The Usability of Data Entry in GPS Navigation Systems

Manuela Quaresma, Anamaria de Moraes

PUC-Rio Pontifical Catholic University of Rio de Janeiro – Brazil
LEUI – Laboratory of Ergonomics and Usability of Interfaces
manu@manuelaquaresma.com

ABSTRACT

This paper presents a study about the usability of destination data entry in three GPS navigation systems with different data entry methods. The study aimed to evaluate which method of entry is easier to use by both experienced and non-experienced users, considering the effectiveness and the efficiency of the methods and the satisfaction with its use. Well-known usability methods and techniques were applied where it was possible to obtain performance metrics such as task success and task efficiency, and user satisfaction.

Keywords: Usability, GPS navigation system, human-computer interaction

INTRODUCTION

Recently, with the development and releasing of new technologies, many new electronic devices have been installed into vehicles, like digital audio systems, wireless communication systems and navigation systems. Due to the time spent in traffic congestion on transport routes and the lack of time, many drivers have been using these equipments with the vehicle in motion. Since they demand a complex interaction between user-equipments, and the way they are positioned on the vehicle dashboard, these devices could cause potential drivers' distractions and thus cause traffic accidents.

Typically, in-vehicle electronic systems are composed by controls and displays. Most of equipments available on the market have very small displays and computer systems with many levels of navigation, due the arrangement of the dashboard, the cost of the displays and the amount of information contained in the systems. From the Ergonomics standpoint, these characteristics are detrimental to effectivesimpler and efficient human-machine interaction, because the use of these equipments requires more visual and cognitive demand from the driver than the use of simpler equipments, such as the conventional audio systems and the onboard computers, which provide simple information of vehicle performance.

The GPS navigation system is a in-vehicle information system that has as primarily objective of guiding the driver to a given destination. Through the GPS antenna, the device locates the position of the vehicle on a map inserted in the database system. To guide to the desired destination, the driver enters the address data in the system and then it calculates its route. The driver enters the data usually by physical buttons or virtual buttons on touch-screens. Once the route is calculated, the system guides the driver with the vehicle moving through maps, voice instructions and indicators (symbols, graphics and messages), throughout the itinerary until the destination.

Although the systems already exist for several decades, they only had a wide spread in Brazil since 2006, when they were authorized for use in automobiles (Contran, 2006, 2007). Before March 2006, the CONTRAN (National Council of Brazilian Traffic) prohibited any device that generates moving images for the driver. Since then, several portable navigation systems have emerged in the Brazilian market. However, as this type of technology is still very new in Brazil and the market is still selling products with foreign translations of content, it is believed that these systems shall be conformed to the Brazilian people and usability tests should be done with this audience.

According to Nowakowski, Green and Tsimhoni (2003), "a well-designed navigation system can prevent wrong turns, reduce travel times, and hopefully, alleviate some of the driver's workload. However, poor usability can misdirect drivers, increase driving workload, and lead drives to make unsafe maneuvers."

The way their interfaces are designed, with content translations of foreign devices, it is believed that this type of system has many usability problems. Therefore, the hypothesis of this research is that the GPS navigation systems sold in Brazil have several usability problems. These problems in human-computer interaction (driver-system) could influence the driving task and, consequently, may cause driver distraction and consequent accidents. Thus, the object of this research is the interaction between drivers and GPS navigation systems available for use in-vehicles.

The research aims to provide GPS navigation systems easy to use and safe during driving. Its overall objective was to define design recommendations for the development of systems interfaces, for use in automobiles.

USABILITY

The usability is defined by ISO 9241-11 (1998) as the "extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use". Where: *Effectiveness* is the accuracy and completeness with which users achieve specific goals, i.e. the degree which a task is performed, if it can finish it or not; *Efficiency* is the resources expended in relation to the accuracy and completeness with which users achieve goals, that is, the level of effort expended by the user to complete a task; and *Satisfaction* is the absence of discomfort and the presence of positive attitudes towards the use of a product.

In order to meet these three requirements in designing a particular product, be it hardware, software or both (an electronic product), some researchers have created a number of usability principles, criteria and heuristics, such as Bastien & Scapin (1993), Nielsen (1994), Shneiderman (1998), Jordan (1998) and Norman (2002, 2006).

The main objective of all these principles is to facilitate user interaction with the product. However, most of these principles is related to user interaction with a computer interface, such as the principles stipulated by the first three authors mentioned above, who are researchers in human-computer interaction (HCI). But the authors Jordan and Norman, defined more general principles and applicable to both physical and computing interfaces. So, this set of principles satisfies the determination of design requirements for electronic products, which are products that contain interfaces both physical and computational, such as GPS navigation systems, digital cameras, cell phones, PDA, MP3 players, etc..

