Introducing Advanced Driver Assistance Systems (ADAS) into drivers' training and testing: The young learner drivers' perspective

Master of Science Thesis
Department of Civil Engineering and Geosciences
Delft University of Technology

Tsapi Anastasia
December 2015

Introducing Advanced Driver Assistance Systems (ADAS) into drivers' training and testing: The young learner drivers' perspective

Master of Science Thesis
Department of Civil Engineering and Geosciences
Delft University of Technology

Tsapi Anastasia
December 2015

Graduation Committee:

Prof. Marjan Hagenzieker	Delft University of Technology
Dr. ir. Haneen Farah	Delft University of Technology
Ir. Peter Morsink	Royal HaskoningDHV
Ir. Paul Wiggenraad	Delft University of Technology
Dr. ir. Joost C. F. de Winter	Delft University of Technology

Key words: learner drivers, Blind Spot Detection system, Adaptive Cruise Control system, drivers' testing

Preface

"The roots of education are bitter, but the fruit is sweet"

- Aristotle

Aristotle described the journey of knowledge and the importance of knowledge in humans' life in such a compact way. Indeed, knowledge is power, allowing one not only to survive, but also to develop and improve as a person. Education makes one wiser, by preventing them from making mistakes that were made in the past. It is the indispensable asset for the ones who want to build the future. It is never static, but dynamic. It comprises a challenge for discovering the unknown and the limits of it. However, the acquisition of knowledge is endless, with numerous obstacles on the way to it. Having completed 7 years of studying in the university, I feel confident to say that I gained knowledge, wisdom and experience. During this period, I realized that the journey can be hard but generous in teaching you how to rise after falling. All we need to do is appreciate the opportunity to taste this bittersweet experience and dive in it.

The present thesis project would not have been carried out without the support and assistance of a group of people. I would like to thank Professor Marjan Hagenzieker for her help and guidance, which was vital in all stages of my thesis. Furthermore, I am grateful to my daily supervisor, dr. ir. Haneen Farah, for her patience, motivation and immense knowledge. Her guidance supported and kept me on track during my whole research. A very special thanks goes out to my external supervisor from Royal HaskoningDHV, ir. Peter Morsink, without whose understanding and technical support I would not have been able to accomplish my aim. A special gratitude goes out to Rene Claesen from CBR, since he has considerably contributed to the project by being involved in the recruitment of the participants. I would also like to thank Paul Wiggenraad and dr.ir. Joost C.F. de Winter for their interest and suggestions throughout my graduation period as well as the time they devoted to review my report.

I am indebted to my family, Georgios, Zografia and Vasiliki for supporting me spiritually throughout writing this thesis. Their patience and continuous support provided me with strength and confidence to overcome the upcoming problems and do my best in this last but important part of my studies. Without them my entire journey in knowledge would not have been a reality. A sincere thanks also goes to my "Delftian" friends from all over the world, whose presence and psychological boost turned problems into challenges. Last but not least, I would especially like to thank Mischa for his sublte but rather enthusiastic support during the last months of my work.

At this point, I will let my research unfold to you, dear reader.

Summary

Novice drivers attract a lot of the attention in terms of their involvement in traffic accidents, especially during the first period of driving. This stems from errors of attention, visual search, speed selection and adaptation, hazard identification as well as control during emergency manoeuvres

In the Netherlands, the crash rate for young novice drivers between 18 and 24 years is five times higher than the rate of experienced drivers. In 2009, 23% of the serious crashes involved young novice drivers, although they consist no more than 8% of the total driving population.

Following the traffic safety facts, safety has become a vital asset for the automotive industry over the past decades. The development of Advanced Driver Assistance systems (ADAS) has shown potential to compensate for the inabilities of drivers to properly react to risky situations. On the one hand, they try to assist drivers using either warning messages to increase their attention or through the automation of standard control tasks, aiming to relieve drivers from manually controlling the vehicle. Thus, they could especially contribute in mitigating novice drivers' crash involvement by assisting them in performing difficult driving tasks, like hazard detection and speed adaptation. On the other hand, such automation may negatively affect driving behaviour and driving performance in terms of reaction time, situation awareness and increased workload stemming from additional tasks depending on the specific type of ADAS.

