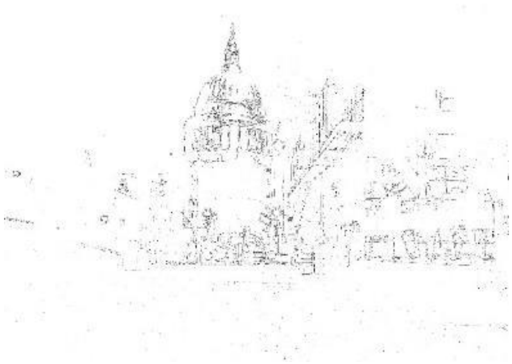
2. Oxford Street



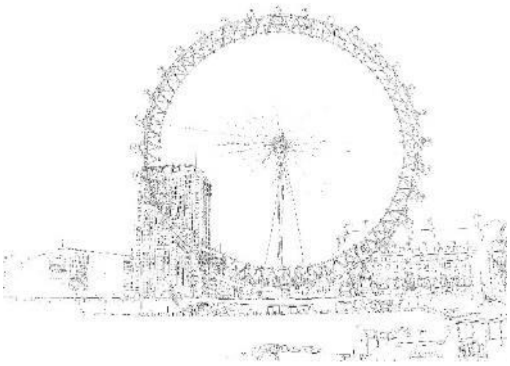
3. Hyde Park

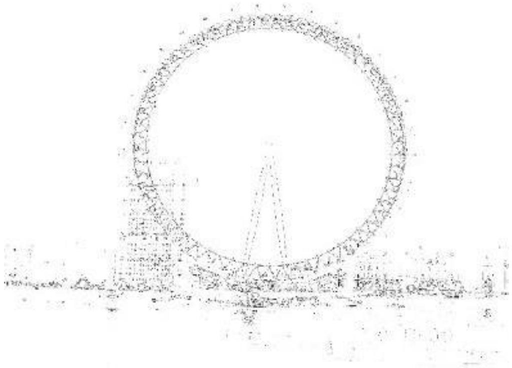
DAY **NIGHT**



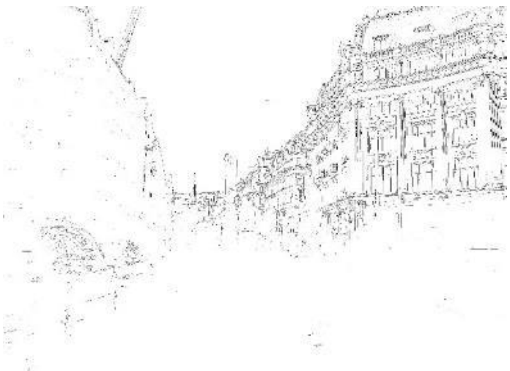


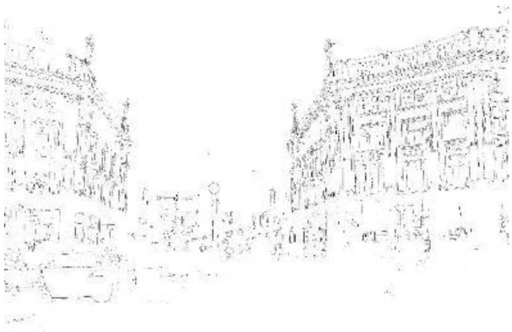
4. Saint Paul's Cathedral





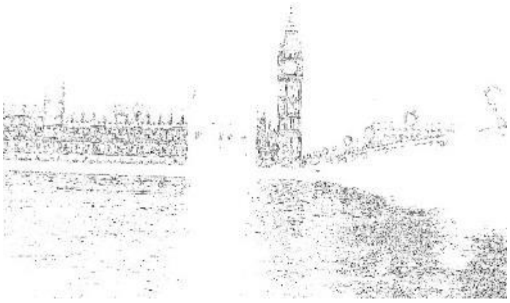
5. The London Eye



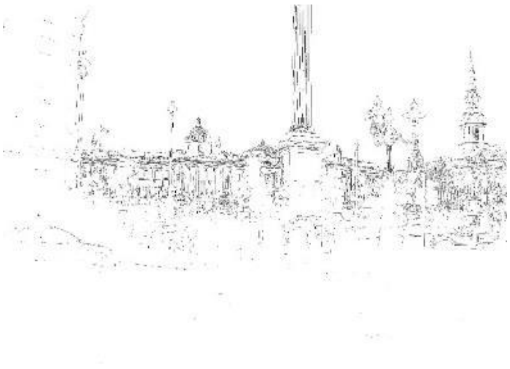
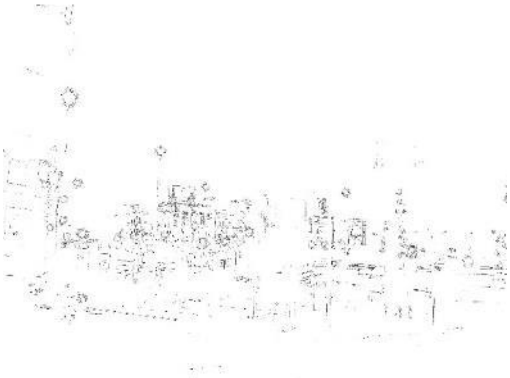


6. Oxford Street

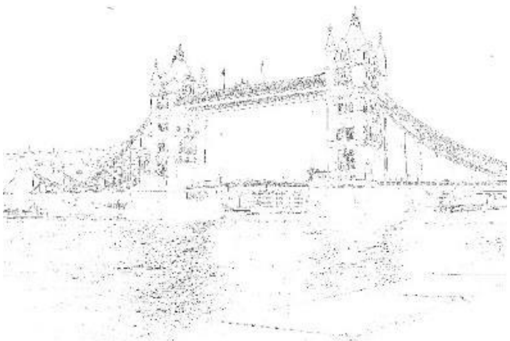
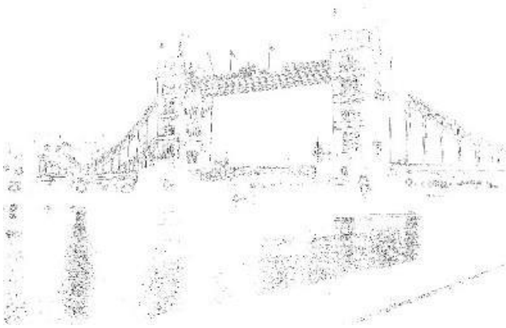
DAY **NIGHT**

7. Big Ben

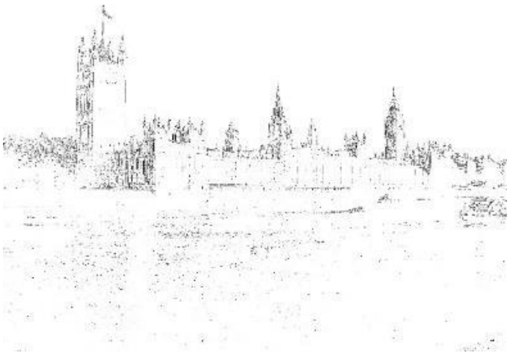



8. Trafalgar Square

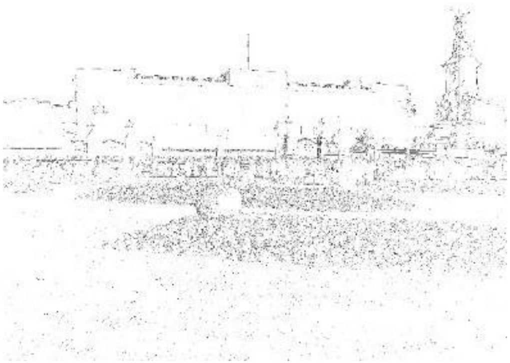
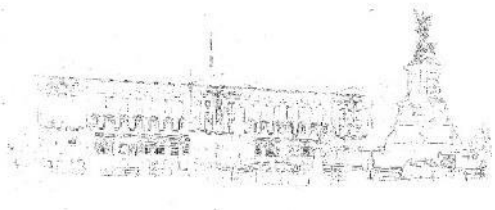



9. Tower Bridge

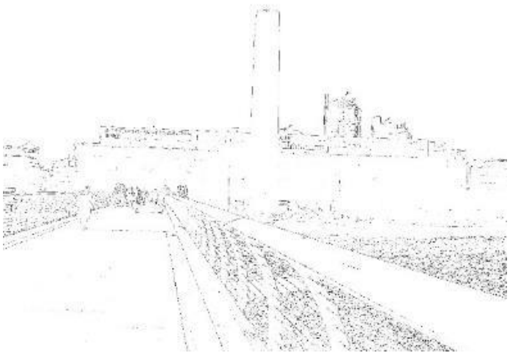
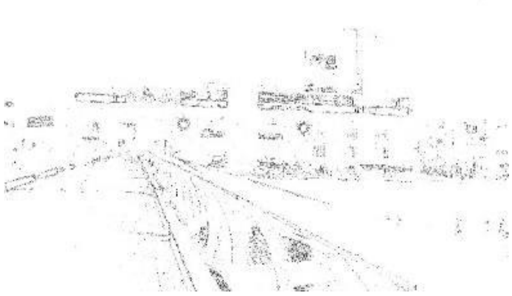
DAY **NIGHT**




10. The Parliament

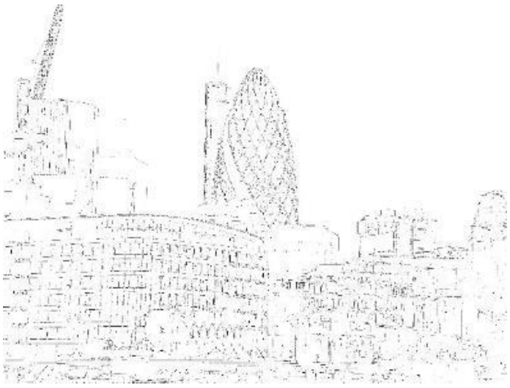



11. Buckingham Palace

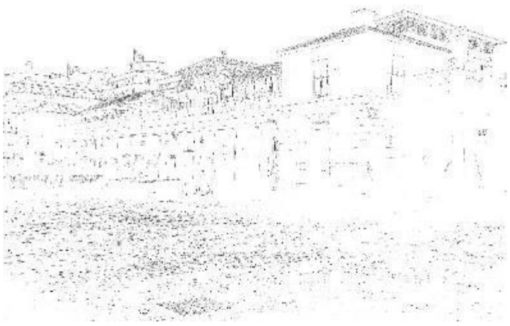
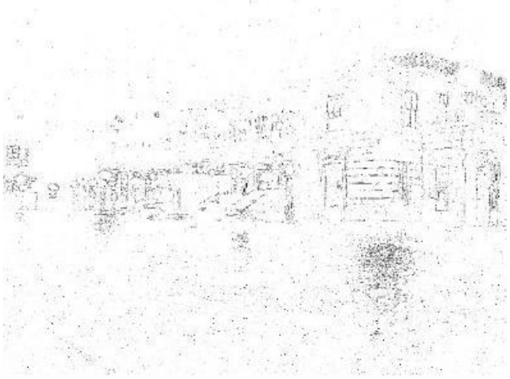



12. The Tate Modern

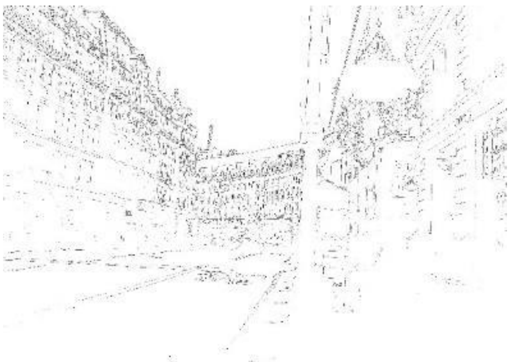
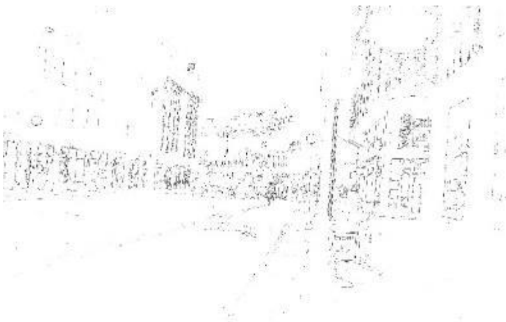
DAY **NIGHT**