Brangier and Barcenilla (2003) classify these principles into four categories according to their specific purposes:

1) Facilitate learning of the system - principles that deal with issues related to the first use of a system, when the user makes deductions about how to interact, helping the beginner to start interacting with the system. This category includes the principle of compatibility between products and situations, and explicitness of the functions and procedures of the system/product;

2) Facilitate the information search, perception, recognition and understanding in the system - principles related to the presentation of information in the system. This category includes the principles of grouping, visual clarity, readability, user cognitive workload, memorization, consistency and standardization of information.

3) Facilitate the interaction control with the system - principles that address issues related to the conduct of activities. The principles of this category are the feedback, the user control and error Management (error protection, quality of error messages and error correction)

4) Consider the system context of use and the type of user - principles related to issues about the advanced use of the system, like the adaptability and flexibility that the system provides to user.

METHODS AND TECHNIQUES

To verify the validity of the hypothesis usability tests were applied with three GPS navigation systems Brazilians, in order to observe its compliance with the usability principles. According to Dumas and Loring (2008) "usability testing is a systematic way of observing actual and potential users of a product as they work with it under controlled conditions. It differs from other evaluation methods (such as quality assurance testing and product demonstrations) in that user try to complete tasks with a product on their own, with little help."

The usability test plan were organized according to the steps outlined by Rubin and Chisnell (2008).

PARTICIPANTS

Eighteen licensed drivers participated in the test, 9 experienced in GPS navigation systems and 9 non-experienced, with a gender split. The participants' ages ranged from 21 to 60 years. More than half (61%) answered that they drive on average more than four hours per week, while the other participants were balanced between up to one hour per week and up to 4 hours per week.

THE SYSTEMS EVALUATED

Three different systems sold in Brazil were evaluated: A – Nav N Go iGO 8.3; B – Route 66 Navigate 7; C – TomTom Navigator 7. These systems have distinct methods of data entry. In the first, the data is typed through a keyboard that automatically reduces the options (by eliminating some keys) as the user types the names of streets, according to its database (Figure 1). In the second, the user enters the address (fully or partially) through a static keyboard and then searches for it in a list of possibilities, on the next screen (Figure 2). And in the third, as the user enters the name of the street, the system filters the options in the database and presents some possible choices in two lines on the top of the screen (Figure 3).

Figure 1. Screens of the first system tested (system A)

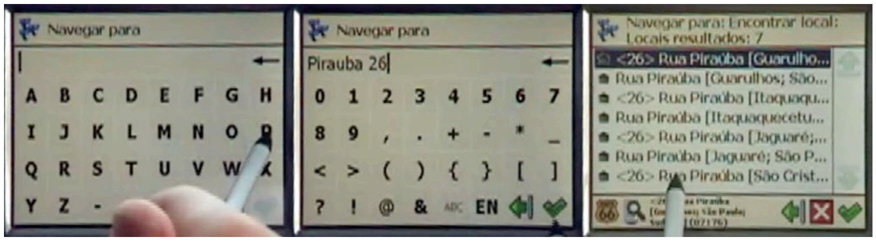

Figure 2. Screens of the second system tested (system B)

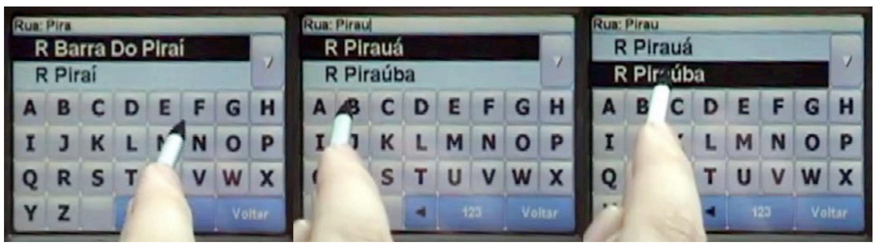

Figure 3. Screens of the third system tested (system C)

TASK AND PROCEDURE

To evaluate the different data entry methods it was asked to each participant to define a destination by address, with the following instruction (scenario): *"You have ordered some invitations at a print shop in São Cristóvão* [a far place and not very well known by the participants in Rio de Janeiro, Brazil] *and need to get them. Since you do not know how to get there, you will use your GPS system to guide you. For this, you need to put the address (below) in the system so that it calculates your route and guide you. How would you do that? <ADDRESS>*"

The tests were performed inside a parked vehicle (always the same vehicle) during the morning and afternoon, so that the incidence of light could be similar. The GPS equipment where the systems were installed has always been installed in the same place - stuck at the bottom of the windshield near the center of the dashboard. This is the place recommended to perform secondary tasks with displays in vehicles, according to the European (EC, 2008) and American (AAM, 2003) guidelines. All stages of the test were recorded on digital video through a camera mounted on a tripod in the back seat of the vehicle.