As with the introduction of all new systems, the ultimate success depends largely on the users' ability to correctly work with the systems, be aware of their potential and limitations in order to take full advantage of them. Despite these technological advancements in the vehicle industry, drivers' training and testing procedures still follow the traditional procedures and did not yet adapt them to incorporate these technological developments. It is very important that the training environment provides trainees the appropriate facilities for learning the knowledge and skills that are relevant to actual driving environments where they will need to interact with these technological innovations.

The main objective of this study is to examine the perception of learner drivers towards in-car driving assistance systems and the possibility of introducing them into drivers' training and testing. The impact of two specific ADAS was examined, which are the Adaptive Cruise Control (ACC) and Blind Spot Detection (BSD) system. These two systems were chosen after taking into consideration the main difficulties young drivers face which include speed selection and adaptation, as well as, hazard and risk detection. The systems' selection was also in accordance with the need of CBR for advancing the drivers' exam with the introduction of these two systems. Taking these issues into consideration the main research question of the study was formulated as following:

"What is the learner drivers' perspective on the Blind Spot Detection (BSD) and Adaptive Cruise Control (ACC) systems and their introduction to drivers' training and testing?"

The research methodology was designed carefully in order to collect the necessary information so as to answer this question and allow a thorough data analysis. The first part of the methodology was literature review in order to imbibe knowledge on previous work in the fields of drivers' behaviour, ADAS systems and widely applied training and testing methods. The identification of gaps in these areas of study together with the recognition of the core driving problems of novice drivers have been used as input for the development of an online multi-content questionnaire (32 questions). The first part of the questionnaire consisted of two existing behavioural inventories, the Driver Self-Image Inventory (15 items) and the Driver Stress Inventory (DSI) (28 items). They helped in gaining information on the driver profiles of the participants (confident,

courteous, and impulsive) and their driving stress causes (Dislike of driving, Hazard monitoring, Thrill seeking). The second part was video-based and has been especially developed for this study. It included a short video for each system, where a brief description of the system was made, and a set of questions about the perception of the respondents towards the BSD and ACC systems. The questionnaire responses to both Likert scale items and open-ended questions have aided in the organisation of follow-up in depth personal interviews, which only focused on the introduction of the systems in drivers' training and testing.

For the data analysis, two groups of participants, 40 learner and 48 experienced drivers, were recruited. The recruitment was mostly conducted in TU Delft and driving schools in The Netherlands. The data has been analysed both quantitatively (statistical analysis and tests) and qualitatively, reaching conclusions on the relation between the profile of drivers, the causes of their driving stress and their perception towards the systems. Specifically, knowledge, usefulness, ease of use and willingness to use of the two ADAS, as well as the acceptance of the systems in training and testing by both groups of participants were investigated through the ADAS related, video-based part of the questionnaire. In the end, a suggestion for the introduction of the systems in drivers' training and testing has been made based on the findings of the analysis.

The research results:

Knowledge of the two systems: The BSD system was found to be relatively known to 45% of the learner drivers, whereas the areas of application of the system seem to be quite unclear to them (33%). In contrast, the ACC system has been confused by more than half of the learner drivers with the Cruise Control system, thus creating a wrong impression of its capabilities and areas of application. Learner drivers' understanding of the systems, after the use of videos as a teaching tool, increased by approximately 30% for both systems. Although not every detail regarding the systems' characteristics, capabilities and application was captured, it has been proved that only the use of a simple video highly contributes to the increase of the learner drivers' acquaintance with the systems.

Usefulness of the two systems: Learner drivers' perception of usefulness of the BSD and ACC systems is highly dependent on the type of driving tasks and safety aspects the systems are used for. The BSD system is considered to be statistically significantly more useful in enhancing traffic safety of drivers as well as in helping them in several driving tasks, such as collision avoidance and lane-changing rather than in improving their driving performance. Concerning the ACC system, its usefulness in properly adjusting to the traffic conditions by maintaining the learner drivers' speed and distance headway from the vehicle in front is statistically significantly higher compared to its usefulness in enhancing their driving performance and safety. Although both systems mainly aim at increasing the safety levels of drivers, the ACC system has been considered more as providing comfort to drivers rather than safety. This is partly explained by the type of driving tasks drivers find most difficult. Identifying objects and especially small vehicles in high speeds has been reported by the learner drivers as one of the most difficult driving tasks, especially when multi-tasking driving is required (such as at intersections). The general impression is that the BSD system is considered to be more needed in drivers' training and testing, since multi-tasking is considered to be highly demanding for learner drivers. The ACC system, from the point of view of drivers, is attractive but not essential to the drivers in terms of traffic safety enhancement.