13. The Gherkin

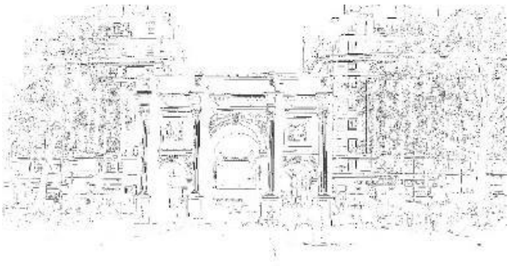



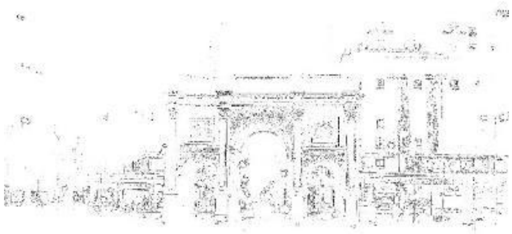
14. Covent Garden

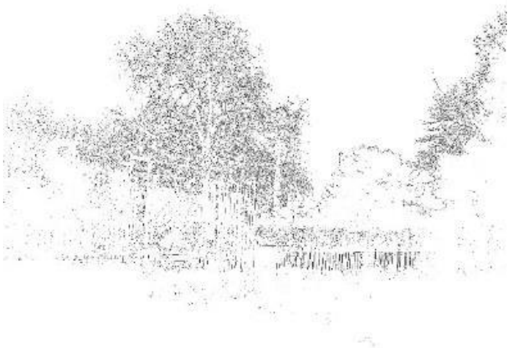
15. Regent Street

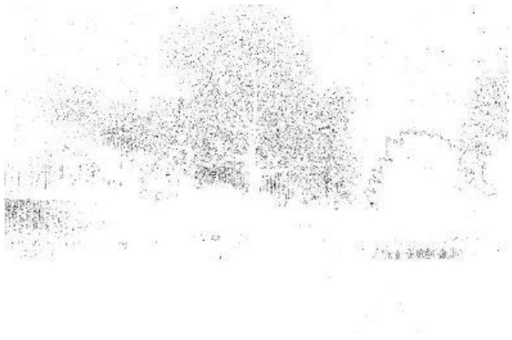
DAY **NIGHT**



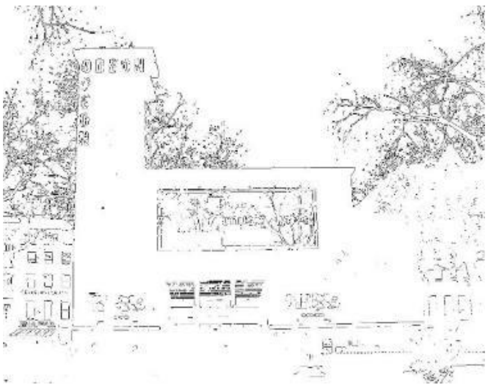


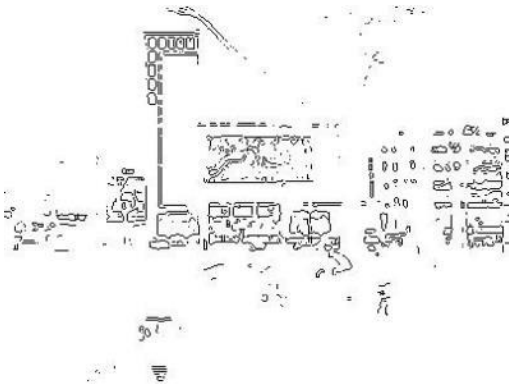
16. Marble Arch





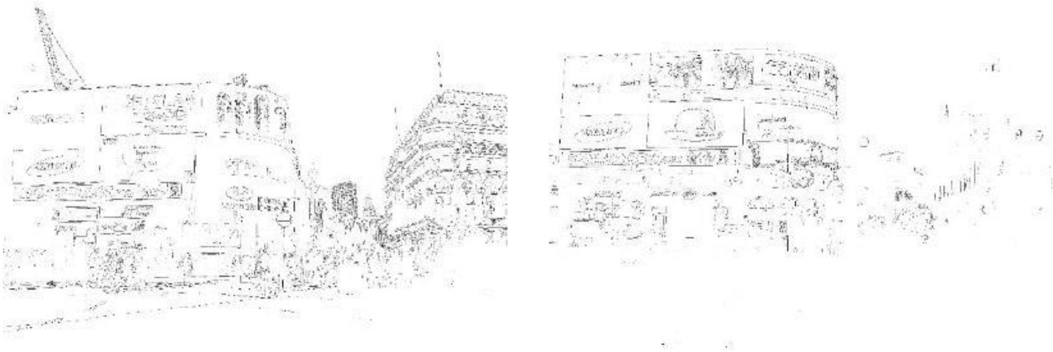
17. Regent's Park





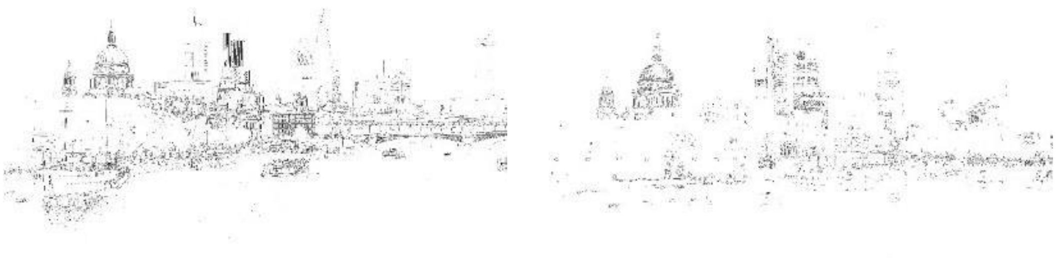
18. Leicester Square

DAY **NIGHT**



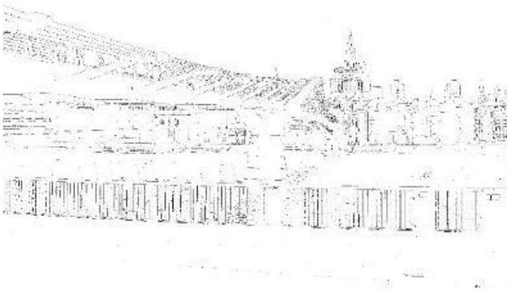
19. Piccadilly Circus

20. Soho

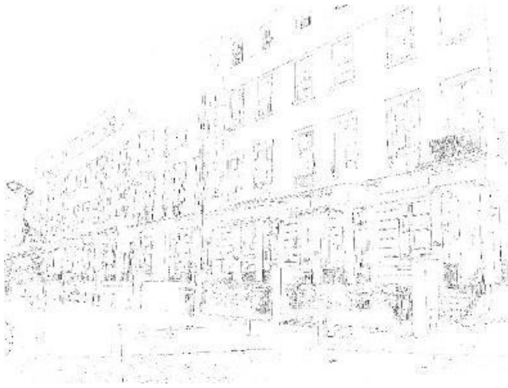


21. The City

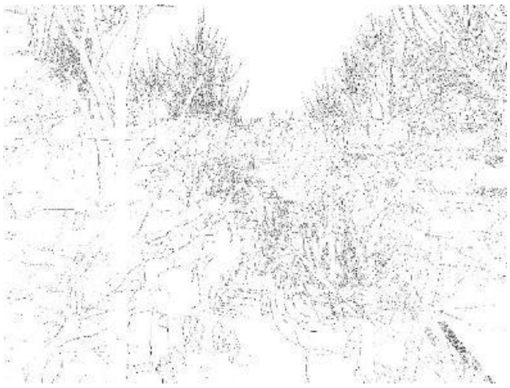
DAY **NIGHT**




22. The Millennium Bridge

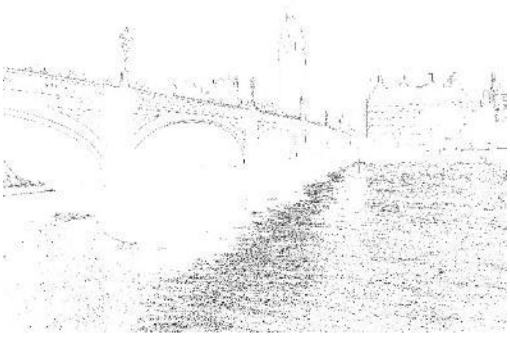
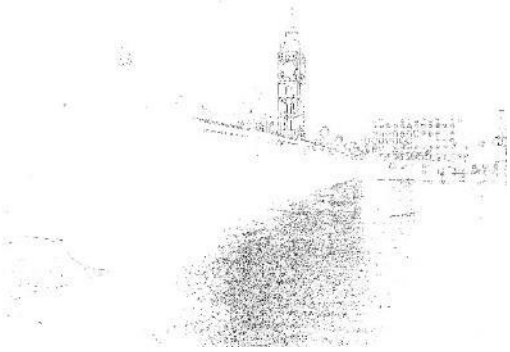


23. Kensington

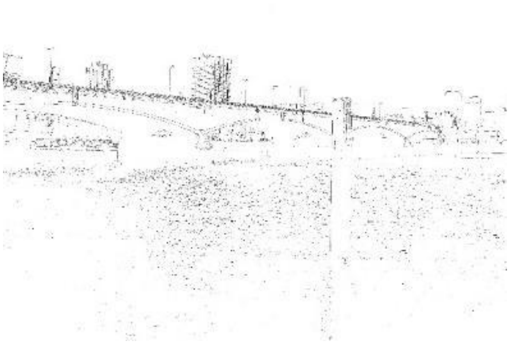
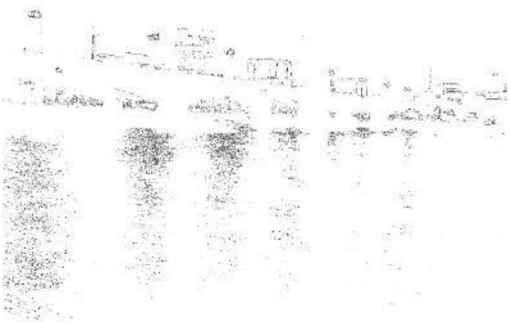



24.The Southbank

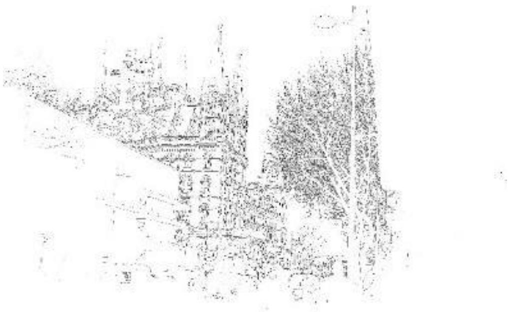
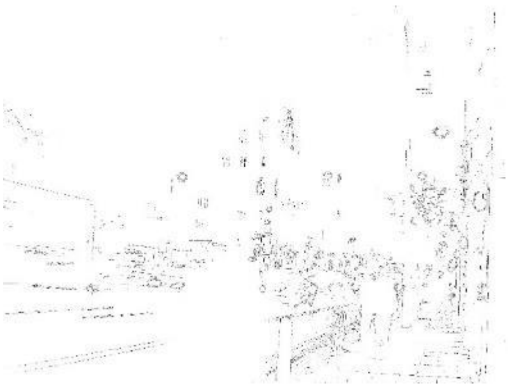
DAY **NIGHT**

25.The Westminster Bridge

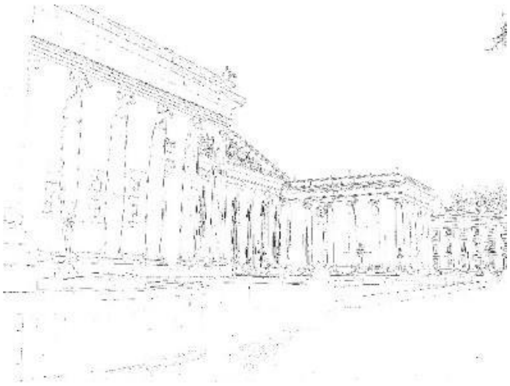
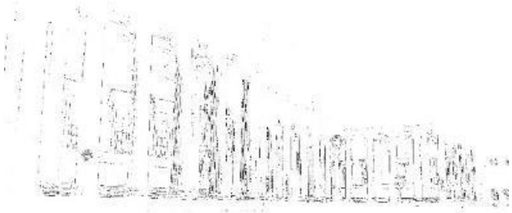



26. Waterloo Bridge

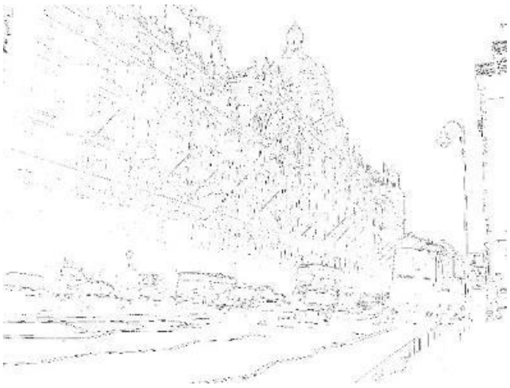
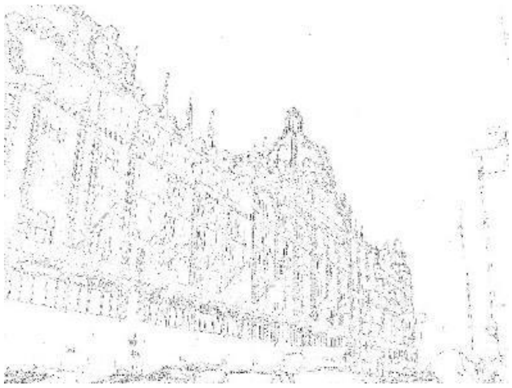
27. Kings Cross/Saint Pancras Station

DAY **NIGHT**

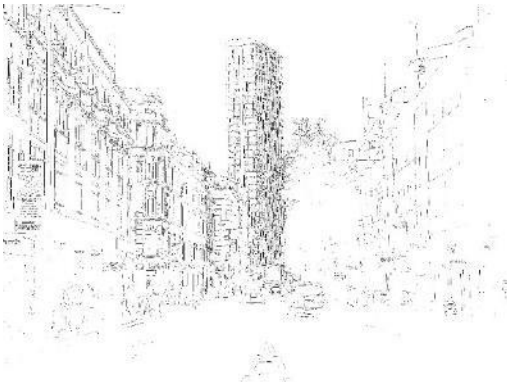
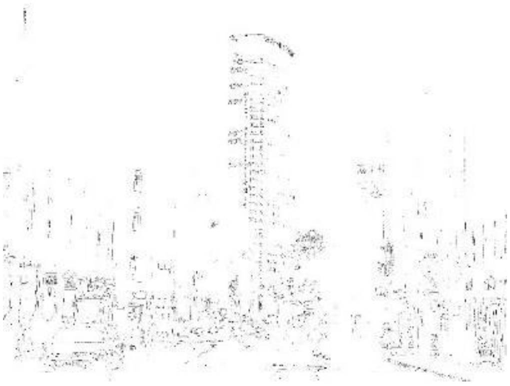
28. The British Museum


