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DRIVERS' REQUIREMENTS FOR IN-CAR ROUTE GUIDANCE INFORMATION: GENDER AND INDIVIDUAL DIFFERENCES

Necessidades dos Motoristas por Informação de Guia de Rota em Automóvel: Diferenças Individuais e de Gênero

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ABSTRACT

This research work aims to investigate drivers' requirements for in-car route guidance information taking into account differences in gender, profession and training in map making. A total of 50 participants (30 female and 20 male), graduate and undergraduate students, as well taxi drivers, participated in this experiment. The map sketch method was adopted to gather data on route guidance information. Results indicate that paths, landmarks and nodes were the most used. The majority of landmarks are located mainly in the maneuvers, and traffic light was the most used followed by hospital. Traffic lights, specifically, were used just in the maneuvers of the route. Furthermore, it was found a high difference for gender and profession, indicating that women use more landmarks than men, and students use more landmarks than taxi drivers. Also, nearly 100% of the participants used street names as references in their sketches, suggesting a need for this kind of information during route following task. The reference system more used was the local scheme (egocentric scheme with presence of landmark). Points of reference along the route may determine an element as an important landmark, even not having a great visual attraction. More implications about drivers' requirements for route guidance information are discussed in this paper.

Keywords: In-Car Route guidance and Navigation Systems, Cognitive Maps, Gender and Individual Differences.

RESUMO

Este trabalho de pesquisa tem o objetivo de investigar as necessidades dos motoristas por informação de guia de rota em automóvel, levando-se em consideração diferenças no gênero, profissão e treinamento em construção de mapa. Um total de 50 participantes (30 mulheres e 20 homens), estudantes de graduação e pós-graduação, bem como taxistas, participaram deste experimento. O método de esboço cartográfico foi adotado para selecionar informação de guia de rota. Os resultados indicam que caminho, marco e nó foram os elementos mais utilizados. A maioria dos marcos que foram usados está localizada, principalmente, nas manobras, e os semáforos foram os mais selecionados, seguidos de hospital. Os semáforos, em específico, foram usados somente nas manobras da rota. Além disso, foi encontrada alta diferença para gênero e profissão, indicando que as mulheres usam mais marcos que os homens, e que os estudantes usam mais marcos que os taxistas. Também, aproximadamente 100% dos participantes usaram nomes de vias como referências em seus esboços, sugerindo uma necessidade por este tipo de informação durante a tarefa de manutenção em rota. O sistema de referência mais usado foi o esquema local (esquema egocêntrico com a presença de marco). Os pontos de referência localizados ao longo da rota podem determinar um elemento como um marco importante, mesmo que não apresente uma grande atração visual. Mais implicações sobre as necessidades dos motoristas por informação de guia de rota são discutidas neste artigo.

Palavras-chave: Sistema de Navegação e Guia de Rota em Automóvel, Mapas Cognitivos, Diferenças Individuais e no Gênero.

1. INTRODUCTION

In order to give support to drivers in route planning and route following, many vehicles are furnished with navigation systems. Thus, the route guidance and navigation systems interfaces should help drivers in the cognitive process (BURNETT; LEE, 2005). In such way they can use the provided information to support their navigation tasks. However, navigation systems could be too visually and cognitively demanding (BURNETT, 1998; GREEN, 2000). Thus, to develop an efficient route guidance system which contains useful information to drivers, it is necessary to understand what kind of information they need, and how they use it (BURNETT, 1998).

With regard to selection of information for designing in-car route guidance and navigation systems it seems that the majority of researches have been developed mainly in Europe, North America and Japan (ALM, 1990; OBATA et al. 1993; BURNETT, 1998; DAIMON et al. 2000; LEE et al. 2008; PAPINSKI et al., 2009). Those studies seek to understand some basic elements that are present in the drivers' cognitive maps, such as paths, nodes, landmarks, edges and districts (LYNCH, 1960). The cognitive maps are inextricably linked with perception of the environment (LYNCH, 1960) and related to group and individual differences (DABBS et al., 1998; BURNETT, 1998).

