CO-230

# SKETCH MAP ANALYSIS TO STUDY DRIVER´S NEEDS OF URBAN ELEMENTS FOR SELECTION OF ROUTE GUIDANCE INFORMATION

*C. REIS Y., M. S. DECANINI M., A. PUGLIESI E., M. TACHIBANA V.*
*Unesp - Universidade Estadual Paulista, PRESIDENTE PRUDENTE, BRAZIL*

## ABSTRACT

The presence and use of in-car navigation systems is currently increasing. These systems are used by people who need navigational information to reach their destinations. However, in some cases (e.g.: commercial systems used in Brazil) they only provided information about the vehicle's location on the display systems and directional arrows. Different studies conducted in the U.S.A., England, Japan, and Sweden investigate what information the drivers of the urban environment select from their memory. These studies suggest that the cognitive map of the drivers is the best source of information for route guidance. Those indicate the need to understand the motorists' internal representations of the environment to conceive systems that provide efficient navigational information. Thus, this research investigates what aspects of environment some drivers use when navigate, assuming people who are familiar with an area as "the best navigation system". For that, the sketch map method was applied for selection of the route guidance information. In this study fifty (50) drivers who were familiar (undergraduate and postgraduate students, as well as taxi drivers) with the study urban area, were given the task of draw a sketch map of a predefined route. The drivers should start in a common place, reach two different places before arriving the final destination in the town of Presidente Prudente, São Paulo State, Brazil. After preparing the sketch map, subjects answered a questionnaire about their individual characteristics. The results show the analysis of Lynch's components for cognitive map, the types of landmarks, and the influence of some individual characteristics of the subjects. In order to analyze Lynch's components, the types of landmarks, and the influence of some individual characteristics of the subjects nonparametric statistical tests were applied. These statistical tests allowed to performeing comparative analysis of qualitative variables. The statistically significant results indicate that people prefer to use Paths, Nodes and Landmarks in their maps to represent a route. These urban elements are closest to the drivers view, or are frequently noted. Additionaly, women representation of landmark are significantly greater than men, as well as student´s representation of this urban element in relation to taxi drivers. Among all the participants, the most drawn types of Landmarks were: traffic lights, hospitals, schools, park and gas stations, components widely used by drivers as shown in other researches in different countries like Sweden, Japan and England. However, some of the current marketed navigation systems in Brazil do not present the most used types of Landmarks found in different studies. Thus, regardless of urban layout in which drivers navigate, it seems that the most used urban elements are similar. In summary, this paper implications are centered in the knowledge of which urban elements people uses when represent a route that contain useful route guidance informations to conceive navigation systems.

## KEYWORDS

Navigation System, Information Guide Route Method, Sketch Map Method.

## 1 INTRODUCTION

It has long been established that drivers have difficulties in planning and following efficient routes to destinations (KING, 1986; STREETER, 1986; WIERWILLE, 1993). To help drivers with their tasks while driving, many modern vehicles are equipped with in-vehicle navigation systems that utilize global positioning systems (GPS), digital maps, and automatic route calculation (LEE et al., 2008). The main objective of in-vehicle navigation systems is to provide drivers with information on the basis of which they can select a route to the desired destination (DAIMON, et al. 2000). These devices meet a need of drivers to enhance the safety, comfort and efficiency of their travel (GIRARDIN e BLAT, 2010) Thus, in order to develop an efficient navigation systems that contains useful information to drivers, it is necessary to understand what types of information they need in their navigation processes, and also how they use it (BURNETT, 1998). Researches related to the selection of information for the designing of Route Guidance Systems have been developed mainly in Europe, USA and Japan (ALM, 1990; OBATA et al. 1993: BURNETT, 1998; DAIMON et al. 2000; LEE et al., 2008). Recently, this subject has also being studied in Brazil (and PUGLIESI DECANINI, 2005; PUGLIESI and DECANINI, 2009; REIS et al., 2010). In this context, studies seek to understand some basic elements that are present in the cognitive maps of drivers, through analysis of their mental maps. A mental map can be a sketch map of a specific region,