29. Saint James's Park

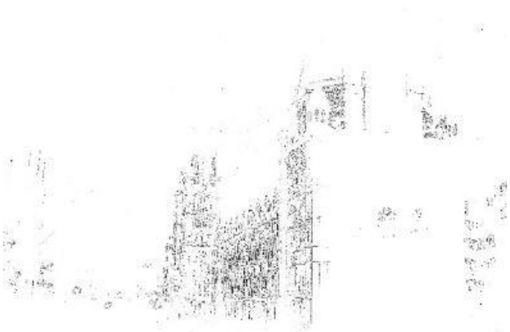



30. Harrods

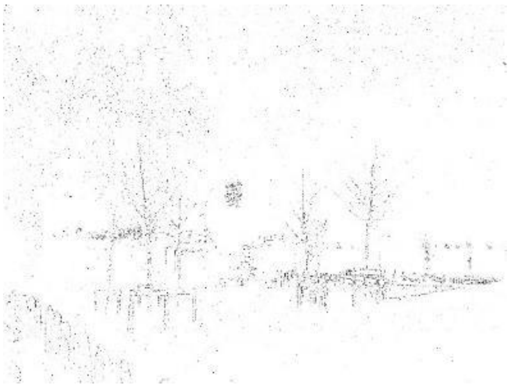
DAY **NIGHT**

31. Centre Point

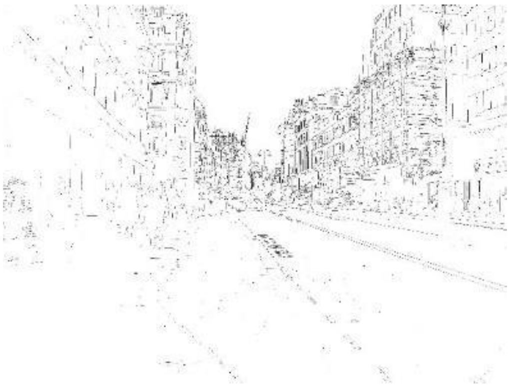



32. The Natural History Museum

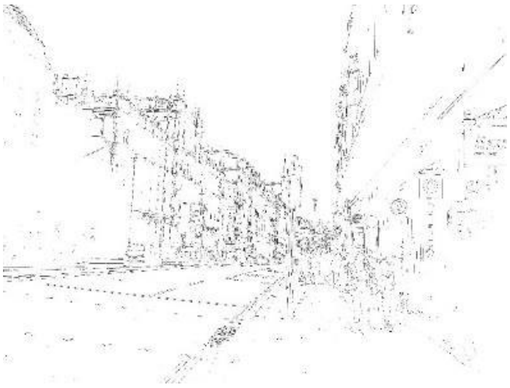



33. Green Park

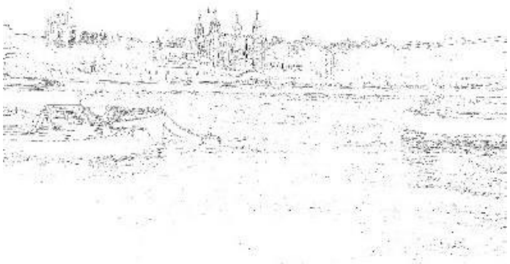
DAY	NIGHT



34. The Strand

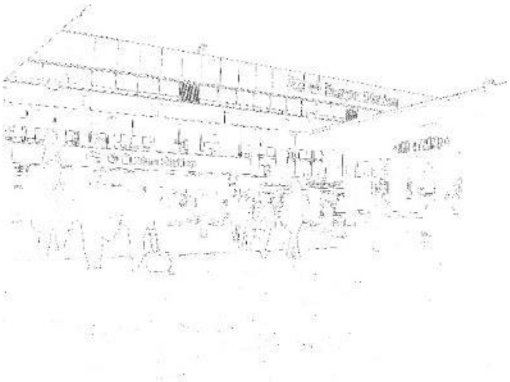
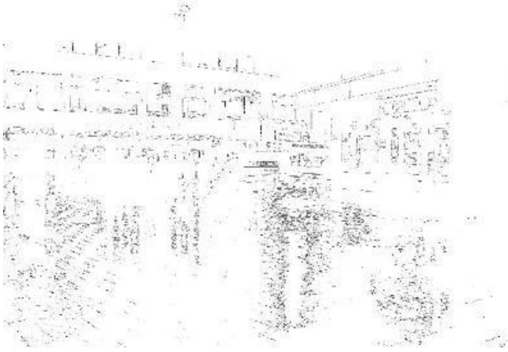


35. Piccadilly

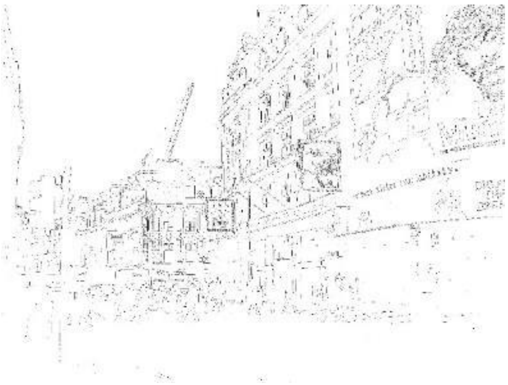
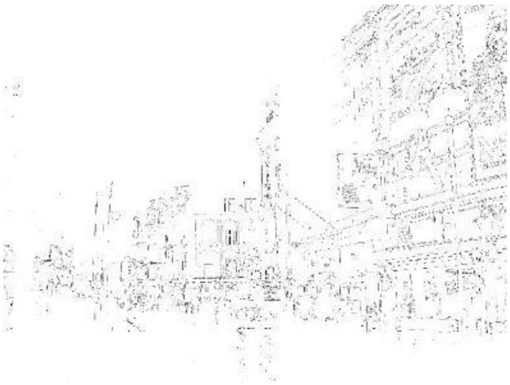


36. The Tower of London

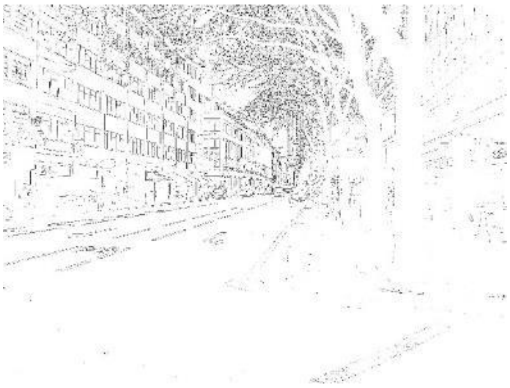
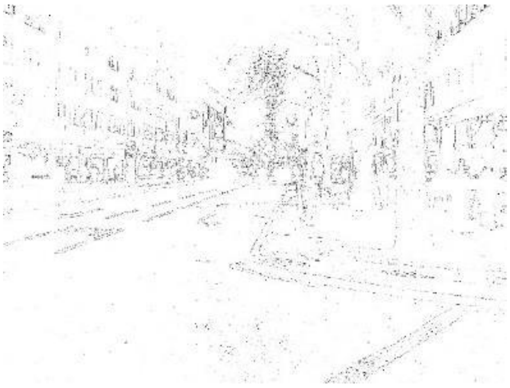
DAY **NIGHT**

37. Euston Station

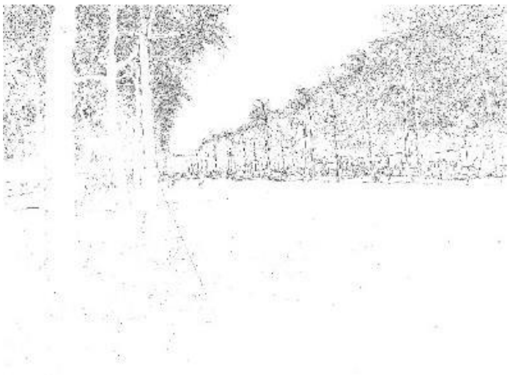



38. The West End

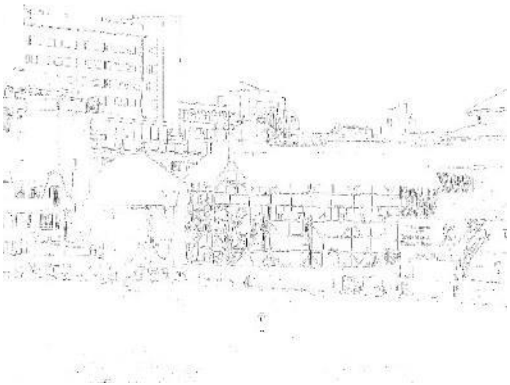
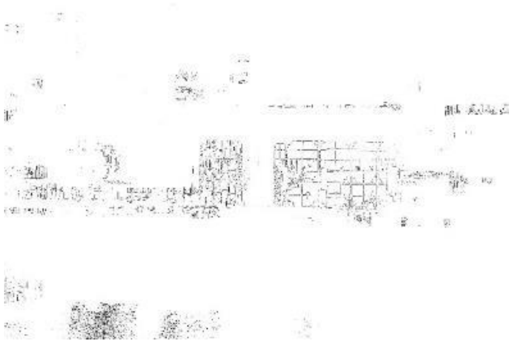



39. Tottenham Court Road

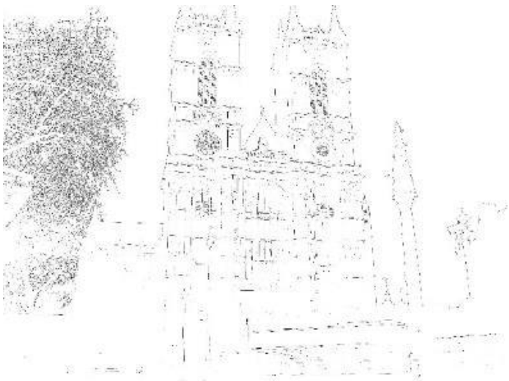
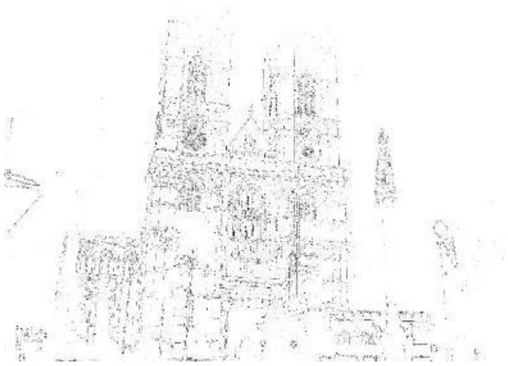
DAY **NIGHT**




40. The Mall

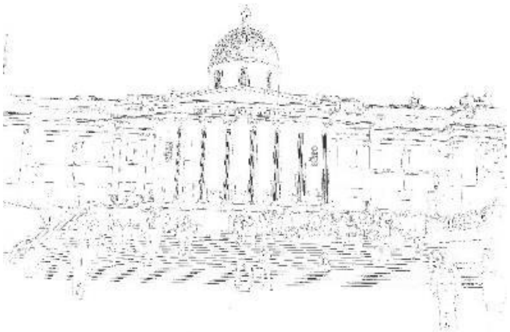
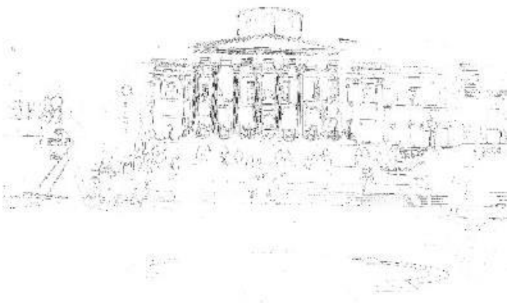



41. Globe Theatre

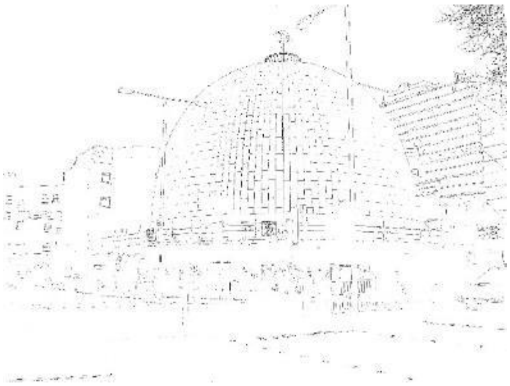



42. The Westminster Abbey

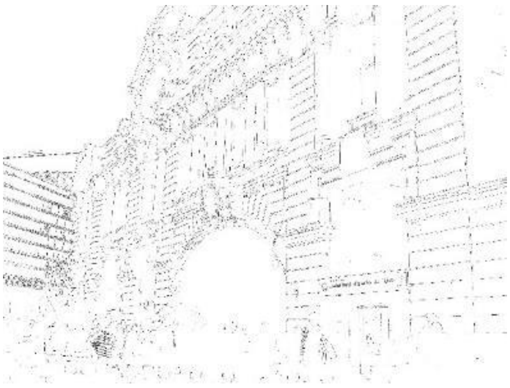
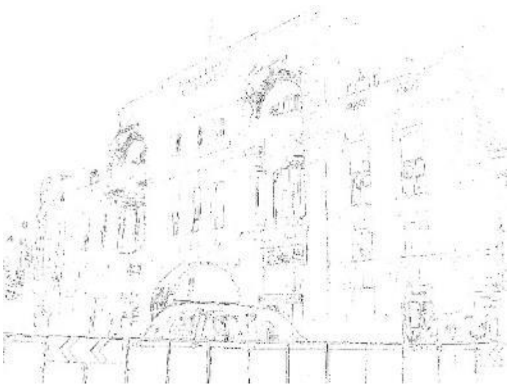
DAY **NIGHT**