Investigations about the use of landmarks to support navigation task have suggested that 'good landmarks' presented visually and/or aurally in a in-car route guidance and navigation system can improve driver safety and performance (BURNETT, 2000; ROSS et al., 2004a; ROSS et al., 2004b MAY et al., 2005a; MAY et al., 2005b; MAY; ROSS, 2006). From a short range of good landmarks, traffic lights have been proposed as the most effective and valued element of information (BURNETT, 2000; ROSS et al., 2004b; MAY et al., 2005b). Additionally, the studies point out that prominent landmark located at or near maneuvers should be used to provide confirmation of the turn (MAY et al., 2005a).

Previous researches have pointed out differences between men and women, revealing that women tend to rely more on landmarks than men (DABBS et al., 1998; BURNETT, 1998). Researchers from different countries have found different drivers' requirements for route following information according to aspects like nationality, technique of externalizing information and urban layout (SOARES et al., 2012). Daimon et al. (2000) point out that to develop an effective route guidance system, it is important to consider the urban layout and regional characteristics. Occurrence of potential cultural indicators suggests differences across cultural groups in different environments (HASNI; BURNETT, 2011).

Drivers' requirements for route guidance

information has also been a subject of interest in Brazil (PUGLIESI; DECANINI 2005; PUGLIESI et al., 2009; PUGLIESI; DECANINI, 2009; REIS, 2010; REIS et al., 2010; MORETTI et al., 2013). However, this subject needed to be investigated in terms of individual and group differences, in a national context. Thus, this research aims to investigate the cognitive maps of a group of drivers, in the urban layout of a city located in the west of Sao Paulo State, Brazil, taking into account gender and some individual differences like profession and training in map making. We intend to point out suggestions for the development of future national navigation systems, in order to reduce the complexity of driver's cognitive processing.

2. METHOD

To understand drivers' cognitive maps, map sketch, verbal notes (also known as written instructions or written notes) and thinking aloud techniques can be used to externalize individuals' environmental knowledge (SOARES et al., 2012). Map sketch and verbal notes use basically paper and pencil in the experiment. Thinking aloud and question-asking protocols could be used also on road in a moving car. It is reported that subjects seem to use more information in each category proposed by Lynch (1960) when they use map sketch instead verbal description (ALM, 1990; OBATA et al., 1993). Furthermore, the map sketch technique has the advantage of being easy to use and allows employing a variety of analysis on the data (OBATA et al., 1993). A previous research summarizes evidences about asking individuals to draw a sketch map as a reliable method of data collection, such as way-finding performance (COLLUCIA et al, 2007). Thus, the map sketch method was adopted to develop this research.

The map sketch method provides different types of elements that can be analyzed, such as topological relationship between geometries of point, line, area and volume, as well sequences of navigational information along the entire route (GOLLEDGE; GARLING, 1989; KIM; PENN, 2004; DALTON et al., 2013). It simply employs the use of information stored in the cognitive maps, from the knowledge acquired in previous navigational experiences (LYNCH, 1960; DAIMON et al., 2000; COLLUCIA et al, 2007). This method provides professionals with elements, which are necessary to develop RGNS that can reduce the system complexity.

2.1 Study Area

It was selected four places in the urban area of Presidente Prudente city (more than 200,000 habitants), which were highly familiar to the subjects who participated of the test. The first and the fourth places were origin and destination of the route, respectively (Fig. 1). There were two intermediate points. The choice of experimental route was important because it directly influence the types and amount of information available, as pointed out by Burnett (1998). The main entrance of the Faculty of Science and Technology of the Sao Paulo State University (FCT-UNESP) was the starting point. The destination was Nossa Senhora Aparecida church, which is located just crossing over a railroad. The intermediate points were the Central Bus Station and the São Sebastião Cathedral (Igreja Matriz). The cathedral was chosen because it is a remarkable landmark and it is located in downtown. The other points are located in different districts.

2.2 Participants

A total of 50 drivers took part in this study (30 female and 20 male): 39 undergraduate and graduate students at FCT-UNESP and 11 local taxi drivers. The students who participated in this study were enrolled in graduate and post-graduate courses. All the subjects had to be experienced drivers; they were living in the city for at least five years and had no color vision deficiency.

2.3 Procedure

The interview took place individually for students and in group for taxi drivers. For each person it was asked to draw a route between the origin and destination points, having two intermediate stopping places. Also, it was emphasized that the sketch should be used by a person totally unfamiliar with the city. To produce the map sketches it was used paper sheet (A4 format) and pencil. Furthermore, a questionnaire was applied to gather information about some individual characteristics.