All participants evaluated the three systems, but the order in which the system were tested was counterbalanced, to avoid the results were biased to either system. Also, three different addresses were used with the same amount of letters and numbers. Before performing the task, the participant did some trials to know the system that would be tested. After the trials, the participant received a card with the task and address to be inserted and then performed the task. At the end of the test of all systems, debriefings sessions were conduct with the participants to clarify some issues that were observed and learn more about their beliefs and preferences.

RESULTS

TASK SUCCESS

To measure the task success, all the clicks made by participant during the execution of tasks were observed and tabulated, through the video recordings. To confirm that the task was completed, even if the participants said they have completed, it was used the activities' task flow defined previously as completeness criteria. If the participant had passed through all the activities of the task from beginning to end, the task was considered as completed. But, if the participant did not end them, failing in one or more activities, the task was considered not completed. For those tasks that have been completed with problems, it was verified that the participant passed through all the activities from beginning to end, but he/she also did other unnecessary activities.

The following graph (figure 4) presents the task levels of success in the systems. It is possible to observe that the system A was the most effective system, with 39% of completion without problems. The system C has also presented reasonable results in effectiveness, but the level of success without problems was very low (11%), which shows that there are efficiency problems. But, the system B has presented the most unsatisfactory results; there was no completion of the task without problems.

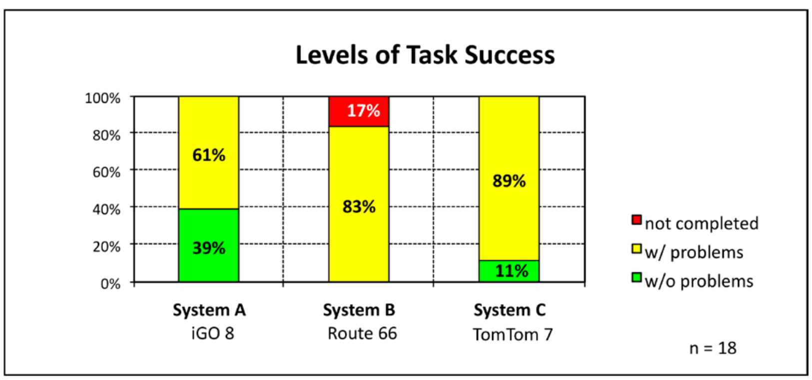

Figure 4. Levels of task success

The reason which led to an incidence of 17% of non-completion of the task, in the system B, was the fact that some participants didn't entered the building number in the system, to calculate the route to the destination. Typically, the entry of an address is done in steps; first the city name is entered, after the street name and at the end building number is entered, in different screens. In this system, the address entry is done differently from both the other systems tested and the other systems in the market. To insert the address in the system B, the user must enter the complete address (including street name, number and city) in one step (screen) and then looks for it and selects it in the list of addresses possibilities, on other screen (figure 2). With this way, some participants didn't know how to enter the number or not realized that they not inserted it, entering only the street name and concluding that the task was completed.

TASK EFFICIENCY

To assess how costly the task may be to the user, or how effective is the task, the numbers of clicks (commands selections or keystrokes) that each participant performed was counted in each task and each system. In addition, the minimum clicks that would be needed to complete the task on each system were counted. Comparing these two values, it was possible to measure the average level of effort that the participants had to complete the task. In this measurement, the tasks that were considered were only the completed ones - tasks completed without problems and completed with problems.

With these comparisons between clicks performed and minimum clicks, it was possible to observe two points: 1st) by the number of minimum clicks, which systems has the task design more efficient, i.e. the system that have lower number of clicks is theoretically the faster and more efficient; 2nd) by the number of clicks performed, which task presents the higher or the lower cost to complete, in each system.

