Drivers and Automation: A Study About Cultural and Behavioral Influence in the Interaction with Driver Assistants

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Abstract. ADAS or advanced driving assistant systems are rapidly gaining popularity all over the world, but in order to work properly and prevent risks, ADAS must be designed considering the context that it will be working on. The problem is that most ADAS sold in Brazil were developed based in others cultures, not considering specific issues of Brazilian traffic. This study aimed to point out the most relevant problems of interaction between Brazilian drivers and their ADAS. The results of this research concluded that the problem is not related to individual aspects of Human-Machine communication, but to social and cultural factors that misrepresents the way that people should use this kind of system.

Keywords: ADAS · Automation · Safety · Ergonomics · Drivers' behavior

1 Introduction

ADAS, or advanced driving assistant systems are automated equipments designed to support drivers in many activities while driving, being by advising the driver or even taking control of the vehicle. Young [1] and Knapp et al. [2], define ADAS as automated systems that supports the driving task. It works by giving information or by performing specific manoeuvres in order to enhance safety. For Young [1] and Knapp et al. [2] all ADAS have 5 specific characteristics: (1) support the driver in the driving task; (2) offer active longitudinal or lateral support for the vehicle with or without alerts; (3) scan and analyse the environment; (4) have complex data processing; (5) offer direct interaction with the driver.

This kind of system is rapidly gaining popularity all over the world [3], even in countries like Brazil, with a little culture of automation consumption [4]. Authors like Norman [5], Reed [3], and Young [1] believe that the technology is continuously evolving towards the autonomous driving, where Vehicles won't need drivers anymore, adding convenience and enhancing safety. Even so, safety-related and primordial conception issues about the state of art of technology makes the full autonomy of vehicles unviable, raising discussions on the subject, far from reach a consensus in the scientific community.

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Due the fundamental gap in common ground for interpretation of the real world [5], ADAS are always susceptible to errors and interaction problems (once it cannot understand social issues, being limited to the numeric data collected by its sensors). To mitigate that issue, ADAS must be designed considering behavioral and environmental aspects of the situation that it will be working on [2]. The problem is that most ADAS sold in Brazil were developed considering others cultures and not considering specific issues of Brazilian drivers and traffic conditions. It is believed that this gap between the parameters used in the design of those systems and the Brazilian context of use may cause some interaction problems that can compromise the driving task and impair the road safety.

This study is an exploratory research that aims to point out the most relevant problems of interaction between Brazilian drivers and their ADAS.

2 Problem

According to Norman [5], there are no "intelligent systems", they are just responsive. In other words, all automation behavior is based on numeric data, gathered by their sensors, but numeric abstractions cannot always translate a real danger situation. There are many abstract variables related to social interactions that may affect the situation, and it's virtually impossible to pre-define numeric parameters for every possible situation that one system may face. Considering that fact, many authors [5–7] states that automated systems are always susceptible to errors, and that must be considered in their design.

According to Norman [5], the main cause of our inability to communicate with machines is the fact that there is no common ground of communication between us and them. The author defines the term "common ground" as a range of common knowledge necessary for the proper understanding of the message between two parties. "People and machines inhabit different universes, one of logically proscribed rules that govern the interaction, and the other one with complex actions, context dependent, where the same condition may result in different actions because the circumstances were different" [5].

The Health and Safety Executive (HSE) [6] and Norman [5] claim that interpretations made by automation are based in pre-defined standards – possible scenarios, pre-programed with their specific conditions for happening. However, this working model is only 100 % accurate when one has control of all the variables interfering with the system in order to be able to predict all possible scenarios. But complex environment like traffic have an infinite number of possible scenarios, and it is unfeasible with current technology fit them into a finite number of responses of a system.