2.4 Data organization

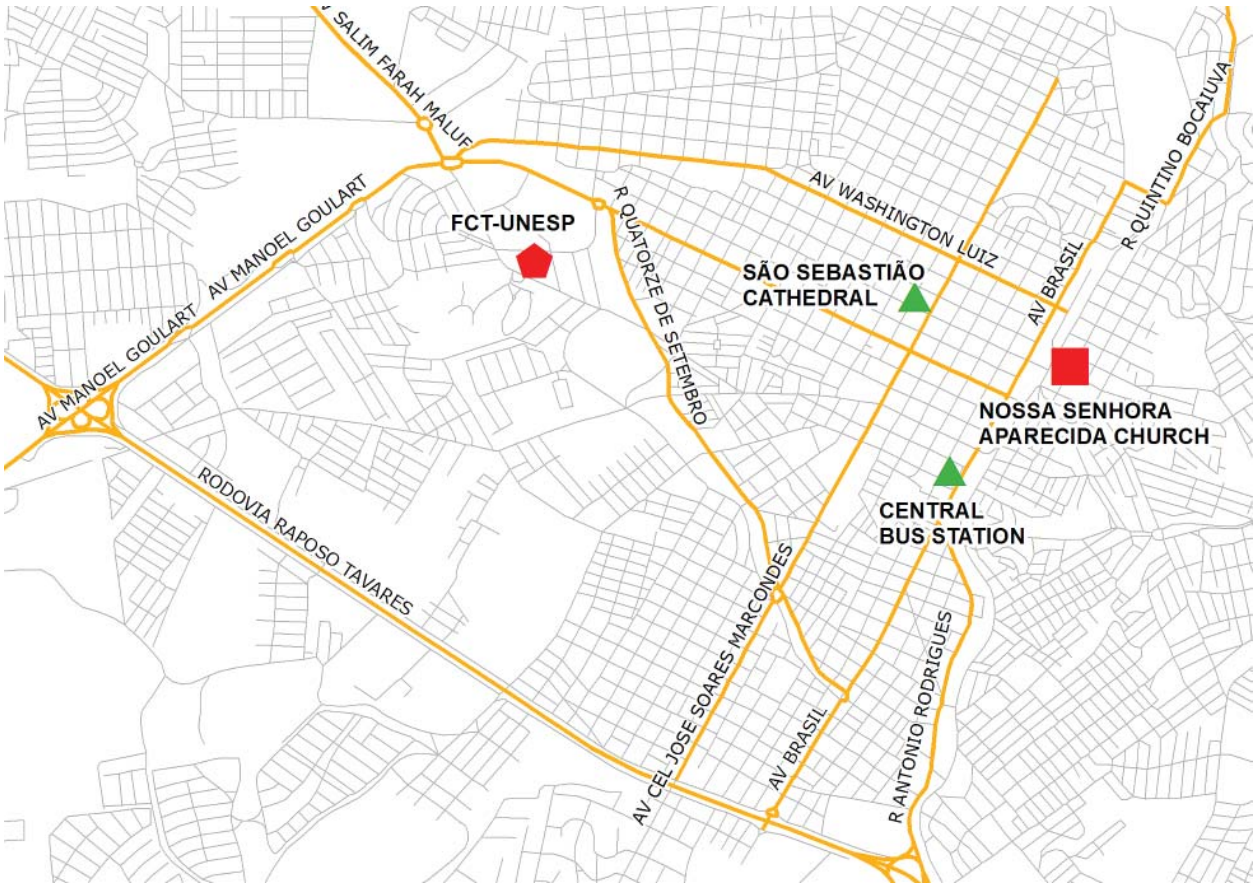

Fig. 1 – Study Area.

The data was extracted from the map sketches and analyzed according to the approach of Alm (1990), Obata et al. (1993) and Burnett (1998), which are based on four types of data classification: urban elements (landmarks, paths, nodes, edges and districts); types and frequency of landmarks; types of reference systems (global, local and egocentric); and street names as references.