which can be drawn on paper and is only based in people's memory (HALLOWELL, 1955). A mental map does not use a base map or any other previous document, so it can be called sketch (LYNCH, 1997; BERTRAND, 1984; DAIMON et al., 2000). The process of preparing a sketch map refers to the external representations, and this is based on cognitive maps as they relate to internal representations, which are structured in the long-term memory (TOLMAN, 1948; DOWNS and STEA, 1973; TVERSKY, 1993; HIRTLE, 1998). The cognitive map is a process composed of a series of psychological transformations by which an individual acquires, codes, stores, recalls, and decodes information about the relative locations and attributes of phenomena in their everyday spatial environment (DOWNS and STEA, 1973). In this way cognitive maps allow people to save time, by using past experiences to understand present and future situations (DOWNING, 1992). Cognitive maps are inextricably linked with the perception of the environment (i.e.: how people form mental images of places) (LYNCH, 1997). It is reported that the behavior of drivers during route selection is influenced by such cognitive maps (DAIMON, 2000), and therefore the consideration of cognitive maps while designing in-vehicle navigation systems is important. To design an effective route guidance, it is necessary to consider factors such as urban layouts and regional characteristics which comprise the driver's daily environment (DAIMON, 2000). Thus, this study aims to investigate the external representation, specifically the cartographic sketches of a group of drivers within the context of a Brazilian urban layout, using information from a guide route, previously known and selected by them to their in-car navigation. This study seeks to provide input to the design of navigation systems, through an understanding of spatial elements that drivers select during their navigation. Therefore, this work is based on the approach of the sketch map method (OBATA et al., 1993; ALM, 1990). This approach take into account that people thoroughly familiar with a particular environment are the best navigators in this location, due to their greater knowledge and prior experience in navigational area, which gives them a cognitive map with greater amounts of information from the environment. To analyze the information contained in the cartographic sketches, this research used the Lynch´s classification of urban elements: paths, landmarks, districts, nodes and edges, and further classification about the types of Landmarks.

## 2 METHOD

A well-formed cognitive map enables a person to navigate for others, for example by providing verbal directions (HILL, 1987). Designing virtual worlds through which subjects can navigate and orientate themselves successfully requires an understanding of cognitive map formation in virtual environments (BILLINGHURST, M. and WEGHORST, S, 1995). Additionally, Golledge (1999) pointed out that cognitive maps are highly subjective and specific. Thus, one challenge to study the cognitive maps of humans is to define the type of extraction method of data. Although individuals using often the same types of elements, based on their memory, there is no evidence to remind the elements just as they are perceived. The methods about the study of cognitive processes aim, in short, understand the procedures for selection of information from the environment through analysis of mental representations of external people. The analyses of these representations were based in studies of cognitive processes, and among different methods. The sketch map method is defined as a mode of assessment of cognitive maps of individuals (GOLLEDGE, 1989; BERTRAND, 1984). The sketch map method used in this work basically consists of asking participants to develop graphical representations, based only in their memory for a particular urban environment.

From the preparation of a sketch map, it is possible to assess the ability of people to recall elements of the environment that were previously stored in its memory. People familiar with the environment provides more information on their sketches (KIM and PENN, 2004). The sketch map method provides different types of elements that can be analyzed, such as topological relations as point, line and area, sequences of navigational information along the following routes or segments, as well as the locations of maneuver along the routes (KIM AND PENN, 2004). This process does not use cartographic databases or any other document in advance. It simply uses information stored in cognitive maps, from the knowledge gained in space (LYNCH, 1997; BERTRAND, 1984; DAIMON et al., 2000). This technique has been used in different fields such as Psychology, Geography, Cartography, Education and others. Thus, it has the advantage of being easy to use and allow different types of analysis. The sketch map method allows the professionals involved in the development of route guide systems to understand the elements used in the direction of car, and how they are used, and it is based on how they are perceived and remembered by drivers.

## 3 SKETCH MAP METHOD: CASE STUDY PRESIDENTE PRUDENTE/SP – BRAZIL.

This technique was chosen because it allows the professionals involved in the development of route guidance systems to understand the elements that people use when they imagine an urban environment that is present in their memories.

### *3.1 Route of study*

First, it was selected a route to be tested in the city of Presidente Prudente, SP. The criteria for the route selection is that it should contain different urban elements. It was established as the starting point of the route, the FCT-UNESP campus. The participants should also accomplish intermediate points: a bus station and the main church of the city (São Sebastião Cathedral), located in downtown. The cathedral was chosen because it is a remarkable landmark in the urban area and it is located in a region that has different urban elements (Paths, Landmarks, Nodes, Districts and Edges). This makes possible an analysis of perceptions and use of different features of a city by participants to represent a route. The ending point was the church Nossa Senhora Aparecida, located at District of Vila Marcondes, located next to a railway line. All the participants showed know the breakpoints of the route in the study area, since they should have some degree of familiarity with the route, to be considered "good navigation systems".