In order to mitigate the issues related to the lack of common ground of communication, ADAS must be designed considering its specific context of use [8]. According to Knapp et al. [2] and International Standardization Organization (ISO) 26262 [8], the design process of any safety-related driver assistant system must consider specific issues related both to the drivers' behavior and to the environment of the place/region it will be used. By doing that, it is possible to adapt the task requirements to the characteristics of the context of use, reducing the fallibility of the system. Dekker [9]

affirms that automation systems must be designed considering that they are susceptible to errors, and must adapt themselves to the user's workflow.

The problem presented by this study is that most of the ADAS sold in Brazil are produced in Europe and USA [4], which consider their local specificities during the design process. The issue resides in the fact that the north American and the European traffic are different from the Brazilian one. DaMatta [10] affirms that the Brazilian traffic has a lot of aspects related to its infrastructure and drivers' behavior that makes it unique. Due the fact that they are not designed with Brazilian driver in mind, many ADAS does not consider the specific issues related to that specific context, which may lead to interaction problems and impair the road safety. According to Parazuraman and Rilley [7], many problems related to Human-ADAS interaction are caused by the non consideration of the user needs during the design process, making it susceptible to failures.

Another aggravating issue is the fact that this kind of system is not fully inserted in the daily lives of many Brazilians, which may cause constraints during the interaction – once issues related to the previous experience are fundamental for the decision making in the Human-ADAS interaction [3, 11, 12].

3 Methodology

The goal of this research was to verify how this differences between the parameters used on the design of ADAS and the Brazilian traffic may affect the Human-ADAS interaction and how it can impact the road safety. The main hypothesis of this research is that the non consideration of Brazilian context on the design of ADAS may impair the interaction between the driver and the system, directly affecting road safety. The secondary hypothesis is that there is a conflict between Brazilian's aggressive driving behavior and ADAS safety boundaries.

To confirm the hypothesis, the research conducted the following methods and techniques:

A focus group with Brazilian drivers aiming to understand the relationship between drivers and ADAS, looking for constraints and common interaction issues;

An online survey based on the data collected by the focus group and the literature review, to confirm some information in a quantitative approach;

The modelling of the communication process between human-ADAS [3, 13], in order to explain the main issues that trigger interaction problems pointed by users.

The focus group's general purpose was to list the different types of constraints that occurred in the relationship between the Brazilian drivers the ADAS. According Markopoulos [14], qualitative research is mainly of an exploratory nature, and then the first step in research. This technique was suitable for research due to its controversial nature: the behavior in traffic. If interviewed individually, participants could feel cornered with questions. Markopoulos [14] states that the group often serves as a protection for the participant, so that he does not feel individually cornered, since the focus is on collective expression of thoughts.

The focus group was composed by 12 open questions divided in 3 themes: (1) relationship with technology/automation, trying to draw a profile of the interviewee

regarding the use of technology; (2) relationship with the traffic, trying to understand the opinion of the interviewee about the experience of drive in Brazil, looking for the up and downsides of it; (3) interaction with ADAS, looking for understand how interviewee interact with ADAS what is his opinion and constrains about the system. The application of the technique took place on August 29, 2014, with a total of nine participants, all belonging to the same age group, with more than 40 years and owners of cars with ADAS, of different models. Nobody was reluctant to answer any questions. They all have agreed to the Personal Release Agreement.

Once collected trends and hypothesis of the qualitative research findings, it was necessary to validate the data by checking whether the information obtained was not just a specific discrepancy of the respondent sample of the focus group. For the verification of the data, an online survey was the chosen technique. According Tullis and Albert [15], an online survey is a very useful tool for the rapid collection of data from a wide range of respondents, with the only disadvantage of the low depth of the answers. This type of technique was ideal to the needs of this research stage, since the in-depth analysis had already been made during the focus group, requiring only a sample that could be taken as numeric representation for the data collected in the previous technique.