43. The National Gallery

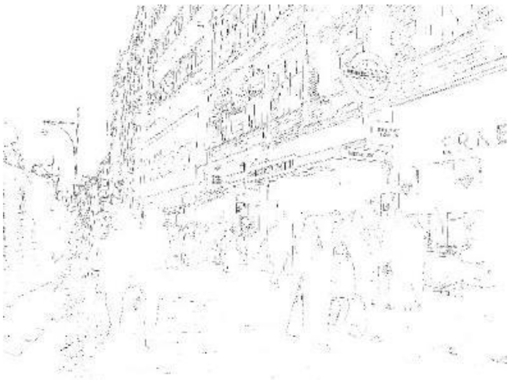



44. Madame Tussauds

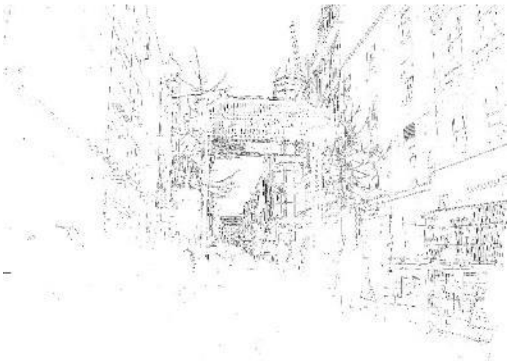
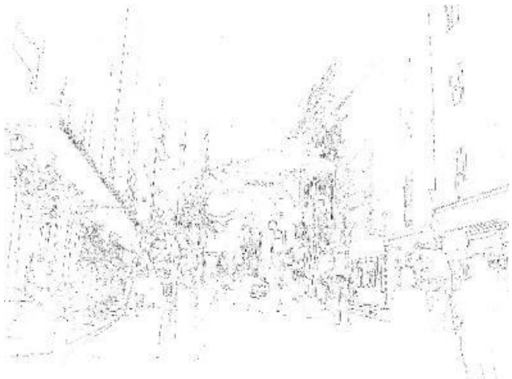



45. Victoria Station

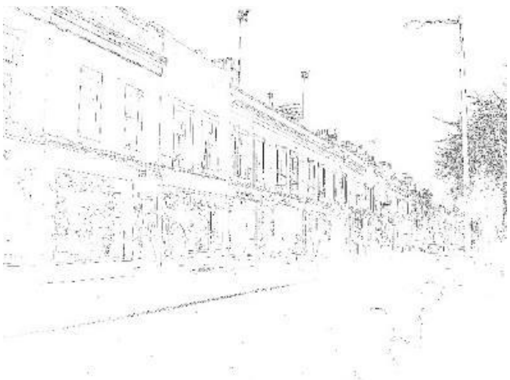
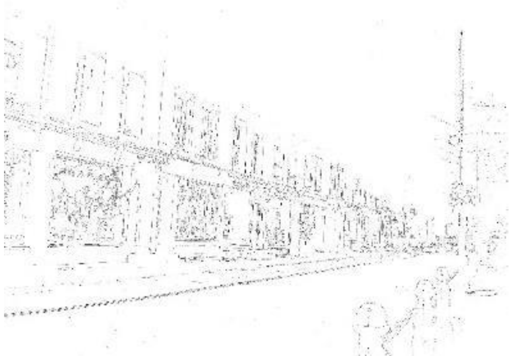
DAY **NIGHT**




46. Bond Street Station

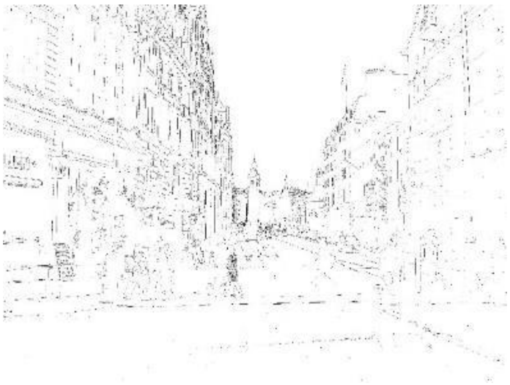



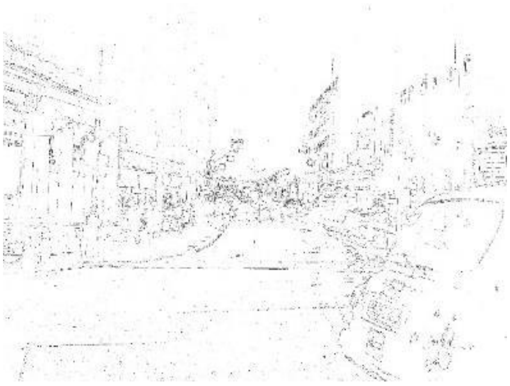
47. China Town

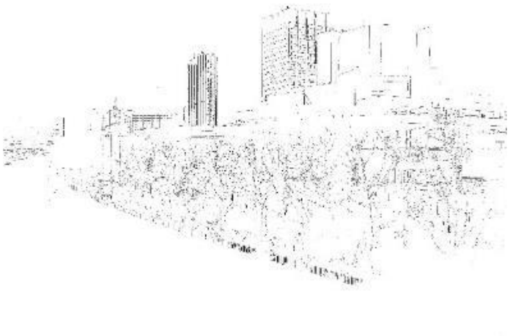
48. Notting Hill

DAY **NIGHT**





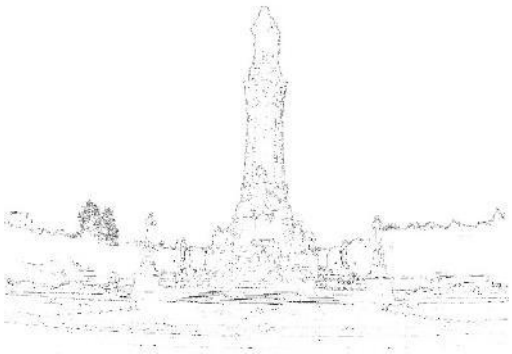
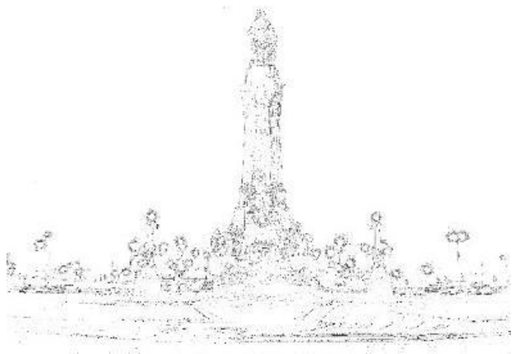
49. Westminster



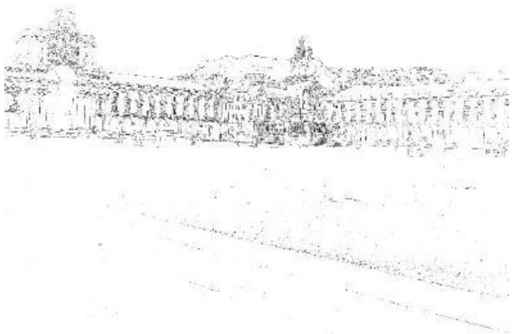
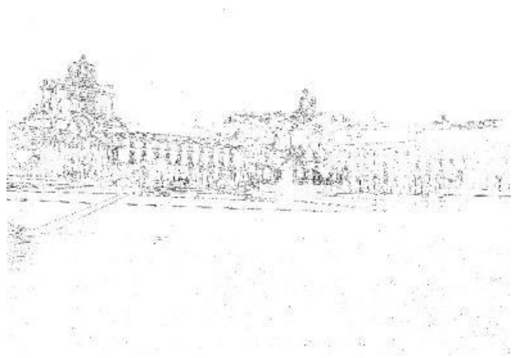
50. The National Theatre

ANNEX 2B: The edge detection for the photographs in Lisbon

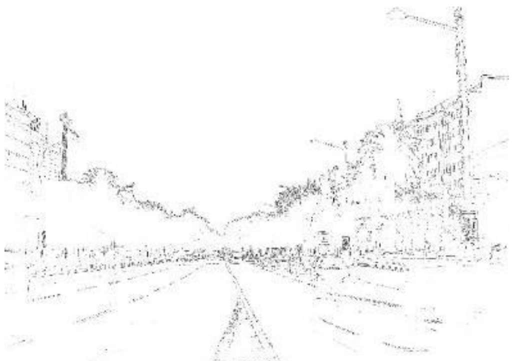
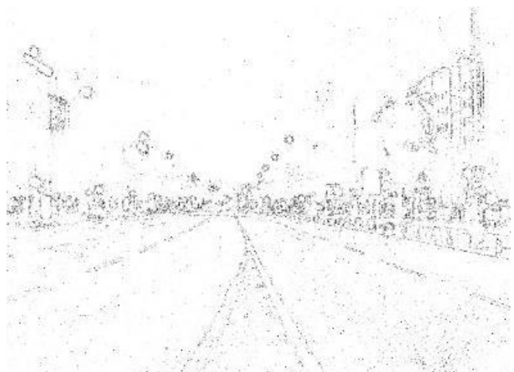
DAY **NIGHT**

1.Rotunda Marquês de Pombal

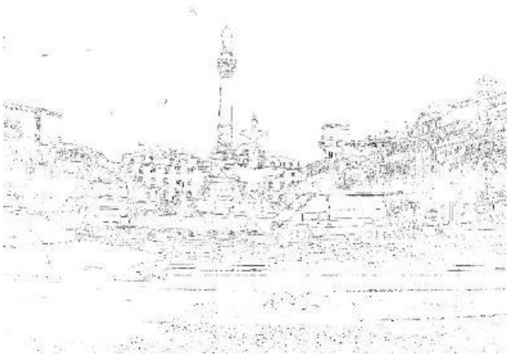
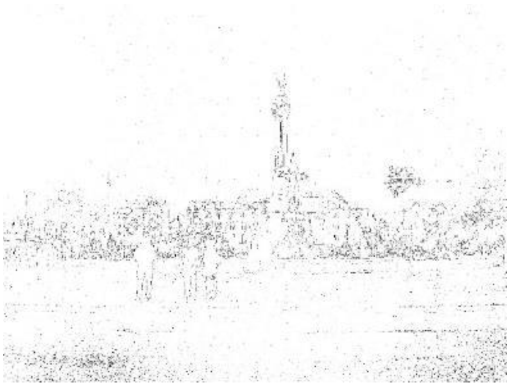



2.Praça do Comércio

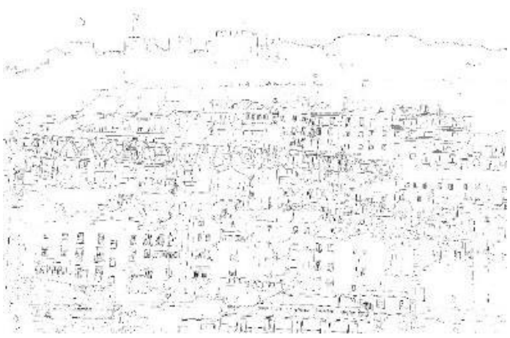
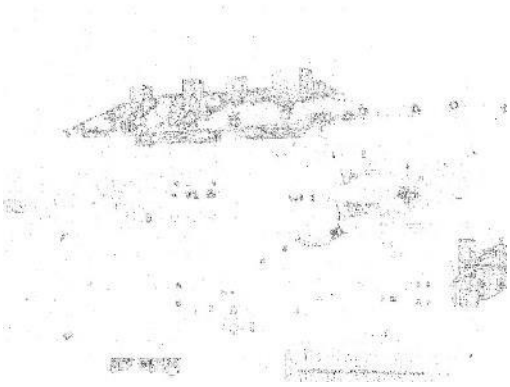



3. Avenida da Liberdade

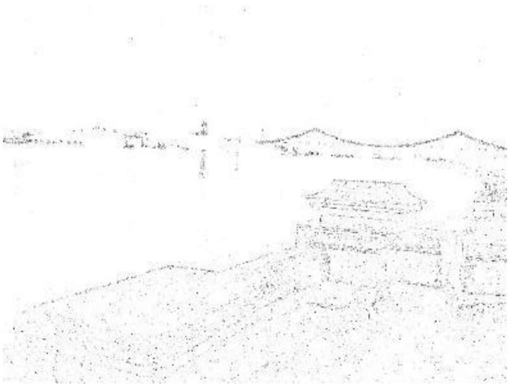
DAY **NIGHT**

4.Rossio

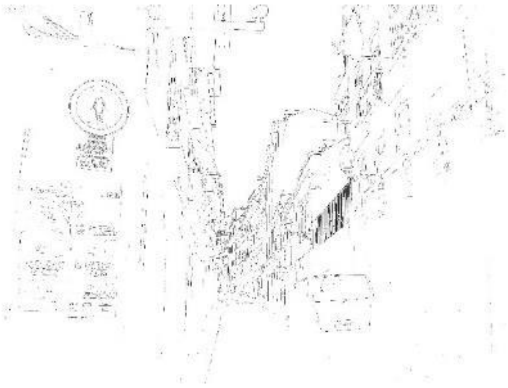
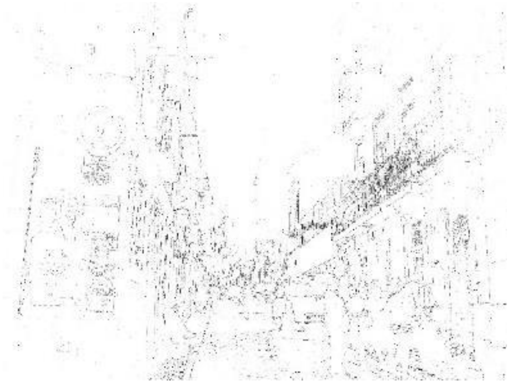