### *3.2 Subjects*

To accomplish this preliminary study, was selected a total of 50 (fifty) people, 30 (thirty) women and 20 (twenty) men. The participants consisted of students from the campus of the FCT/UNESP (Students of the Post-graduate Program in Cartographic Science, Architecture, Geography, Education, Physical Therapy, Mathematics, Environmental Engineering, Physical Education) and also taxi drivers of the city of Presidente Prudente. To participate of the test were adopted the following criteria: subjects should assure experience with direction by car, live in Presidente Prudente city for at least 5 (five) years, and have no visual impairment, such as color blindness, and any type of blindness.

### *3.3 Materials*

To produce the cartographic sketches were used basic drawing paper (A4) and pencil. The method of data collection and data analysis was based on the approaches of Alm (1990), Obata et al. (1993) and Burnett (1998). Furthermore, a questionnaire was applied to gather individual characteristics data.

### *3.4 Test Procedures*

In developing the cartographic sketches, the participants were approached individually, and in groups in the case of taxi drivers. To each person was given guidelines about how to proceed in the test.

### *3.5 Data Organization*

The data was organized according to the approach of Alm (1990) wich was based on 3 (three) classifications: the urban environment elements (LYNCH, 1997), frequency of use of the element Landmark, and the types of landmarks used by the participants. It is noteworthy that these three aspects in the data organization took into account the influence of certain individual factors: gender (male and female), profession (students and taxi drivers) and training with maps (people graduated-trained with maps and untrained with maps). Furthermore, this research used non-parametric statistical tests that allow performing comparative analysis of qualitative variables using scientific methods. The non-parametric statistical tests used are specific for situations in which the variable distribution is not known, or the variable does not have normal distribution, in this research the data are discrete. This study adopted the Cochran's Q test, Correspondence Analysis and Fisher's test.

## 4 RESULTS

### *4.1 Urban Elements*

To evaluate the information to be presented to drivers in navigational systems, studies should compare the efficiency of different types of information as the urban elements represented in the sketches maps (BURNETT, 1998). Thus, it was analyzed the use of urban elements by the statistical test of Cochran that showed the difference in use between the elements was significant. The results of this analysis show that people most frequently used the elements Paths, Nodes and Landmarks to represent a route ($Q = 174,4$). It is important to point out that the element Landmark was represented in all the cartographic sketches of the participants. Figures 01 and 02 are two examples of cartographic sketches in which can be seen the higher presence of urban elements, in the case, Paths, Nodes and Landmarks.