The urban elements identified in the sketch maps are the same structured by Lynch (1960). Landmarks were recognized as point symbols (geometrical, pictorial and letter). Paths were identified as linear elements outlined as single lines or double lines. Nodes were typically connections of paths. Edges were identified as lines or areas that limit the continuity of certain paths, like river and railway. Districts were recognized as names that identify large regions in the city.

In order to perform the evaluation of reference systems it was made a categorization of them based on the schemes adopted by Alm (1990). An egocentric reference system (or scheme) was identified if the subject indicated direction of change. A global reference system was recognized by the presence of at least one of the cardinal points. The local reference system keeps the characteristics of an egocentric reference, additionally with the presence of points of interest, such as landmarks for navigation (Fig. 2). However, some sketches that did not matched with those mentioned before were considered as “Not clear”.

3. RESULTS

In order to analyze the urban elements and the reference systems we have considered the influence of gender (male and female) and some individual characteristics as profession (students and taxi drivers) and training in map making (trained and untrained). This research adopted non-parametric statistical tests that allow performing comparative analysis of qualitative variables.

The non-parametric statistical tests are appropriate when there are no assumptions about the shape or parameters of the distribution (SIEGEL, 1975; CONOVER, 1999). We used Cochran Test and Fisher Test to perform the statistical analysis. Statistical Package for the Social Sciences Software 16.0 (SPSS) includes

these tests for non-parametric analysis and provides the significance level (p = p value). From statistical point of view, a significant influence of the elements was defined as the significance level less than or equal to .05

3.1 Urban Elements

The urban elements outlined in the sketch maps were analyzed using Cochran test (Table 1). The results of the test, which was applied to the five categories showed significant difference in their use ($Q = 174.4$; $p<.01$), confirming that some elements are used more than others. These findings reveal that drivers do not use all the urban elements in the same proportion. On the other hands, the differences in the use of these elements by the drivers are statistically significant. The most used elements were paths, nodes and landmarks. Due to the difference between paths and landmarks, a new analysis was conducted and the results showed significant differences in the choice of them ($Q = 18$; $p<.01$).

3.2 Types and Frequency of Landmarks

To understand what types of landmarks were most used by the participants, the specific elements were classified according to the frequency in which they were presented in the map sketches. Table 2 shows the types and frequency of landmarks that were mentioned more than once by men or women. The frequency for each landmark corresponds to the number of subjects who represented it. In an overall glance it is possible to see that women use more landmarks than men, confirming previous investigations (DABBS et al., 1998; BURNETT, 1998). Fig. 3 shows the spatial distribution of the most used routes segments and landmarks. Except for one subject, 49 drivers chose two main route segments when leaving the origin point: 'Route A' and 'Route B'.

3.3 Reference Systems and Street Name

Table 1: Number of subjects using different urban elements

Urban elements	Subjects
Paths	50
Nodes	50
Landmarks	41
Edges	2
Districts	0

The Cochran test was applied to verify the use of different reference systems (Table 3). The results point out a significant effect on the use of schemes ($Q = 34.72$; $p < .01$). Also, an overall analysis was carried out taking into account the use of street names. From the 50 drivers, just one woman taxi driver did not used street names in her map sketch.

3.4 Group and Individual Differences

A more detailed analysis was carried out using Fisher test to evaluate gender, profession and experience in map making for the use of landmarks (Table 4). Related to gender, a significant difference was found between men and women when they used landmarks to navigate ($p < .01$). This indicates that women used a higher number of landmarks than men. Taking into account differences in gender between taxi drives, there was a significant statistical effect between men and women when selecting landmarks ($p = .01$), revealing that women taxi drivers use more landmarks than men taxi drivers (Table 4). Considering profession, all students used more landmarks than taxi drivers, and this was significant different statistically ($p < .01$). On the subject of experience in map making, the results indicate a trend in the difference of using landmarks between trained and untrained drivers ($p = .10$). Table 4 shows that drivers who did not have training in map making trend to use more elements to help in route following tasks.