5. Castelo de São Jorge

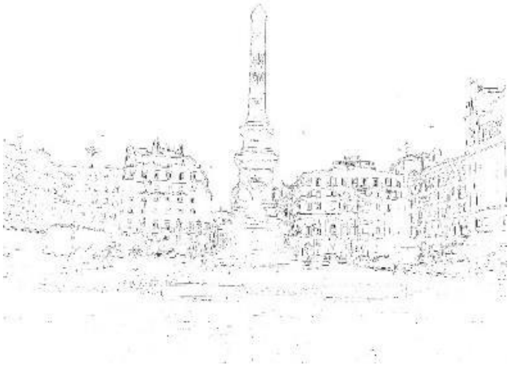
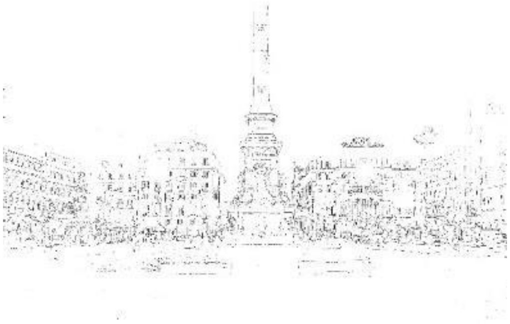



6. Rio Tejo

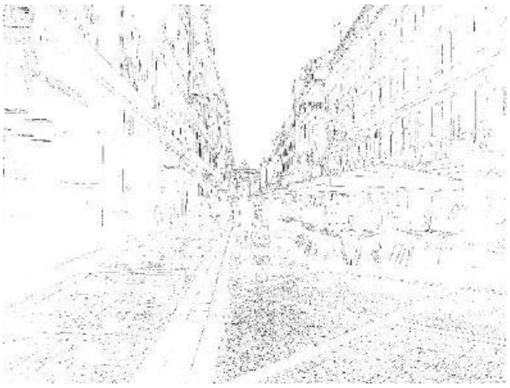
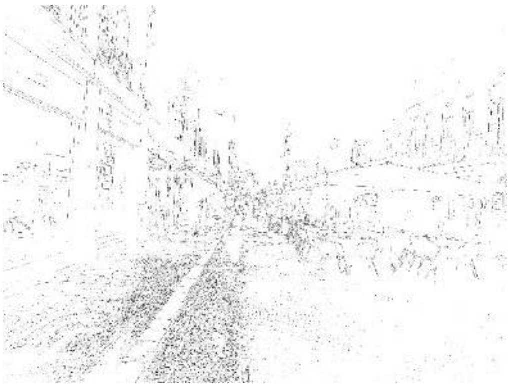
DAY **NIGHT**

7. Bairro Alto

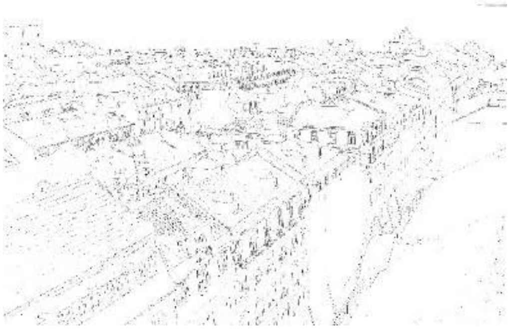



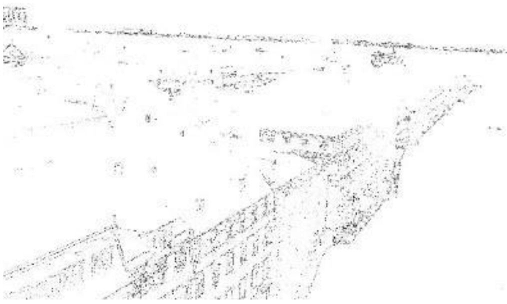
8. Restauradores

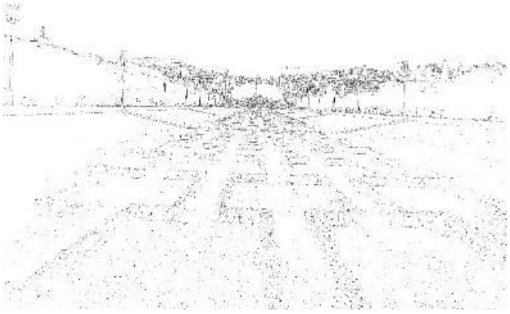
9. Rua Augusta

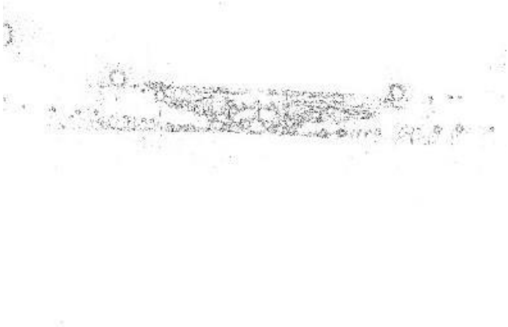
DAY **NIGHT**



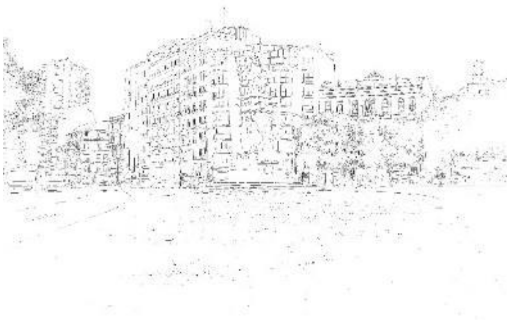


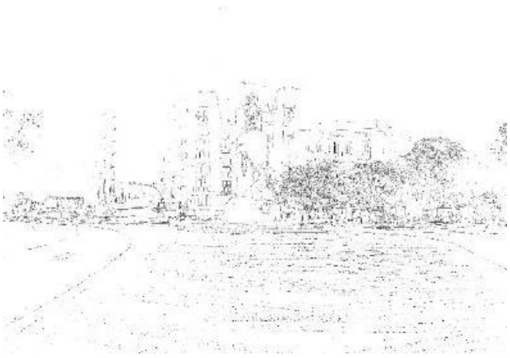
10. Baixa Pombalina





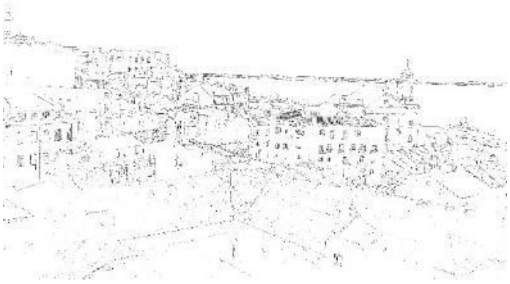
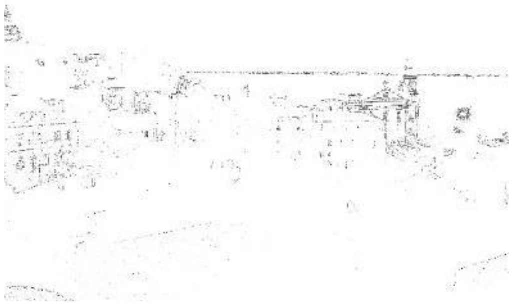
11. Parque Eduardo VII



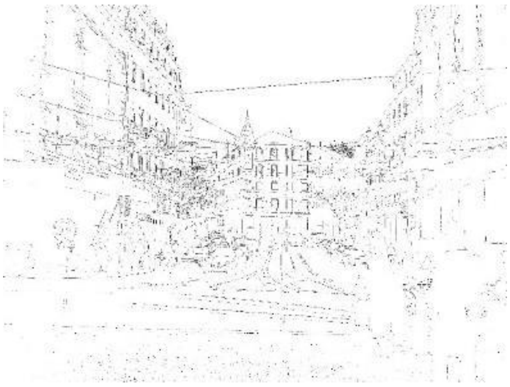
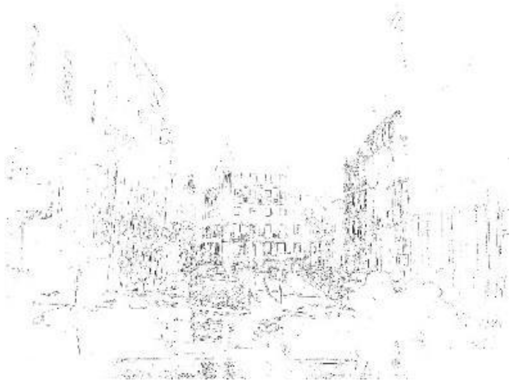


12. Praça Saldanha

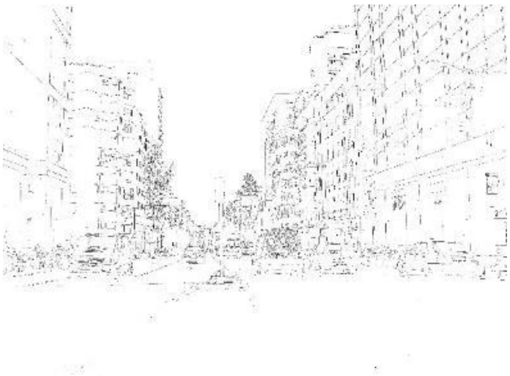
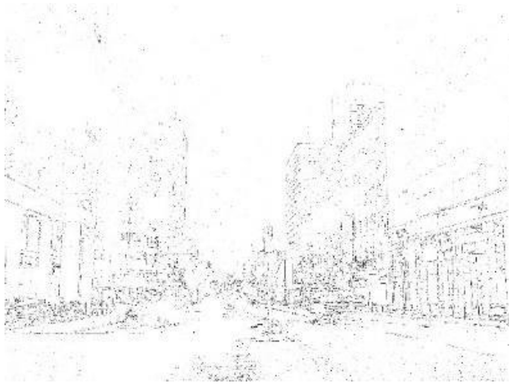
DAY **NIGHT**

13. Alfama

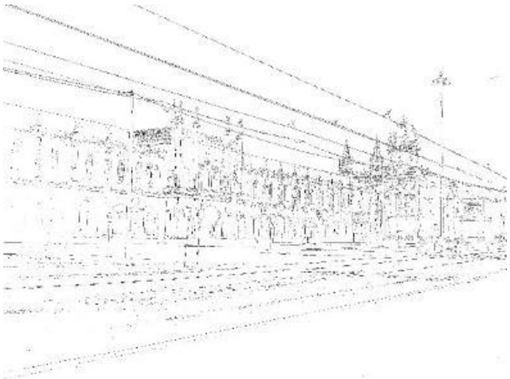
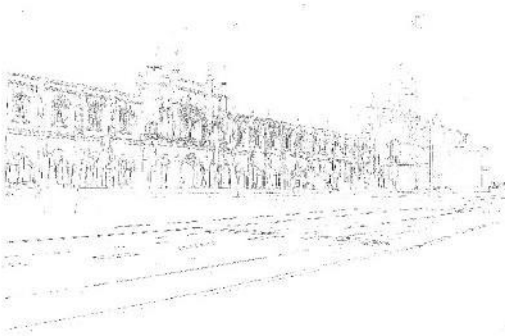



14. Chiado

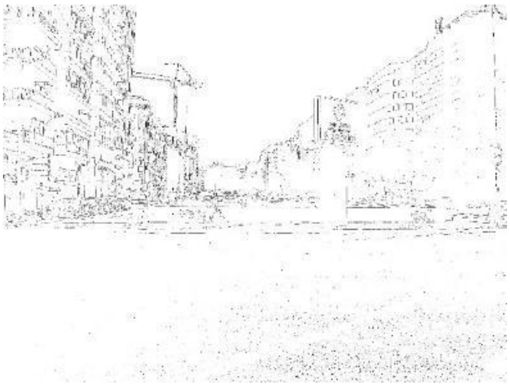
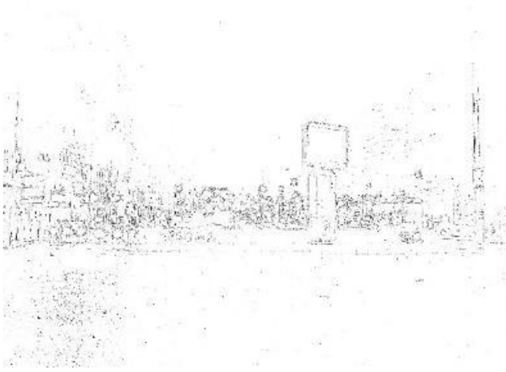