In the following graph (figure 5), it can be seen that the systems A and C have the lowest number of minimum clicks (14 clicks) to complete the task. This means that the task designs in these systems, in principle, are more efficient than in system B. By observing the average number of clicks exceed and/or wrong made by the participants in the graph on the next page (figure 6), it can be concluded that the design of the system A is the most efficient among the three systems, with an average of 70% more clicks than needed to complete the task. To obtain this result, in the graph (figure 6), the amount of exceeded/wrong clicks made by the participants who completed the task with problems was computed. Thus, the 61% of participants who completed the task with problems in system A, they performed an average of 70% more clicks than needed. In system B, 83% of participants clicked on average 165% more clicks, and in system C, 89% of participants exceeded the amount of clicks by 121%. Therefore, it was concluded that the system A is more efficient, even if it is considered their level of success with no problems (39%) compared to the same level from other systems.

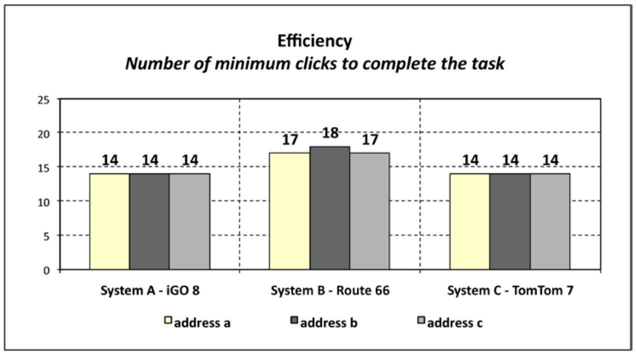

Figure 5. Number of minimum clicks needed to complete de task

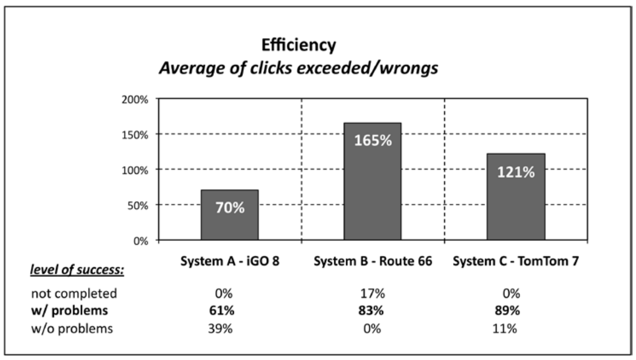

Figure 5. Average of clicks exceeded/wrongs made by the participants

Although the system A has presented more efficiency, it also occurred usability problems. To set a destination, the user first find address and then says he/she wants to use it as a destination. This way of thinking is not compatible with the way users think, because usually when the user wants to go somewhere, first he/she tell the system what is your goal, enters the address and then confirms the address entered. In this system the logic is different, the goal with the address is given only after it was found. Thus, after entering the address, some participants thought that they had already finished or were in doubt whether they had completed the task before making the last click in the command "Set as Destination". This shows an inconsistency of this system with others, that instead of use the label "Find", use terms like "Navigate to," "Go to", "Navigate", "Where to?" etc.

In system B, which presented a greater number of problems, one of the reasons that led to excessive clicks was the same problem occurred with the non-completion of the task, where many participants did not entered the building number with the name of the street. Therefore, the participants who noticed this problem of compatibility restarted the task and, consequently, exceeded the number of minimum clicks needed.

In the system C, one of the reasons that led to excessive clicks was a lack of information/confirmation, since at no time it presents the neighborhood where the address is located. Although this information is not required in the process of data entry, the other two systems (A and B) show the neighborhood at the time of address selection. According to what was discussed with some participants, this feedback is important because in a city may have streets with the same name or parts of name. For some participants this was seen as a problem because they did not trust in the system, so they restarted the task entering the address by ZIP code.

THE USER SATISFACTION

One of the issues most discussed by participants in the debriefing session was the long process required for entry the address data. In general, it is needed to enter the three main components of an address – the city name, the street name and the building number, usually on separate screens. Many participants questioned the need to insert the city name, since the GPS signal has recognized the city where the user is. In this case, most participants preferred the data entry method of system A, which has a screen where all the address data are inserted, and on this screen, it is possible to leave as default the city name, and the country name. This makes the process more efficient, because the user only needs to enter the street name and the building number.

Despite the participants criticized the long process, it was almost unanimous the preference for the data entry in separate screens, such as systems A and C.

The system B was very criticized for the fact of having to enter the building number with the street name and then select the address in long list of all places in the country, because there is no filter for the city.