The survey was composed by 31 questions, being 3 of them open-ended. The questions were divided in 4 different groups: (1) preliminary questions, aiming to filter respondents that don't fit in the frame of this research (non drivers/non ADAS users); (2) questions aiming to identify the relationship of the respondents with the traffic, and related to road safety; (3) questions about the use of ADAS, aiming to understand the relationship between the respondents and their ADAS, also looking for their most common problems during the use of the systems; (4) demographic questions, looking for a better comprehension of the sample of the respondents gathered.

To obtain a diagnosis of the main problems of interaction with ADAS in Brazil, techniques of Human-Machine-task modelling ([13]) were used to depict the process of interaction between the driver and their ADAS in order to characterize each of the elements that compose the relationship between the parties involved.

All the models were based in real stories of interaction problems reported by users during the focus group or in online interview with some specific respondent of the survey that claimed to have constant problems with his ADAS. Those storylines were modelled using a flowchart, identifying all the stages of the studied scenarios. The Driver-ADAS communication process was modelled by the communication model [13], analyzing the information and reception channels of both the driver and the system, looking for problems in the way the message was being passed. For the modelling of the mental model of the driver, it was used the OODA LOOP model [3], analyzing every step of the decision-making process to get the elements that led to the error and complete the diagnosis.

In the end 3 scenarios were modelled, each one of them characterizing what is believed to be the main problems of interaction between Brazilians and ADAS. All models were compared with the findings of the survey and focus group, and after that compared with the literature reviewed about this topic.

4 Findings

The findings of this research can be divided in two main topics: drivers' opinions and reported errors.

4.1 Drivers' Opinion

The results of the focus group and the survey verified a general consensus that the Brazilian traffic is extremely chaotic, due mainly to two factors: the low infrastructure of roads compared to the number of cars and the Brazilian drivers' behavior, being extremely individualistic and inconsequential. Considering the drivers' inappropriate behavior, this opinion could be seen in sentences that were repeated several times during focus group such as: "No one respects anyone," or "if somehow one find a way to take advantage, he will always go for it". DaMatta [10] claims that this is a critical issue typical of the Brazilian traffic. Due historical factors related to individualism and problems in the supervision of traffic laws, many drivers in Brazil have a selfish behavior, often disregarding traffic regulations. Machado [16] and DaMatta [10] believe that the main cause of this kind of behavior is the conflict between the traffic regulations on paper and their appliance on real situations. According to Machado [16], when someone is inside his car, this person tends to feel "apart" of all the issues related to traffic, making excuses to himself by committing minor infractions, and most often end up unpunished, which reinforces such behavior. The survey data shows that 72 % of the respondents think that the traffic rules are not well supervised, which shows that drivers also perceive this issue in their daily life, and understand that problem.

Another issue pointed out in the results is that roadways and traffic signs in Brazil present poor infrastructure. Figure 1 shows that 65 % the survey respondents think that the Brazilian roadways have severe problems of signalling and conservation. It is

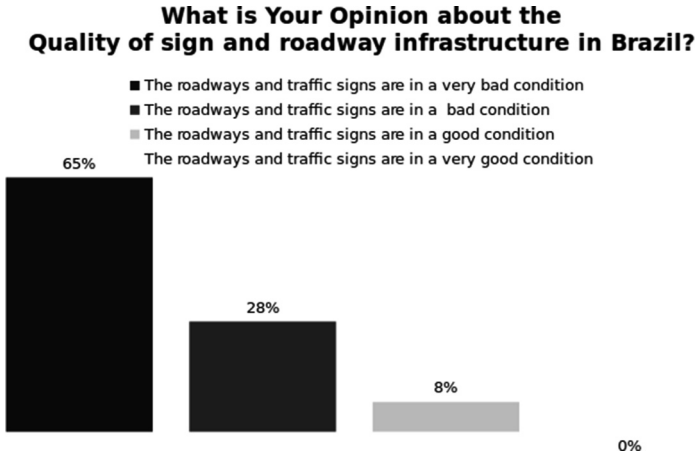

Fig. 1. Graph of the opinion about the quality of traffic infrastructure in Brazil (n = 93)