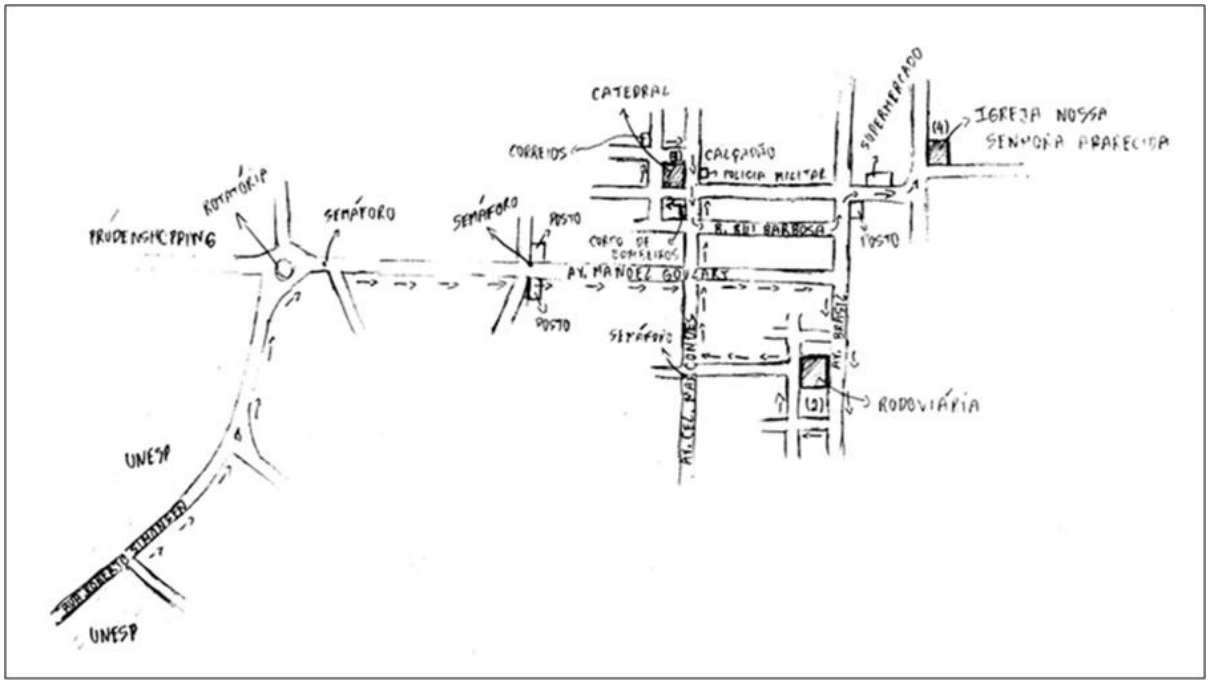


*Figure 01 - Example of cartographic sketch with high presence of the elements Paths, Nodes and Landmarks.*

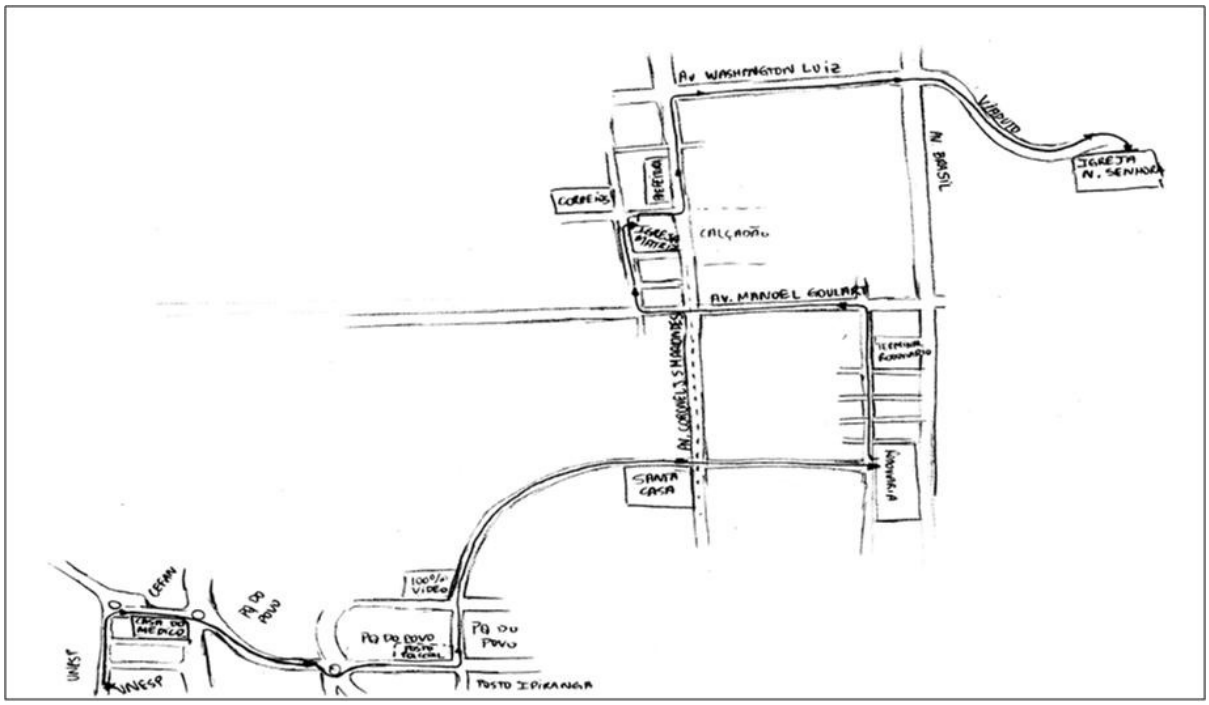


*Figure 02 - Example of cartographic sketch with high presence of the elements Paths, Nodes and Landmarks.*

Additionally, it was noted that a few subjects mentioned the railway line located as a potential Edge in the cartographic sketches. The lack of that element in the sketches may be related to its deactivation for passengers use. It shows that people most often represent the elements that are nearby and easily located in their visual field, as well as the ones highly visited by drivers.