15. Avenida Fontes Pereira de Melo

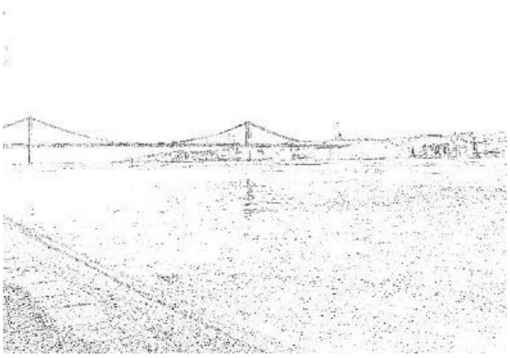
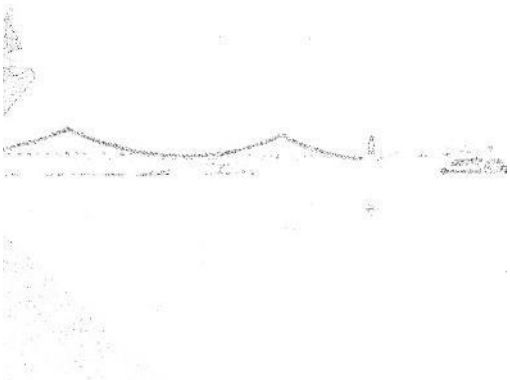
DAY	NIGHT

16. Jerónimos

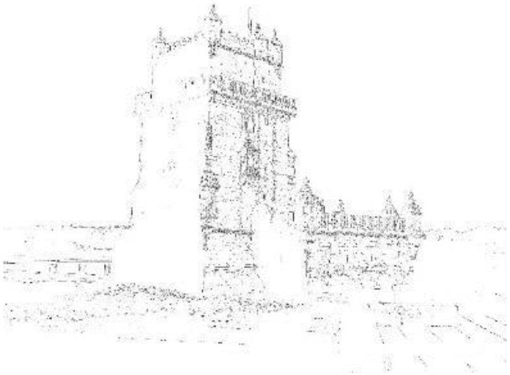
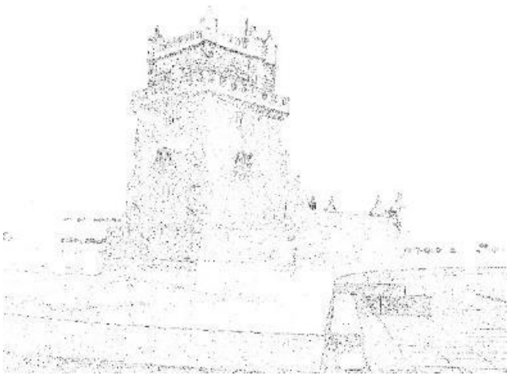



17. Avenida da República

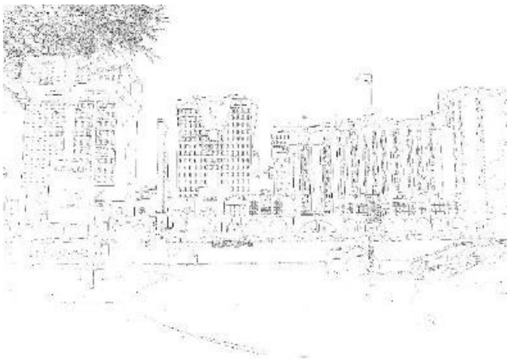
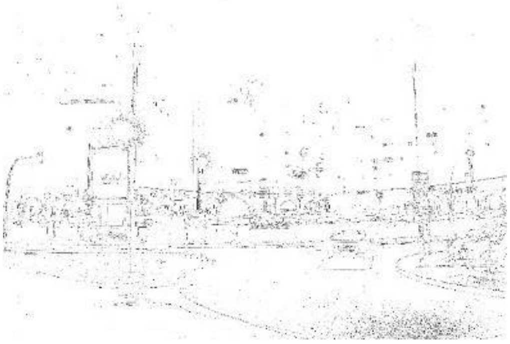



18. Ponte 25 de Abril

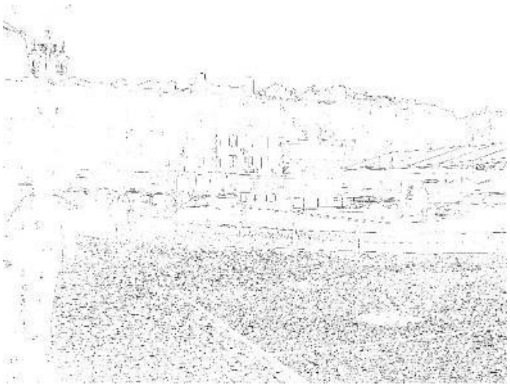
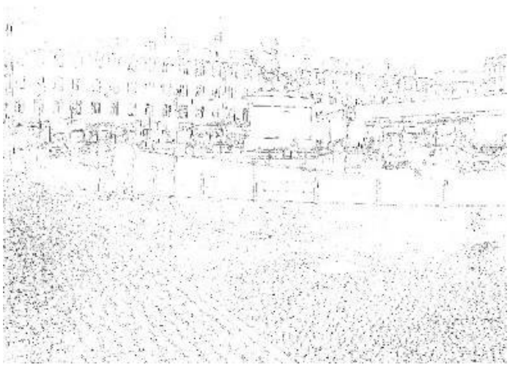
DAY **NIGHT**

19. Torre de Belém

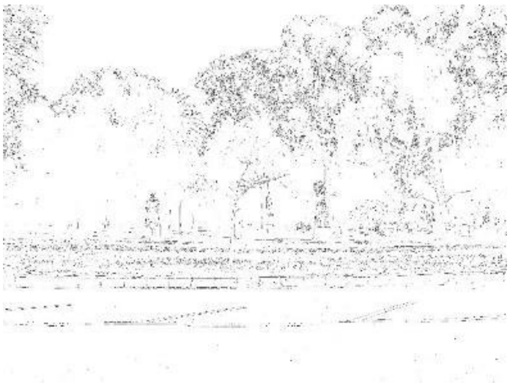



20. Amoreiras

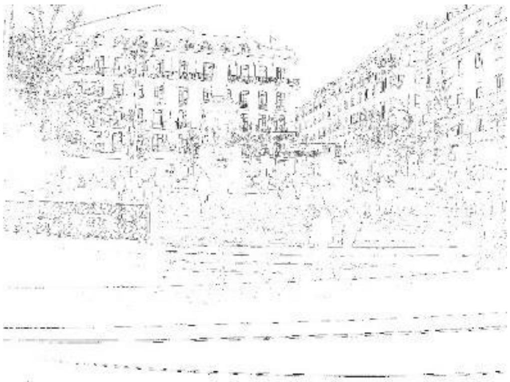
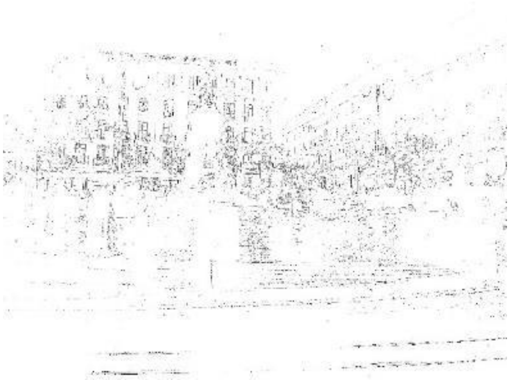



21. Praça da Figueira

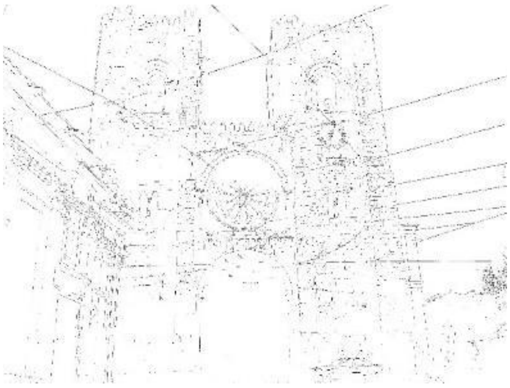
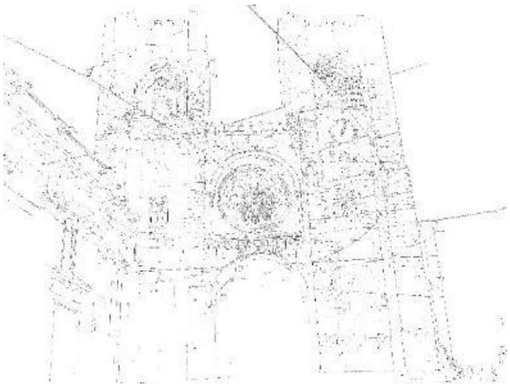
DAY	NIGHT




22. Campo Grande

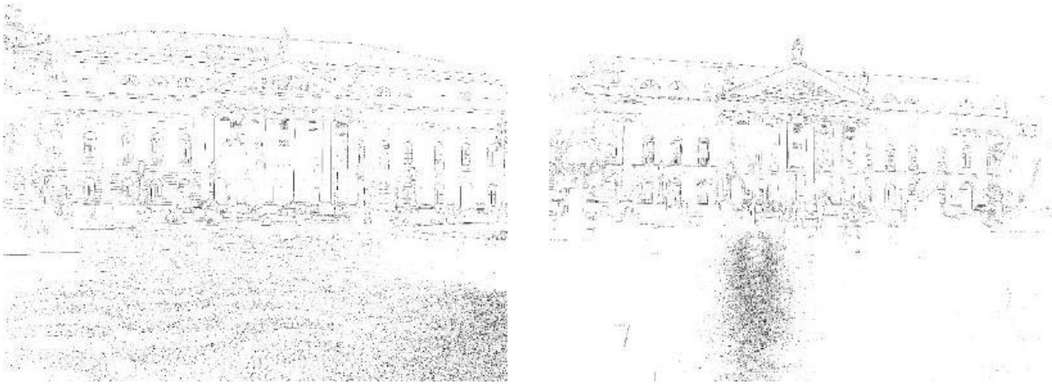



23. Largo de Camões

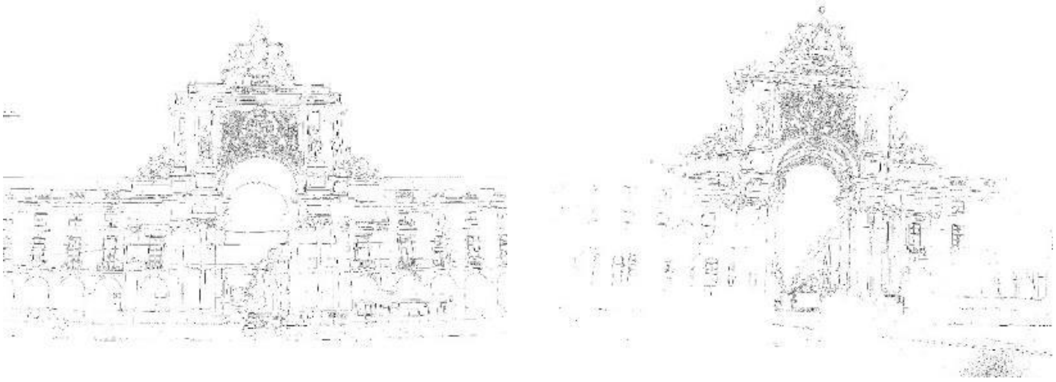



24. Sé de Lisboa

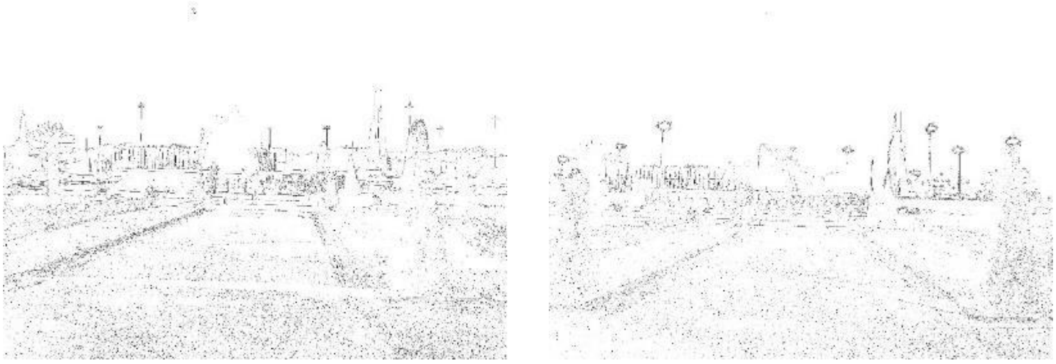
DAY **NIGHT**



25. Teatro D. Maria II

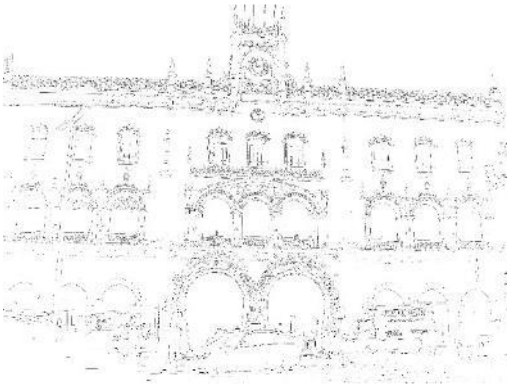
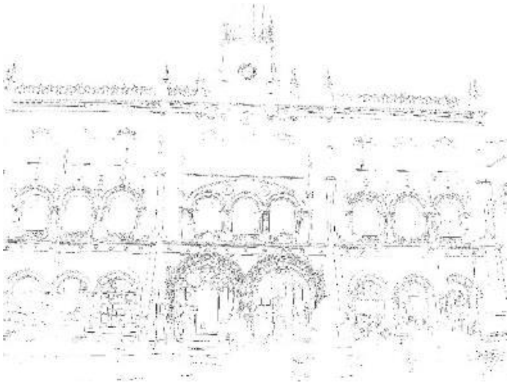