believed that it can be a factor that may lead to problems related to the ADAS workflow, impairing the correct sensor readings. It is also believed that the low infrastructure of the roadway and traffic signs may also be a problem of the social interactions in Brazilian traffic. Machado [16] claims that when there is no strong force of ruling one environment, it becomes susceptible to social interventions, diverting its use from the original project. In other words, when there is no sign to tell people what they can do, they'll do what suits to themselves, which might not be the correct action. This could lead to possible problems in the driving context, once all the rules must be applied equally to everyone, cause any action that favors only one individual over the others may compromise the whole structure of this public environment. Noriega [17] claims that environmental issues are crucial to the safety oriented driving, acting as a conditioner of drivers' behavior and problems in it may generate undesired outcomes that may impair the road safety.

It is believed that both the problems on traffic infrastructure and the drivers' inappropriate behavior may transform driving in Brazil a very stressful task. Figure 2 shows that 92 % of the respondents of the survey are unsatisfied or very unsatisfied with the stress level related to driving in urban roadways in Brazil. This stress level may affect the way people look to their ADAS, favoring sometimes features that brings comfort to the driving rather than safety-related ones. This phenomena can be perceived in phrases spoken during the focus group such as: "The traffic annoys me too much, I want something that relax me!".

Regarding drivers' opinions about their previous experience with more complex ADAS and how it may affect other interactions, when the sample of respondents of the survey is divided in 3 different groups - based on the level of complexity of their ADAS, it's possible to perceive some variations on their relationship with the systems. The fist group was composed by respondents that claimed to possess ADAS with simple data processing, generally soft automations, used to advertise the driver about some specific aspect of the driving task (e.g., Parking assistant). The second group was composed by owners of ADAS of medium complexity, capable to interfere in the driving task, but with all its readings based on specific discrete data, such as the speed of the vehicle (e.g., Cruise control systems). The third group was composed by respondents that interact with complex data processing ADAS, capable of predicting scenarios and situations to interfere directly on the driving task (e.g., Lane keeping systems).

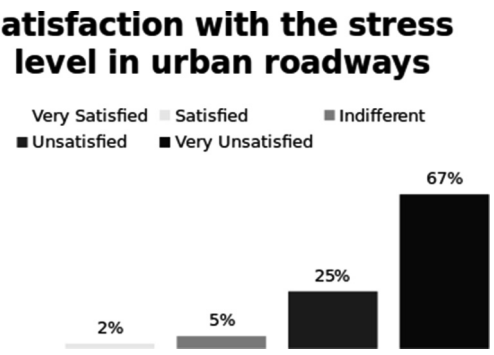

Fig. 2. Graph related to the satisfaction with the stress level in urban roadways (n = 92)