Expected ease of use: It is relatively high for both systems, with 31-33 out of 40 learner drivers reporting that they agree or strongly agree with the following statements: 1. "My interaction with the system will be clear and understandable", 2. "The system will be easy to use", 3. "It will be easy for me to become skilful at understanding and using the system". Nonetheless, although the ease of use and the simplicity of the systems increases the willingness to use them, it seems to decrease the total need of introducing them in drivers' training education.

Willingness to use: Learner drivers are statistically significantly more willing to use the BSD system in highway environments and rural roads than in urban environments. The same applies for the ACC system, as learner drivers significantly prefer to use it in highways and rural roads than in urban and congested environments. Also, a distinction is made between highways and rural roads, with the learner drivers being considerably more willing to use the system in the former.

Correlations between learner drivers' **self-images**, **causes of** their **stress** during driving, and **ADAS need in training and testing**: It was found that the need for the BSD system is unrelated to learner drivers' self-images. This means that although all drivers who expressed their need of the system have different driving behaviour, they equally recognise the necessity of the introduction of the system in training and testing. However, the more learner drivers feel confident, the less they say they need the ACC system ($r=-0.318^{**}$) and the more they argue against its introduction into drivers' education.

Comparison between the two groups of participants: No statistically significant differences in the answers of learner and experienced drivers were found. Accordingly, age and experience seem not to play an important role in the perception of the drivers towards the BSD and ACC system and their introduction to drivers' training and testing.

The answer to the main research question is given through the analysis of the above mentioned components. Both systems are thought to be important for different reasons, based on learner drivers' perceptions. Relieving the young driver from the stress caused by multitasking, as well as, increasing traffic safety levels lead to ranking the BSD system first in their preferences for driving assistance. The BSD system is considered as an ADAS increasing traffic safety, whereas the ACC system is believed to be a luxurious system assisting in harmonising the traffic flow. For these reasons, learner drivers ranked the BSD system at a higher priority over ACC when they were asked about sequence of the systems' introduction in the drivers' education.

Concerning the **systems' integration in training and testing procedures,** their integration should ensure that drivers learn to react safely to all input interfaces and properly perceive all the systems' indications. The training should also teach drivers about handling systems' possible failures. Thus, after determining the sequence of the systems' introduction, theoretical behavioural tests should be made to the trainers before the practical lessons and specific elements need to be included in both training and testing, depending on each system's specifications and demands. In this way, elements for all levels of drivers' training, from tactical to strategic, are incorporated.

Recommendations for future research: First of all, it is suggested to increase the reliability of the results by increasing the sample size and improving the videos used for increasing awareness. Moreover, it is proposed to assign weights to the used measures (usefulness, ease of use, etc.) and to identify other measures influencing drivers' perception towards ADAS, such as their familiarity and occupation with technological advances or sociodemographic characteristics. Finally, it is recommended to conduct a driver simulator study and field studies and examine driving behaviour and drivers' performances in relation with ADAS.

Table of Contents

List of Figures

List of Tables

Introduction

The increasing number of road crashes in which young inexperienced drivers are involved in has created an increased concern among scientists and researchers. According to SWOV (2012), the crash rate for young novice drivers between 18-24 years of age in the Netherlands proves to be five times higher than the rate of experienced drivers, whereas the respective rate for young males is considered to be seven times larger than that. In 2009, 23% of the serious crashes involved young drivers. Considering that novice drivers consist no more than 8% of the total driving population, both the concern and urgency for dealing with this situation increase (SWOV, 2012). The question lies on the identification of the exact factors that contribute to an accident, as well as to the countermeasures that could prevent the latter.