### *4.2 Landmarks Types*

The absence or presence of landmarks along the route of drivers change their navigational behavior, this suggests that the same may occur when they are exhibit in the display of the navigation systems (BURNETT, 1998). People with low spatial ability or that do no navigate in environments with a certain frequency, present greater number of landmarks in their cartographic sketches (STREET AND VITELLI, 1986). Landmarks reduce the navigational uncertainties and mental workload, and also increase the

usability of navigation systems (BURNETT and LEE, 2005). Thus, to understand what types of Landmarks people used most, these were classified according to the frequency in cartographic representations and related to the driver´s individual characteristics: gender, profession and training with maps. The correspondence analyses were divided into two classes: participants who used the element Landmark, and participants who did not use this element. This was done in order to analyze the proximity of the urban elements and the individual characteristics variables. It was observed the distance of the variables from the classes. In the variable gender, women had a high proximity with the class "used landmarks", on the other hand, men were more closely with the class "did not use landmarks."

By analyzing the individual characteristics “profession” and “training with maps”, the students, in general, had higher proximity with the class "used landmarks." However, the taxi drivers were more closely with the variable "did not use landmarks”, like men in general, but with less closeness than them. Gender differences related to spatial ability, involve biological factors influenced by experiences and learning throughout people's lives (GUALIN AND HOFFMAN, 1988). Given this, testing was undertaken to ascertain the influence of gender, previous experience, training with maps and profession of participants in the representation of the elements related to car navigation in urban environments. These characteristics were analyzed in relation to the Landmarks. The elements Paths and Nodes were not analyzed at this time because all were represented in cartographic sketches, as well as the element that unlike Districts, was not represented in any draft. The element Edge also had insignificant representation in the sketches maps. In analyzing the gender of the participants regarding the use of the element Landmark, women used it in greater quantity in their sketches (women = 233 and men = 85), and also in different total types of landmarks in relation to men (women = 43 and men = 31), with the p-value = 0,001685. Observing the use of different types of landmarks by drivers, regardless of individual characteristics, they use more frequently the follow Landmarks: lights (10.6%), hospitals (8.7%), schools (7.7%), the Parque do Povo (6.5%), service station (5.6%) and an overpass (5.6%), called by people as "small bridge". Together, these six types of landmarks corresponding to approximately 45% frequency of use among the 76 (seventy-six) different types of marks. It is worth noting that the Landmark “Parque do Povo”, whose use was represented in the sketches, is a site of extensive use by city residents, giving it a constant presence in sketches, this indicates that the places frequented largely by people in cities are characterized as notable landmarks, and so are represented in most of the cartographic sketches. The results of the percentage frequency of analysis related to frequency and types of Landmarks used, point out the Landmark "Traffic Light" as the most represented in the cartographic sketches. There are compelling research findings that using landmarks such as traffic lights in the navigation can enhance the acceptability, usability and safety of vehicle navigation systems (ROSS et al., 2004). There are similarities between studies of Obata (1993) and Alm (1990) regarding the use of such Landmark "traffic light ". Thus, it may indicates that regardless of the urban layout, high frequency of drivers use this type of landmark, followed by gas stations, shops, signs of guidance, and specifically in the sketches that represented the city of Presidente Prudente, hospitals, schools and park people.

## 5 CONCLUSIONS

The sketch map method allowed collecting urban elements that drivers use and analyze them in relation to different individual characteristics in the city of Presidente Prudente / SP. From the results it was possible to observe what types of information drivers represent in their cartographic sketches. It can be concluded that drivers prefer to use urban elements which are closer to theM, or are observed most frequently. Thus it is recommended that these elements should be added when designing navigation systems, since they are located in the immediate surroundings of the perception of drivers, and can be regarded as the most used elements especially in comparison to items less selected, the Edges and Districts. Those elements may generate topophobia, a aversion to a site, due to its low usage in inhospitable place or location (TUAN, 1980). In representing “mega-environments" as the element Districts, these are possibly not drafted because people observe with greater efficiency places closest to their vision. Thus the Districts are left out of the representations as they are continuous and open spaces, with no boundaries clearly defined, (PINHEIRO, 2006). It was also analyzed some individual characteristics in relation to the element Landmark. Women used this element with higher significance than men, as well as students and taxi drivers. The most used Landmarks were the traffic lights, hospitals, schools, Parque do Povo, gas station and a bridge, elements also widely present in other studies, realized in different countries, like Sweden, Japan and England (ALM (1990), OBATA et al. (1993) and BURNETT (1998)). However, the landmarks "traffic lights" are not represented in the navigation systems available in Brazil, for example: Igo, Destinator, Miomap, and Polnav. It can be concluded that the results have certain similarities with studies carried out in other countries. However, due to the constrain of thE SKETCH method, such as loss of

realism, it is suggested that other methods , in which the driver has to drive effectively, like drive in the streets and driving simulator should be applied. It can help researchers to observe driver´s reactions while they actually drive. Therefore it is recommended the use of equipment that simulates the real environment of a vehicle. Thus, further research is required by combining different methods, in order to evaluate with more accuracy the type of information that are needed by drivers at the moment of their navigation.