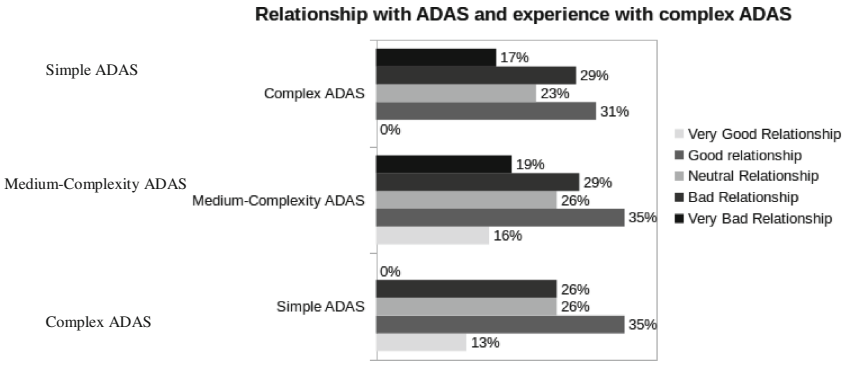

Fig. 3. Graph of the relationship of ADAS in different levels of complexity

When analyzing the answers of each group individually, it is possible to see that their affinity with ADAS is directly related to the kind of ADAS they have and their previous experience with the more complex ones. Figure 3 shows that the group with experience with more complex ADAS has good acceptance to the use of ADAS, while people with experience in the use medium-complexity ADAS have a more distributed result and the sample that owns more simple ones has almost the opposite result of the first group. According to Parazuraman [12], Degani [11], Reed [3], previous experiences in the use of ADAS are crucial for the good relationship with them. The problem resides in the fact that ADAS are still not fully adopted in the Brazilians daily lives. According to Veja [4], ADAS in Brazil are still very expensive and not affordable to most part of the population. Considering this fact, the use simple and most common ADAS may cause bad experiences to the user, compromising their trust in the systems and impairing the interaction, once trust is one of the most important factors to a smooth Human-ADAS interaction [12].

4.2 Reported Errors

The survey data found that the most common errors reported can be divided in 3 categories, as defined by of Sharit [18], Dekker [9] and Reason [19]:

1. Mode error: A specific kind of error that occurs when the driver's mental model and the actual workflow of the systems are different, making the controller misjudges the real current state of the systems, leading to unexpected outcomes.
2. Overtrust: A specific kind of error that occurs when, despite noticing an abnormality in the system functions, the operator refuses to accept such issue as an error, relying more on the system accuracy than in himself.
3. Out of the loop: A specific type of error that occurs when driver's monitoring is in low or nonexistent levels, disregarding the operation of the system thus becoming unable to react properly during an abnormal situation.

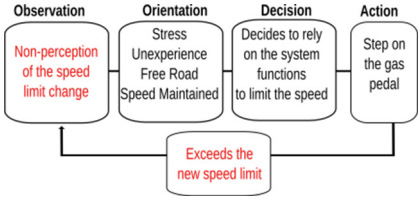

Fig. 4. Cognitive model of the first scenario (extended model available in: http://imgur.com/gOM48Pk)

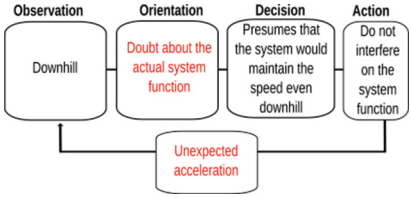

Fig. 5. Cognitive model of the second scenario (extended model available in: http://imgur.com/jn62CqZ)

For each of those kind of errors, scenarios were modelled, for better comprehension of the factors that led to the failures. The first scenario is based on a story of a user that became out of the loop by using a speed control on a freeway, and, because of that, didn't noticed the change of the speed limit when exiting it, exceeding the speed limit..

What can be perceived in this model (Fig. 4) is that the problem was caused by an observation problem, due a lack of attention. Conditioned by a successfully working system operation in the previous situation, the driver was unable to perceive the change of the speed limit. It is believed that this kind of over relaxed behavior may be caused by a previous experience of stress in traffic, making the driver look for comfort every time he is able to.

The second scenario is based on the story of a driver that misjudged the behavior of a cruise control (mode error) when he was going downhill. He thought that the speed of the vehicle would be maintained, without consider the action of the gravity, which resulted in an unexpected acceleration.

What can be perceived in Fig. 5 is a problem on the orientation process caused by a lack of experience in the use of this system. It is believed that it may be affected by the high cost of this kind of system in Brazil, making it unfamiliar for the new user. Another thing to be pointed out is that the user was in doubt about the system behavior and, even knowing that it may put himself in danger, he preferred to trust in the system rather have to act. It is believed that it may occurred because the driver was looking for comfort in the use of this system.

The third scenario was based in the history of a driver that overtrusted his lane keeping system, even in a clear problem situation. The driver clearly saw that the lanes were worn out near a curve, but even so, disregarding his own integrity, opted to not interfere, which caused the loss of control.