1.1. Problem Statement

Analysis conducted in this field has concluded that the majority of young people's crashes stem from errors of attention, visual search, speed selection and adaptation, hazard identification as well as control during emergency manoeuvres. A number of studies (Ferguson, 2003; Williams, 2003; Auberlet, Pacaux, Anceaux, Plainchault, & Rosey, 2010) claim that this category of drivers is overrepresented in crashes characterized by extreme driving speeds, alcohol, fatigue and distraction. The belief that the primary effect of young drivers' lack of experience is related to their ability to appropriately handle the vehicle in difficult scenarios has been replaced by the inability of them to apply higher-level cognitive skills in demanding situations (Ranney, 1994; McGwin Jr & Brown, 1999; Mayhew, Simpson, & Pak, 2003). Lack of such skills contributes not only to failure of control at the operational level but also to collapses in tactical and strategic levels, largely undermining driving safety.

The mechanisms that underlie the road accidents of young drivers are difficult to isolate. This happens, on the one hand, due to the natural bewildering of age, status and experience, but on the other hand it results from the complex character of the multi-level control task of driving (Summala, 1996).

Following the radical increase in risk development not only among young inexperienced drivers, safety has become an indispensable asset for the automotive industry over the past decades. Numerous surveys and tests have been conducted to address the type of enhancements in in-vehicle technologies needed to improve driving performance and increase traffic safety.

Nowadays, Active Safety Systems, also known as Advanced Driver Assistance Systems (ADAS) are designed in order to dynamically assist the driver in escaping from accidents before they occur by taking part of their responsibility in certain situations (Lindgren & Chen, 2006). ADAS attempt to amplify drivers using either warning messages to decrease risk exposure or through the automation of standard control tasks, aiming to relieve a driver from manually controlling the vehicle. To be more specific, ADAS could replace some of the human driver decisions and actions with precise machine tasks, managing to lessen a variety of the human errors which would probably result in accidents, while reaching more balanced and steady vehicle control with enlarged capacity, related energy and environmental benefits (Piao & McDonald, 2008). Thus, driving safety is augmented even before critical situations arise. Nevertheless, several studies have proved that such automation may negatively influence driving performance in terms of increasing the driver's reaction time, affecting their situation awareness and other tasks depending on the type of ADAS (Brookhuis, De Waard, & Janssen, 2001). Outcomes of recent studies have also shown that ADAS have behavioural influences on the driver (Saad, 2004) .

Given the current situation in these two areas of studies, the issue of the relationship between ADAS and young inexperienced drivers comes to the forefront. Based on the nature and aim of advanced in-vehicle technologies, up to now the emphasis has been on experienced drivers and especially on the older ones, where health problems and impairments hinder the successful completion of the driving tasks. Despite the fact that several studies have tried to assess the influence of ADAS on different types of drivers, almost no research has focused on young novice and learner drivers. Albeit different proposals and strategies have been formulated to tackle young drivers' driving problems through a graduated driving licence, almost no research has been made for the impact of ADAS on inexperienced drivers and thus on driving education, meaning the time period of acquiring the necessary skills and capabilities in order to obtain the driving licence.

1.2. Research Objective

The previous paragraphs have provided brief information on the current problems regarding traffic accidents and the availability and use of ADAS. It is seen that novice drivers attract most of the attention in terms of high tendency to participate in traffic accidents. Meanwhile, there is a radical development of ADAS systems, some of which could compensate for the inabilities of young people to take full control of the vehicle in risky situations.

However, limited literature is found that focuses on the effects ADAS could have on novice drivers (Turetschek C. , 2006; Young K. L., Regan, Triggs, Jontof-Hutter, & Newstead, 2010). It is generally considered that these kinds of systems may help young inexperienced drivers to counterbalance their lack of experience. The positive effects on traffic safety depend on a variety of elements, including subjective versus objective risk perception, behaviour generalization, conflicts between motives but also the adoption of a system. In the meantime, weaknesses of such systems have been found for all driver groups in general, not only concentrating on novice drivers. For instance, a failure of the mechanism or a failure to handle technology may lead young drivers to face a situation of increased complexity characterized by multiple driving tasks and emerging technologies. Although interesting enough, the latter case is not going to be examined in the present study.

Considering that the near future will bring highly compound distractions and complex vehicles as well as very self-confident but unprepared drivers, traffic safety would probably deteriorate more than it would due to the factors mentioned before (Lee, 2007). Since the aim of ADAS in only a positive one, there is an urgent need for research, designs and policies to define the way the potential benefits of emerging technologies are exploited.