4. DISCUSSION

The most used types of information were paths, landmarks and nodes. This result is similar to the findings showed by Alm (1990), Obata et al. (1993), Daimon (2000) and Lee et al. (2008). Additionally, the analysis showed significant differences in the use of landmarks, paths, nodes, edges and districts, possibly indicating different levels of importance of them for route guidance system. The element district was not used by anyone and edge (specifically a railroad) was used by only 4% of the drivers. This low frequency could be related to the characteristics of the area. The two best ways to reach the destination cross the railroad over two bridges. While driving over the bridges it is not possible to see clearly them. In this case, the railway could be considered as a type of 'topophobic'

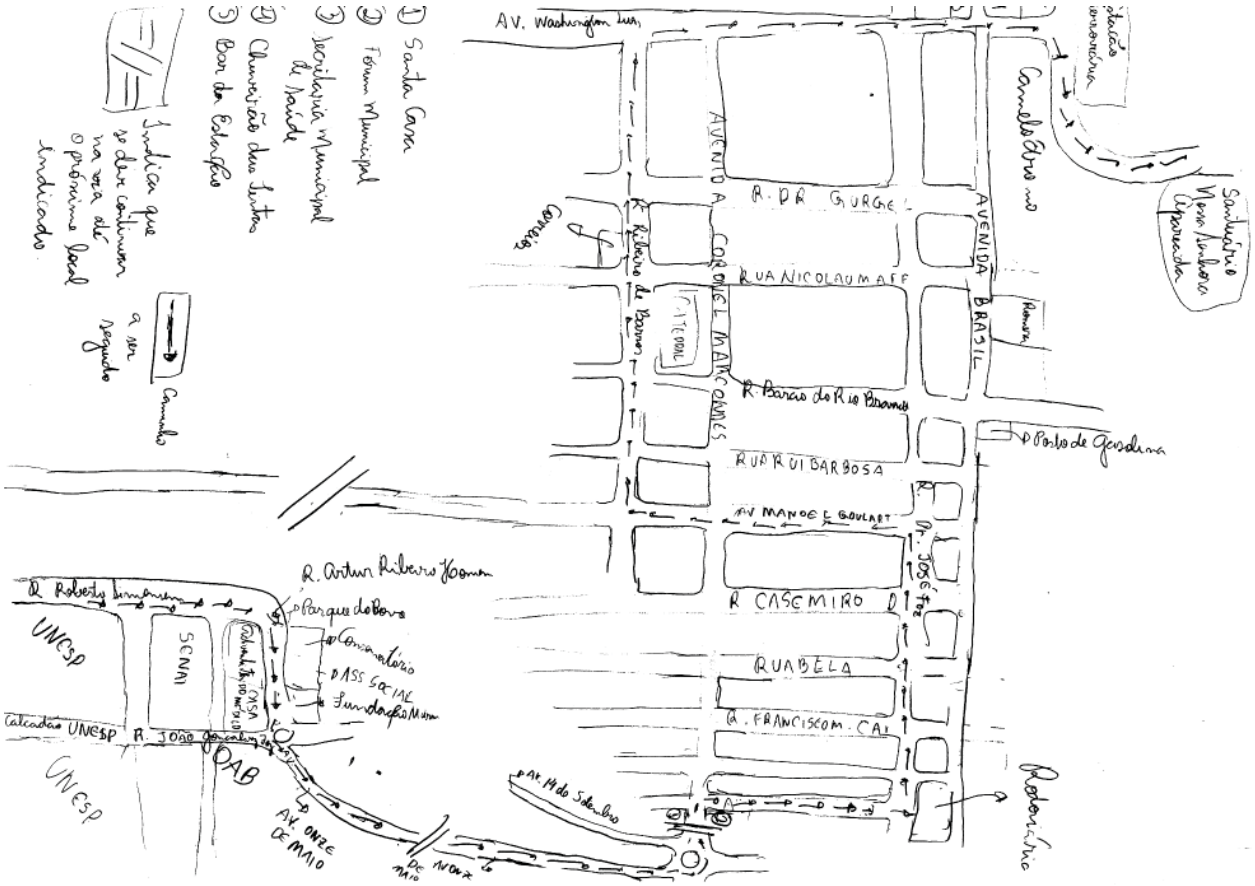

Fig. 2 - Example of a map sketch drawn by one participant.