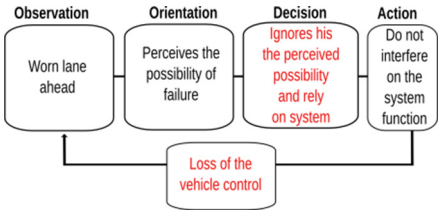

Fig. 6. Cognitive model of the third scenario (extended model available in: http://imgur.com/LfoGL2U)

According to Fig. 6, the problem occurred during the decision-making process, opting to not interfere in the system even perceiving a possible failure situation. It can be observed the driver was favoring comfort aspects, disregarding his own safety. The other problem that can be seen in this scenario is that problems in the roadway infrastructure may have caused the system failure.

Analyzing the models, it can be seen that even different, all of them had some points of similarity, and it is believed that those are the main cause of the interaction problems. The relationship between them is that all the scenarios were susceptible to one same environment, the Brazilian traffic, and all the variables inherent to it, such as the stressful conditions for the driver, the low roadway infrastructure and the high cost of ADAS, which may cause problems for the user experience. Neither of the scenarios have presented the direct communication process as a source of the interaction problems, but external factors that may have conditioned the drivers' behavior to take wrong decisions. Another issue to be pointed out is the favoring of comfort aspects rather than safety.

5 Discussion

The research concluded that there are no specific elements in the ADAS workflow not aligned to the driver's behavior, there are issues related the Brazilian traffic environment not considered in the design of this systems, which may affect the way people use this kind of system and consider their own safety. The results of this research can be split in two main points:

1. The problems of interaction are directly related to user experience with more complex ADAS. The data collected shows that people with simple and primitive ADAS complained about the alarms and the insistence of their systems, while the respondents with more sophisticated ADAS claimed to have a smooth relationship with them, even knowing that they are susceptible to the same problems. It is believed that this is a reflex of the low concern of safety issues by most of the Brazilian drivers – making the more autonomous ADAS look more attractive, and impairing the relationship with the more simple ones. So, the more complex someone's ADAS is, the better their experience with it and the fewer their concerns with problems. This is a crucial point in Brazil, since most of the ADAS sold are not

produced inside the country, which raises its costs and make them unaffordable for a big part of the population.
2. The stress related to traffic is a huge problem in Brazil [10, 16]. Most of people interviewed affirmed that driving in Brazilian traffic is a very stressful task, and at most of the times they prefer to delegate some of their activities to an ADAS than worry about all driving demands, even knowing that it could cause some eventual accidents. In other words, due to a stressful environment, once again Brazilian drivers favor comfort aspects rather than safety in the use of ADAS. Those characteristics reduce the risk perception of drivers and increase the probability of accidents.

This non consideration of the drivers' own safety may affect the way ADAS are faced and consumed in Brazil. This systems are designed to assist the driver taking control of some tasks in order to enhance safety. But, because of the stressful environment of the Brazilian traffic, combined to the high costs of the systems, ADAS are faced as luxury products, used to give drivers comfort and make the driving task more tolerable. The problem with this is that those kind of systems are not designed for that function, which may influence a non safety-oriented behavior, lowering the risk perception of the drivers.

6 Conclusion

The study was able to confirm its main hypothesis, but the secondary one was not confirmed. The main issues of the relationship between Brazilian drivers and ADAS are not related to individual aspects of Human-Machine communication, but to social and cultural factors - such as the stressful environment of Brazilian traffic, that misrepresents the way that people should use this kind of system.

It's important to remember that the results of this research are not confirmative; it has explorative data that points out for new hypothesis that must be confirmed in future researches. Even so, these results cannot be disregarded, since the analytical criteria were based on data extracted from actual users. Other researches are required to generalize the findings and treat them as a rule.

This study was part of a bigger research that aims to create guidelines for the design of ADAS better adapt to the Brazilian context in a user-centered approach. For the next steps, the research aims to confirm the findings of this study through simulator testing and understand the impact of the use of ADAS in the drivers' behavior.

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