Furthermore, up to now there is no ITS technology that has been developed to advance and enhance the training and education of drivers (Malik & Rakotonirainy, 2008). It is a matter of significant importance that the training environment provides trainees the appropriate facilities for learning the knowledge and skills that are relevant to the actual driving environment. An incongruity between the training environment and the world of real driving is there, the skills developed during training may transfer differently. The latter could cause confusion and ineffectiveness while driving. Although a lot of research has given emphasis on practices to improve driver training methods, the impact of ADAS on driving students has not been examined, thus a thorough solution is yet to be found.

Taking the aforementioned discussion into account, the research objective is clearer. The achievement of an ultimate level of traffic safety, thus the elimination of road accidents of all drivers requires the examination of all possible mechanisms. The present study consists of an attempt to examine the perception of young inexperienced drivers towards in-car driving assistance systems and their introduction to drivers' training and testing. Depending on the results of the latter, the possibility of introducing certain ADAS in the driver training and testing procedure will be investigated. Taking into account that the main difficulties young drivers face include speed selection and adaptation, as well as, hazard and risk detection, the attitude towards two specific ADAS will be examined, being Adaptive Cruise Control (ACC) and Blind Spot Detection (BSD) system.

The development of the research and the necessary methodology to create a structured study implies the existence of specific research questions, the answers to which formulate the scope of this thesis.

<u>Main Research Question</u>

> ***What is the learner drivers' perspective on the Blind Spot Detection (BSD) and Adaptive Cruise Control (ACC) systems and their introduction to drivers' training and testing?***

The answer to the main research question can be given by answering a number of other questions that can be divided in three main aspects:

Systems design

- What is the technical design of the system?
    a) What types of BSD and ACC systems are available at the automotive industry and what are the main differences between them?
    b) In which situations does the system fail to work appropriately in which the driver should be aware of?

Knowledge and need for a system

1. What is the need of the introduction of the BSD and ACC systems in driving training and testing from learner drivers' perspective?
   a) To which extent do learner drivers know about the systems and their operation?
   b) To which extent do learner drivers understand how the systems operate?
   c) What is the learner drivers' perception of usefulness of the systems in different driving situations (hazards, overtaking, etc.)?
   d) What are the driving related characteristics of drivers from which each system is asked more?
2. To which extent are learner drivers willing to use the systems?
   a) Do learner drivers find the system easy to use?
   b) In which traffic and road conditions are learner drivers most willing to use the system?

Comparisons

3. What are the differences between learner and experienced drivers in terms of usefulness, ease of use as well as training and testing of the systems?

The present work intends to provide clear answers to these questions, while reviewing the state of the art methodologies that will lead to the development of a methodology relevant to the needs of the study. Based on the results, conclusions will be drawn regarding the possibilities of introducing these systems into driving classes, attempting to compensate for the existing gaps between training and real life driving.

1.3. Scientific Relevance

As already mentioned, very limited research has been conducted in the field of ADAS and learner drivers. Several attempts have focused on young drivers' accident causes (Chliaoutakis, Darviri, & Demakakos, 1999), while simulator studies have examined the use of ADAS by young novice drivers (Horberry, Anderson, Regan, Triggs, & Brown, 2006; Kass, Cole, & Stanny, 2007). Studies related to learner drivers have focused on research based both on stated preferences regarding graduated driver licensing and influence of parental guidance (Scott-Parker, Watson, & King, 2009) and field work (Lotan & Toledo, 2007). Therefore, the relationship between ADAS, driving education and testing as well as learner drivers remains unexplored. Using previous research as the fundamental stone, the present study consists the first step of examining the potential of introduction of ADAS into driving training and testing procedures.

1.4. Methodology

To answer the posed research questions, this study employs literature research, presentation of theoretical framework, questionnaire development and interviews (Figure 1). Literature is used in order to identify the most considerable driving problems of young drivers by understanding their general attitude and their cognitive abilities. The alternative types of studies that have been conducted in this field and their main conclusions are reviewed in order to understand the areas of research that have not been covered yet and need to be tackled by this study. In the meantime, an analytical description of the chosen ADAS is made so as to display their relation to the needs of young drivers, training and testing. The theoretical framework is highly associated with the literature research and the questionnaire development, covering all aspects that appear not only to explain but also to influence young people's driving behaviour and performance. Thus, the cognitive processes related to the driving tasks are analysed. Finally, questionnaire development uses input from the theoretical framework and operates as a source of input for the interviews which are conducted after the distribution of the questionnaire.