Table 2: Frequency of the most used landmarks (M = Men; W = Women; T = Total)

Types of landmark	Frequency			Types of landmarks	Frequency		
	M	W	T		M	W	T
Traffic light	12	22	34	City Hall	1	5	6
Hospital	7	21	28	Police station	1	5	6
School	3	22	25	Sidewalk street	1	5	6
Park	5	16	21	Fire Station	1	5	6
Gas station	3	15	18	Office boy's house	5	1	6
Bridge over railroad	4	14	18	Supermarket	0	6	6
Square	2	10	12	Traffic signal	0	6	6
Bar	2	9	11	Small shops	2	3	5
Railroad station	4	6	10	Post office	1	3	4
Shopping	3	7	10	Doctor's house	2	1	3
Olympic Center	5	4	9	Restaurants	2	1	3
Lawyer's House	2	7	9	Bus station	0	3	3
Vertical Buildings	2	6	8	Soccer square	2	0	2
Bank	2	5	7	Gym	0	2	2
Hotel	3	4	7	Residential Condo	0	2	2
Popular market	3	4	7	Drugstore	0	2	2

element (TUAN, 1990), due to the deactivation of railroad service.

Considering types and frequency of landmarks, some elements such as traffic light and hospital were used more than 50% by all drivers. Taking into account the frequency of traffic lights, similar findings are shown by Alm (1990), Burnett (2000), Ross et al. (2004b) and May et al. (2005b). The spatial distribution of landmarks contributed for additional findings. Some traffic lights selected to support route following that are located distant from the