26. Arco da Rua Augusta

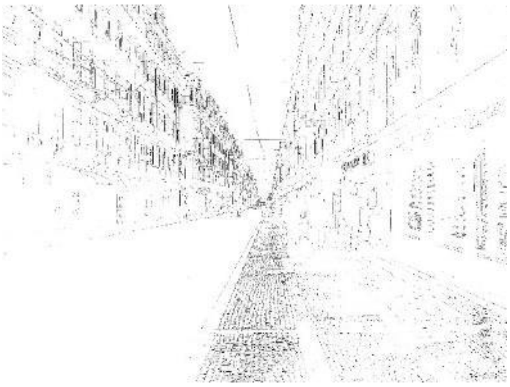
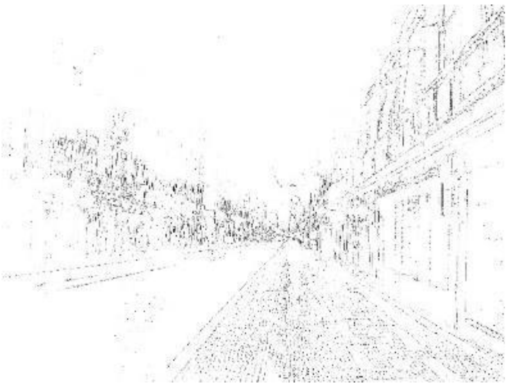


27. Belém

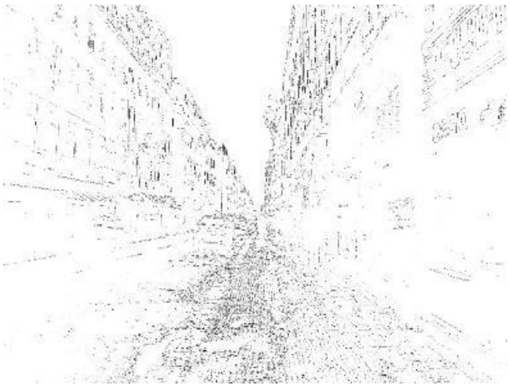
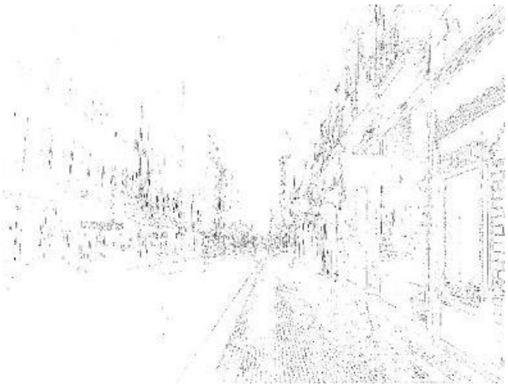
DAY **NIGHT**

28. Estação do Rossio

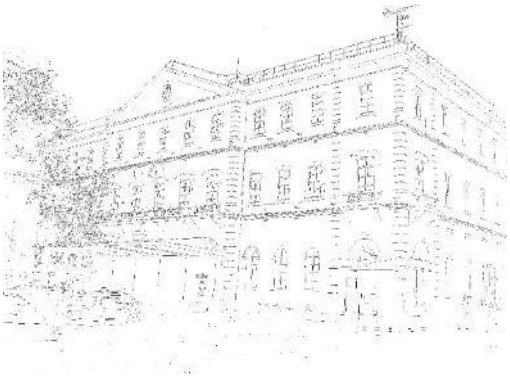
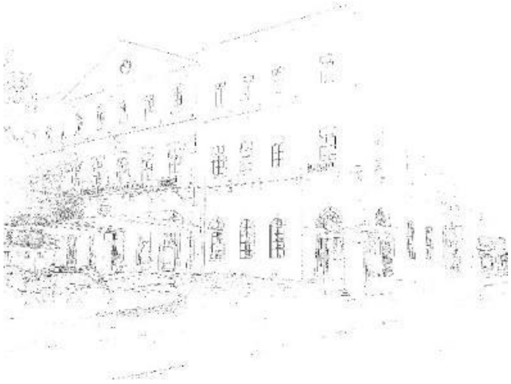



29. Rua da Prata

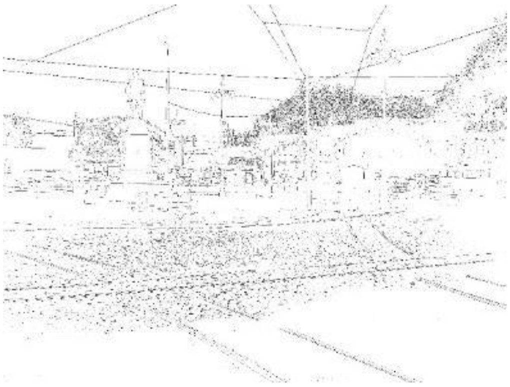
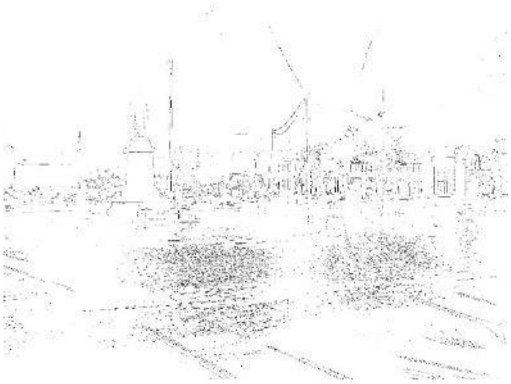



30. Rua do Ouro

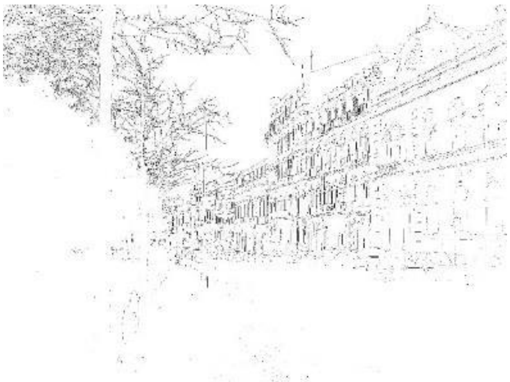
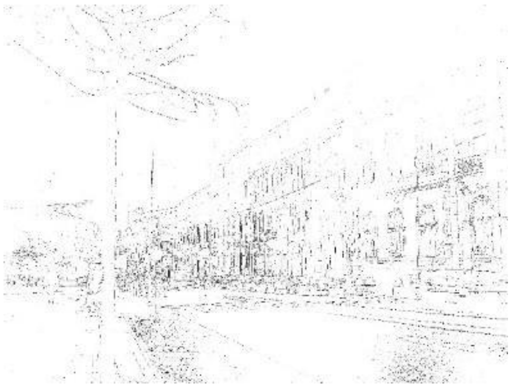
DAY **NIGHT**

31. Estação de Santa Apolónia

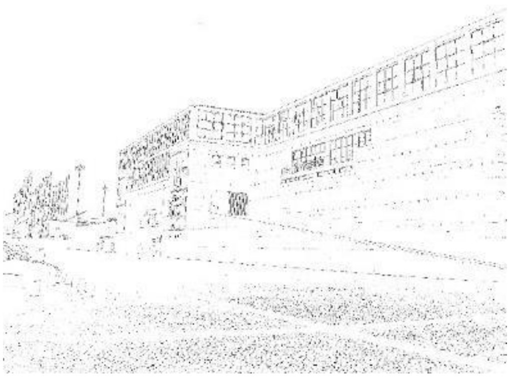
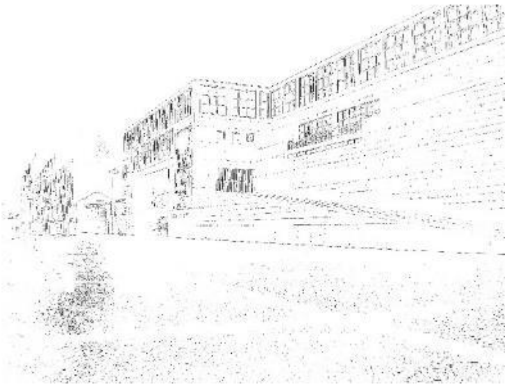



32. Cais do Sodré

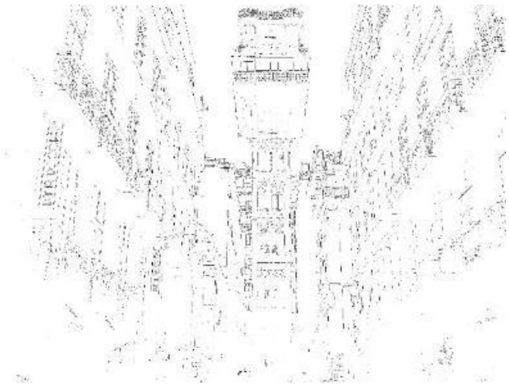
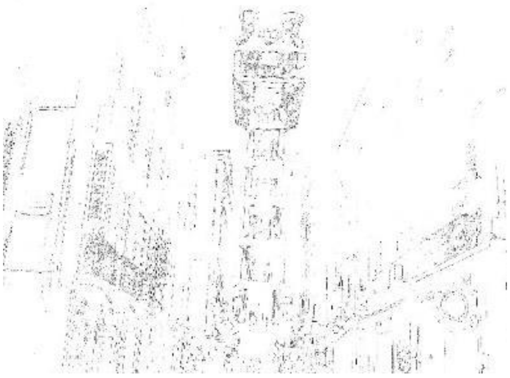



33. Príncipe Real

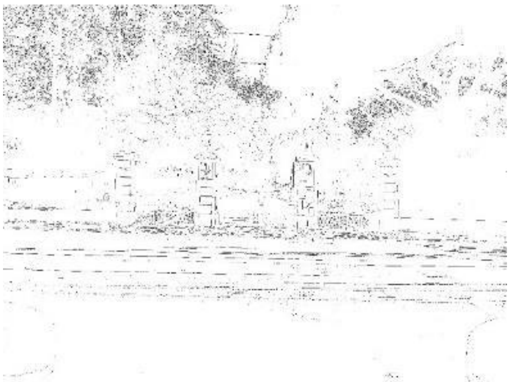
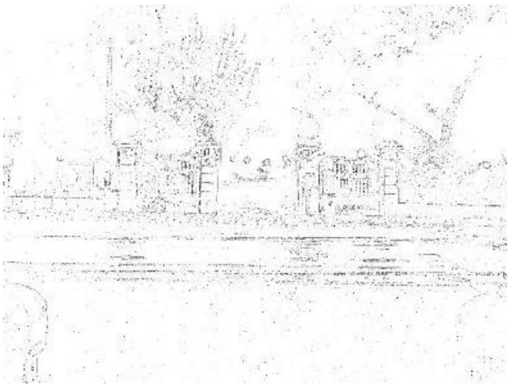
DAY **NIGHT**

34. Centro Cultural de Belém

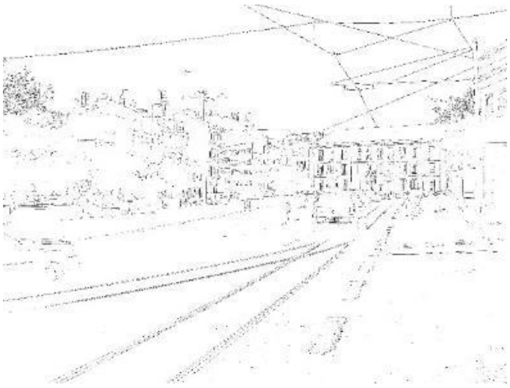
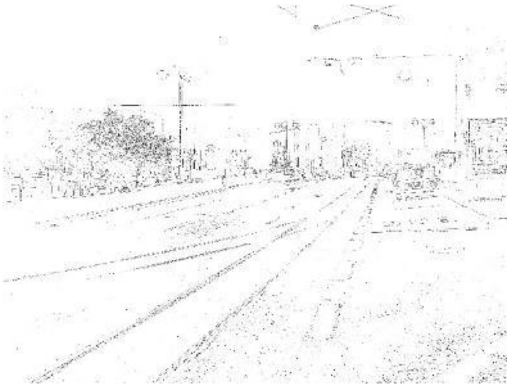



35. Elevador de santa Justa

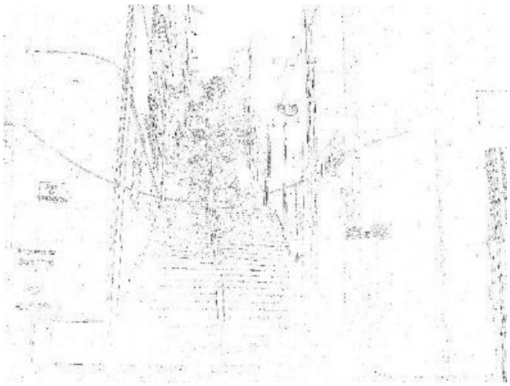



36. Jardim da Estrela

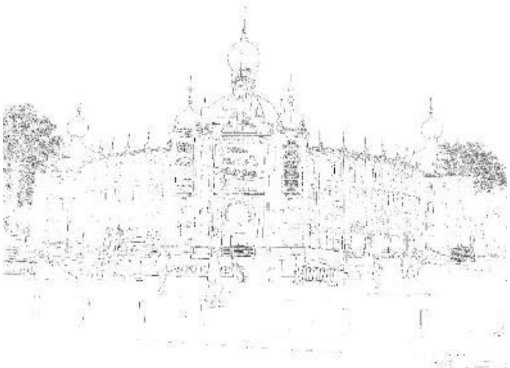
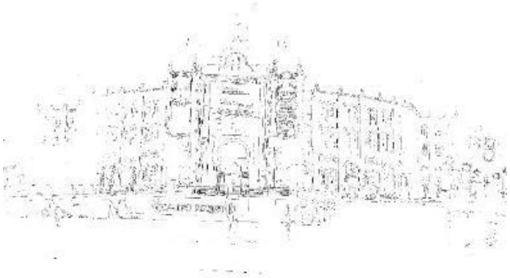
DAY | **NIGHT**