The method of typing the street name in the system A was seen also as a positive item of the system. The fact that the letters fade, during the typing, was very remarked. However, some participants doubted about the effectiveness of this type of method, because if a user tries to enter an address misspelled (with one letter wrong), the system blocks the entry process. In this case, participants preferred the system C, which gives options to the streets as the name is entered, even if the name contains wrong letters. For example, when someone tries to enter the "*Paissandu*" street, typing with only one "s" or "ç", in the system C, there will come a time that the system will display the correct street and then the user can select it. In the system A this is not possible, because it does not recognize that name in the database.

CONCLUSION

Therefore, it was concluded that for an effective, efficient and satisfactory destination entry, it is necessary a task execution in short and sequences steps, with a navigator aid (with a filter of street names) and with a screen of address data where the city can be left as default. Also, the task must be initiated by a command like "Navigate to". The diagram below (figure 6) shows an ideal sequence of screens for entering address data into GPS navigation systems.

With the research results and conclusions, the hypothesis mentioned above could be proved and the research goal was achieved – set design recommendations to GPS navigation system interfaces. It is emphasized that this paper presents only a few results. Other tasks were also tested, as well as other techniques were applied in Quaresma (2010).

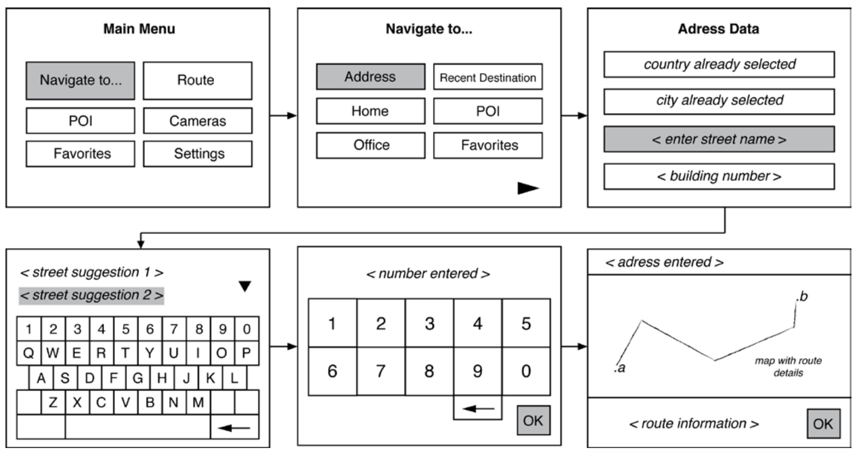

Figure 5. Ideal sequence of screens for address destination data entry

REFERENCES

Alliance of Automotive Manufacturers (2003) Statement of principles, criteria and verification procedures on driver interactions with advanced in-vehicle information and communication systems. Washington, D.C.: Alliance of Automobile Manufacturers.

Bastien, J.M.C. & Scapin, D. (1993). Ergonomic Criteria for the Evaluation of Human Computer Interfaces. Le Chesnay: INRIA.

Brangier, E.; Barcenilla, J. (2003). Concevoir un produit facile à utiliser. Paris: Éditions d'Organisation.

Dumas, J.; Loring, B. (2008). Moderation Usability Tests – Principles & Practices for Interaction. Burlington: Morgan Kaufmann Publishers.

European Communities (2008). Recommendations on safe and efficient in-vehicle information and communication systems: update of european statement of principles on human machine interface. Brussels: European Union (Official Journal 2008/653/EC), 2008.

International Organization Standardization (1998). Ergonomic requirements for office work with visual display terminals (VDTs) -- Part 11: Guidance on usability. Génève: ISO.

Jordan, P. W.. An introduction to usability. London: Taylor & Francis, 1998.

Nielsen, J.; Mack, R. (1994). Usability inspection methods. New York: John Wiley & Sons.

Norman, D. (2002). The design of everyday things. New York: Basic Books, 2002.

Nowakowski, C.; Green, P.; Tsimhoni, O. (2003). Common Automotive Navigation System Usability Problems and a Standard Test Protocol to Identify Them. In: Proceedings of

ITS-America 2003 Annual Meeting. Washington DC: Intelligent Transportation Society of America.
Quaresma, M. (2010). Usability evaluation of in-vehicles information systems: an ergonomic study of GPS navigation systems. Rio de Janeiro, 2010. 340p. DSc. Thesis – Departamento de Artes e Design, Pontifícia Universidade Católica do Rio de Janeiro.
Rubin, J.; Chisnell, D.(2008). Handbook of Usability Testing – how to plan, design and conduct effective tests. Indianapolis: Wiley Publishing. 2ed.
Shneiderman, B. (1998). Designing the User Interface. Massachusetts: Addison-Wesley. 3rd Ed.. 639 p.