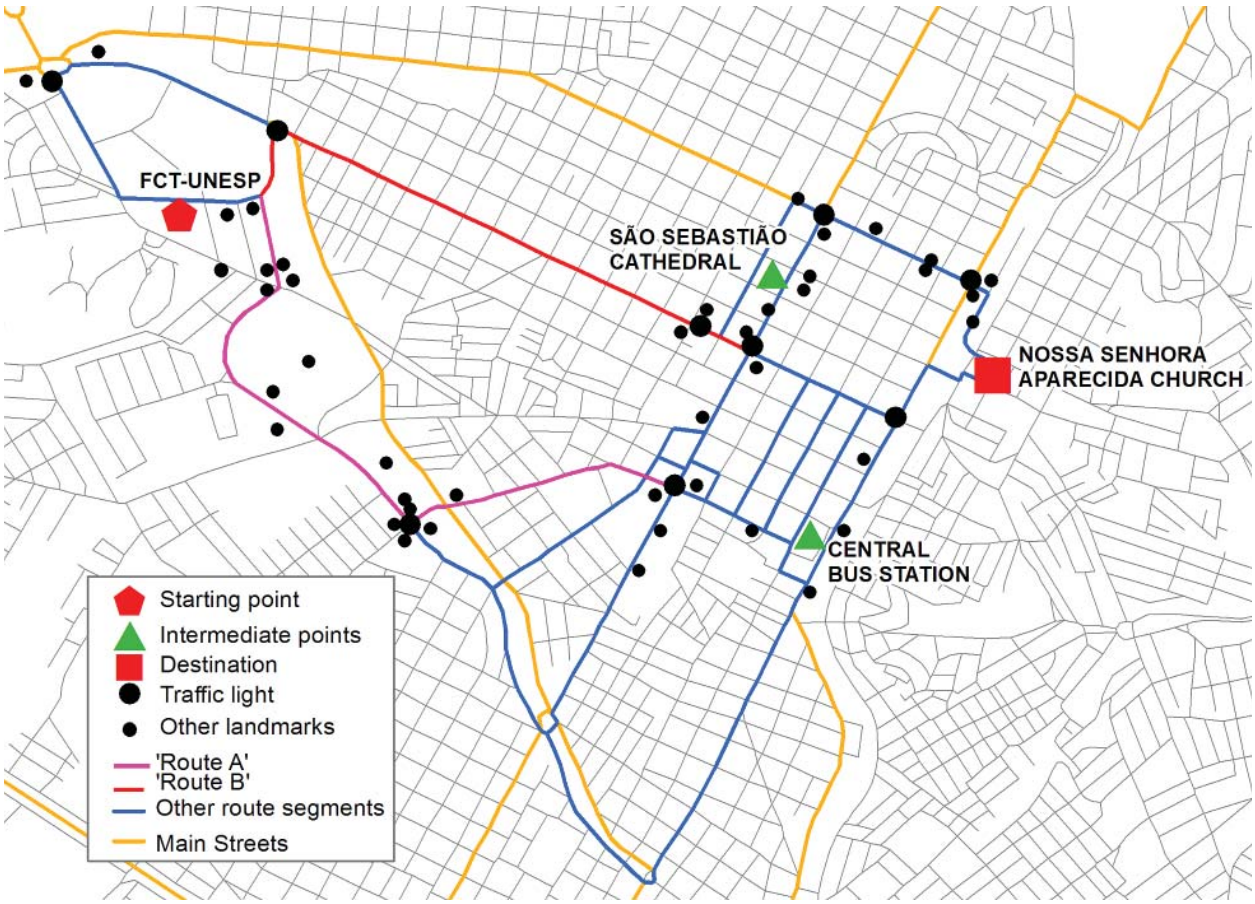

Fig. 3 - Spatial distribution of routes segments and some landmarks.

Table 3: Number of subjects using different reference systems

Type	Subjects
"Not Clear"	10
Egocentric	4
Local	36
Global	0
Total	50

Table 4: Number of subjects using or not using different types of information (Dvr = Drivers)

Gender			Taxi driver gender		
Category	Present	Absent	Category	Present	Absent
Women	29	1	Women	4	0
Men	12	8	Men	1	6
Profession			Training in map making		
Category	Present	Absent	Category	Present	Absent
Students	36	3	Trained	20	2
Taxi Dvr	5	6	Untrained	21	7

maneuvers were not sketched. On the other hands, traffic lights located in the maneuvers were more used. Even not having a great visual prominence, the majority of landmarks is located mainly in the turns and secondly near 'road obstacles' that are commonly used to reduce vehicle speed in Brazil.

Although there was significant influence on the use of different reference systems, the highest frequency occurred for the local scheme. This is quite different from Alm's work, which indicates the egocentric as the most used by the participants, followed by a combination of egocentric and others. In this research no one used global reference, similar to the findings provided by Alm (1990), Burnett 1998) and Reis et al. (2010).

Regarding to individual differences, the high difference for the use of landmarks between men and women corroborates previous findings (DABBS et al., 1998; BURNETT, 1998; ALLEN 2000). Also, results reveal that female students and female taxi drivers do not have difference on the need for landmarks. Concerning experience in map making, it was found a trend for participants who were untrained in using less number of landmarks than those who had experience.

5. CONCLUSIONS

The results allow us to express forward recommendations concerning what kind of

information should be used and where it should be represented in a map of a route guidance and navigation system. The majority of landmarks selected for route following were mainly located in the turns and secondly next to 'road obstacles'. Traffic light was the most used by the drivers and they were located in the maneuvers. Some prominent landmarks, such as high buildings, located distant from the maneuvers, were also used; possibly supporting navigation along the of route segments. While district does not seem a relevant element, the employment of edge requires further investigation in different regions of the city.

Taking into account individual differences, women relied on landmarks more than men. The choice of landmarks was more influenced by gender than experience with driving. In the matter of profession, students used more landmarks than taxi drivers. The fact of nearly 100% of the participants has used street names as references in their sketches indicate a need for this kind of information during route following task. Considering reference schemes, the largest use of local systems (egocentric scheme with the presence of landmarks) seems to indicate this one as the best for in-car route guidance.

Concerning experience with map making, future researches may investigate if those people who did not represent landmarks are not good at spatial skill or at drawing skill. Additionally, it would be relevant to use different methods of extracting route following information by using the same area of study to compare and integrate the findings. An investigation of the most important reference points, taking into account visual, cognitive and structural attractiveness, is a subject that should be conducted to provide more elements for designing route guidance systems.

Furthermore, a research work should be carried out in order to evaluate the usability of in-car route guidance and navigation systems that provide landmarks, which have presented them in different ways, such as 2D pictorial point symbols and 3D iconic point symbols having different levels of iconnicty. The evaluations could use specific techniques like those pointed out by Pugliesi et al. (2013). Further research is required to understand the reasons in which drivers select landmarks when following a route, in terms of different levels of attractiveness, like those provided by Burnett et al (2001), Sorrows and Hirtle (2002), May et al. (2005a) and May et al. (2005b).

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