37. Largo do Rato

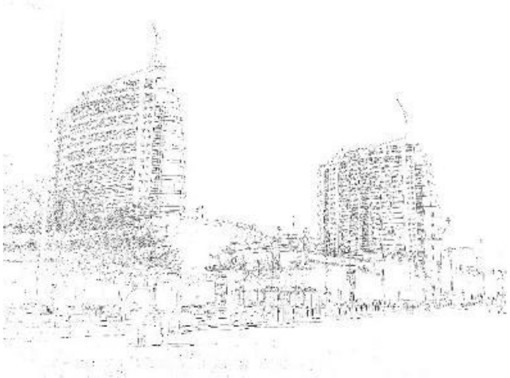



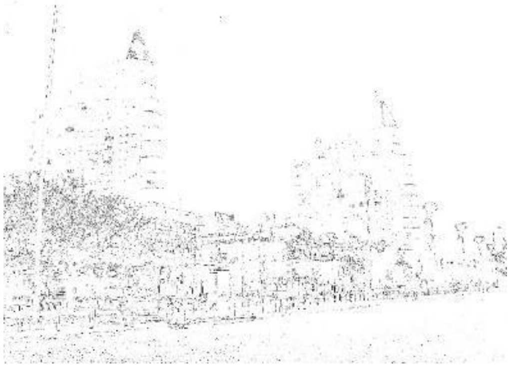
38. Mouraria

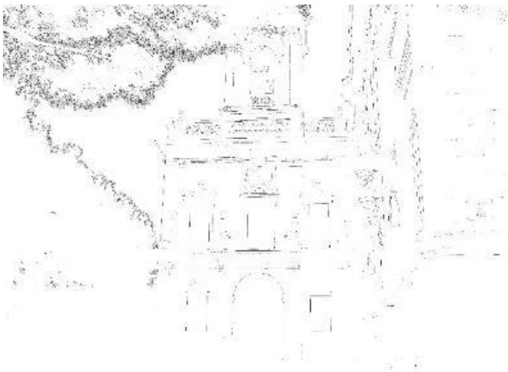
39. Campo Pequeno

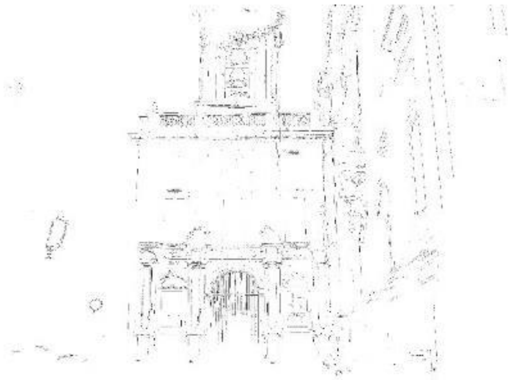
DAY **NIGHT**



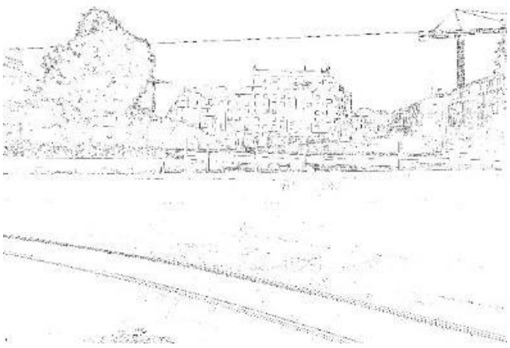


40. Parque das Nações

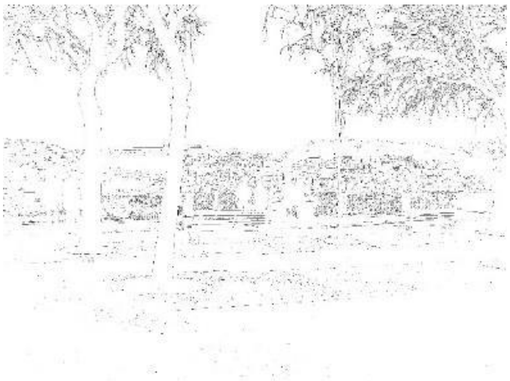
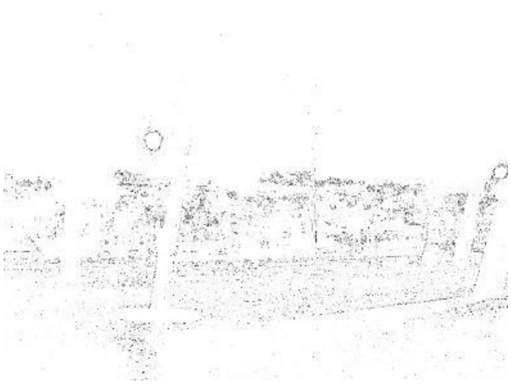




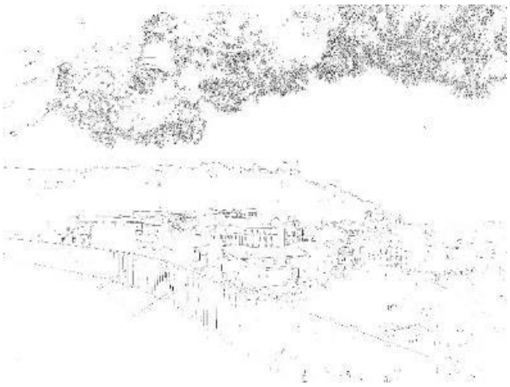
41. Graça



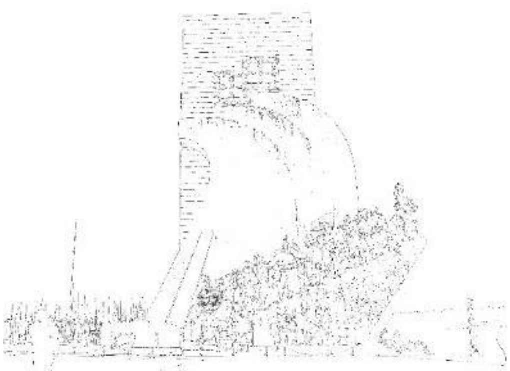
42. Martim Moniz

DAY	NIGHT
	

43. Miradouro de São Pedro de Alcântara

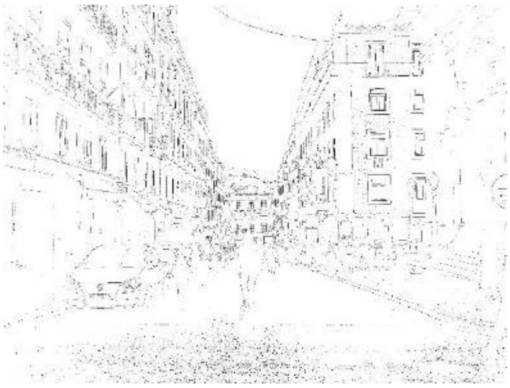
 

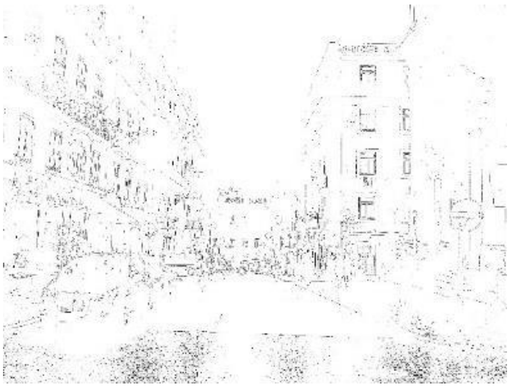
44. Miradouro da Graça

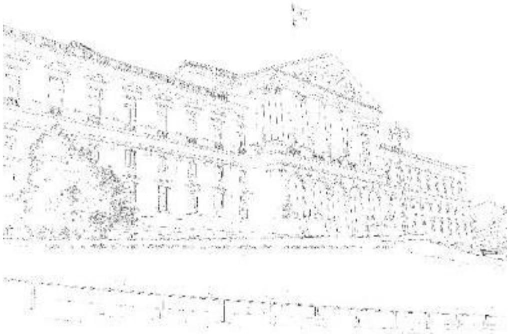
45. Padrão dos Descobrimentos

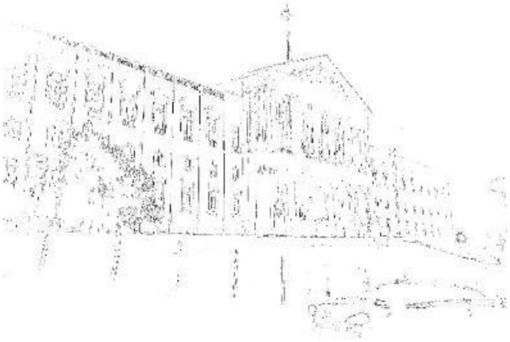
DAY **NIGHT**



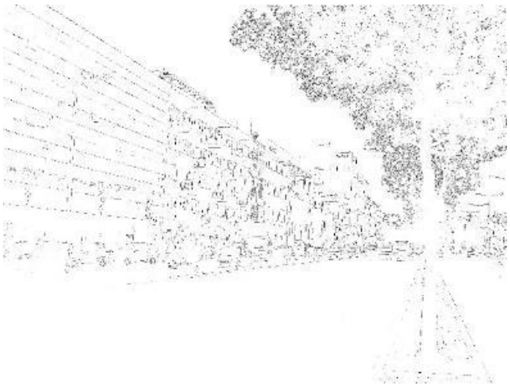


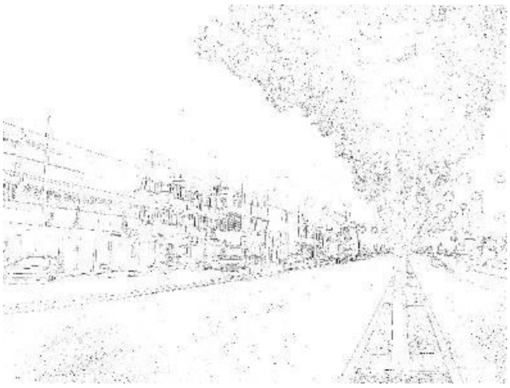
46. Rua Garrett





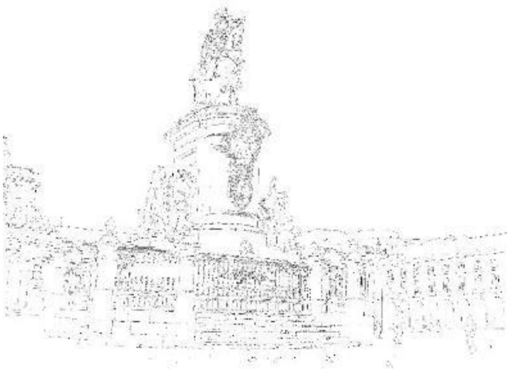
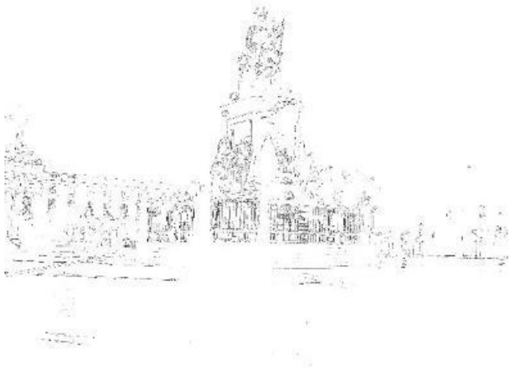
47. Assembleia da República



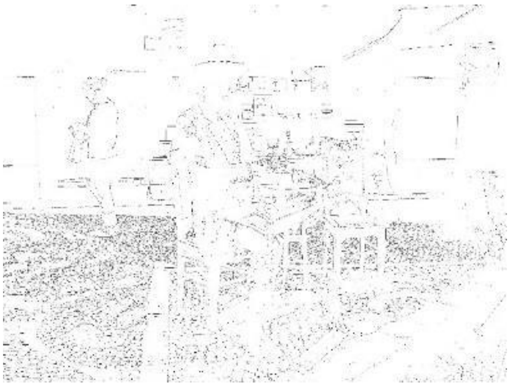
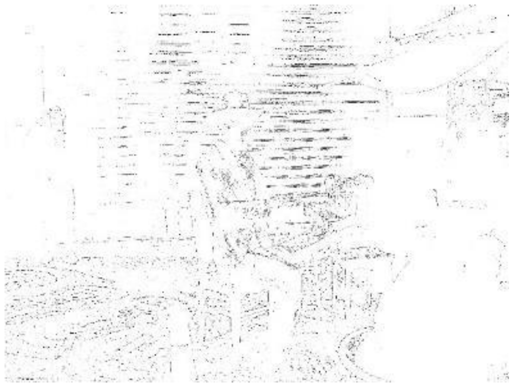


48. Avenida 24 de Julho

DAY **NIGHT**

49. Estátua de D. José

50. Estátua Fernando Pessoa