**ACKNOWLEDGEMENTS**

The authors thanks the graduate program in cartography, faculty of science and technology, Unesp, Presidente Prudente and Capes for the scholarship provided to the author in the period that he developed the content of this research.

**REFERENCES**

ALM, H. Drivers cognitive models of routes. DRIVE project V1041 (GIDS). Groningen, The Netherlands: University of Groningen, Traffic Research Centre.1990.

BERTRAND, R. J. Mental Mapping Experiments at ITC. ITC Journal, Cartography Department, ITC. 1984.

BOARD C. Map Reading Tasks Appropriate in Experimental Studies in Cartographic Communication. The Canadian Cartographic, v. 15, n. 10, p.32, pp. 1-12. 1978.

BURNETT, G.E., LEE, K. The effect of vehicle navigation systems on the formation of cognitive maps. Final draft of paper for G. Underwood (Ed.) Traffic and Transport Psychology: Theory and Application, Elsevier. 2005.

BURNETT, G. E. "Turn right at the King's Head": Drivers' requirements for route guidance information. PhD Thesis, Loughborough University, UK. 1998.

DAIMON, T., NISHIMURA, M., KAWASHIMA H. Study of Driver´s Behavioral Characteristics for Designing Interfaces of In-Vehicle Navigation Systems Bases on National and Regional Factors. Journal of Society of Automotive Engineers of Japan, Inc. and Elsevier Science. pp. 379-384. 2000.

DARKEN, R. P. Navigating virtual worlds: Wayfinding and locomotion in real and not-so-real environments. Carnegie Mellon University, HCI Seminar Lecture Series. 1997.

FREKSA, C. Spatial aspects of task-specific wayfinding maps. A representation-theoretic perspective. In J.S. Gero and B. Tversky (Eds.), Visual and spatial reasoning in design. Sidney: Centre for Design Computing and Cognition. pp. 15-32. 1999.

GOLLEDGE, R. G., GARLING, T. Environmental perception and cognition. In: E. H. Zube and G. T. Moore, Editors, Advances in Environment, Behavior, and Design, Plenum Press, New York, pp. 203–236. 1989.

GOLLEDGE, R. G. Wayfinding behavior: Cognitive mapping and other spatial processes. Baltimore, MD: Johns Hopkins Press. 1999.

GOULD, M. D. Considering individual cognitive ability in the provision of usable navigation assistance. Proceedings, First Vehicle Navigation & Information Systems Conference (VNIS '89), IEEE Vehicular Technology Section, Toronto, Ontario, September 11-13, 1989, pp. 443-447. 1989.

JOHNSON, R. A., WICHERN, D. W. Applied multivariate statistical analysis. Upper Saddle River, NJ: Prentice-Hall. 2007.

KIM, Y. O., PENN, A. Linking the Spatial Syntax of Cognitive Maps to the Spatial Syntax of the Environment. Environment and Behavior. 2004

LOVELACE, K.; HEGARTY, M.; MONTELLO, D. Elements of Good Route Directions in Fa-miliar and Unfamiliar Environments. In: Freksa, C.; Mark, D. (Eds.), Spatial Information Theory. Lecture Notes in Computer Science, 1661. Springer, Berlin, pp. 65-82. 1999.

LYNCH, K. A imagem da Cidade. São Paulo. Martins Fontes, 1997.

OBATA, T., DAIMON, T., & KAWASHIMA, H. A cognitive study of invehicle navigation systems: aplying verbal protocol analysis to usability evaluation. In Proceedings of Vehicle Navigation and Information Systems Conference. Piscataway, NJ: Institute of Electrical and Electronics Engineers. pp. 232-237. 1993.

RAUBAL, M., WINTER, S. Enriching Wayfinding Instructions with Local Landmarks. In Geographic Information Science. (Egenhofer, M.J., & Mark, D.M., (Eds.), Lecture Notes in Computer Science, Vol. 2478, Berlin, Springer, pp: 243-259. 2002.

SIEGEL, S. Estatística não-paramétrica para as ciências do comportamento. São Paulo: McGraw-Hill, 1975.