1.5. Thesis Outline

Chapter 2 presents the literature review. In Chapter 3 the proposed methodology to tackle the research questions is illustrated along with the alternative options for this type of research. Chapter 4 elaborates on the data collection and the data analysis, providing insight to the software used for this aim and the variables tested. Chapter 5 presents the drawn conclusions, followed by Chapter 6 where recommendations for future research are given (Figure 1).

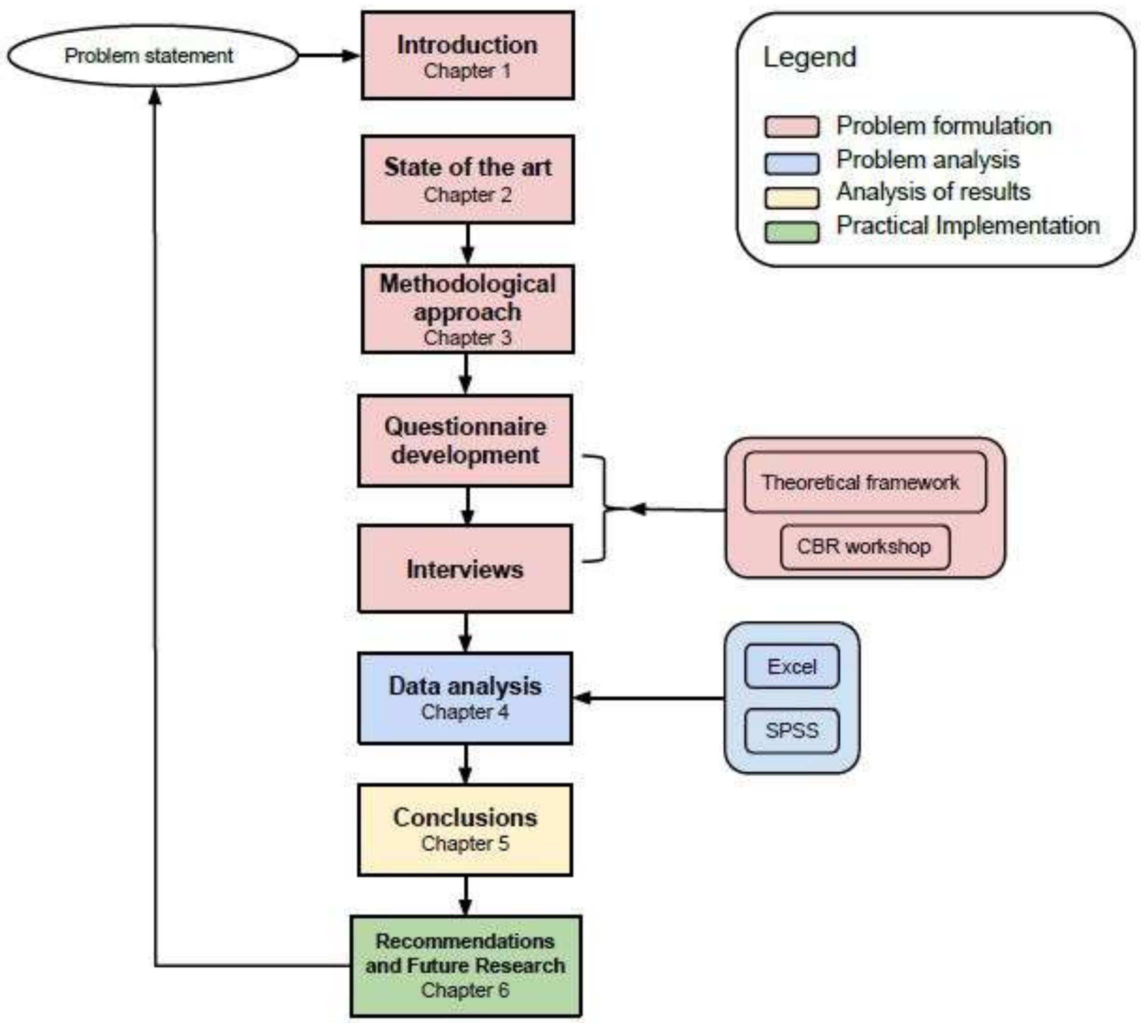


Figure 1. Report structure based on Dym et al. (2009) and Walker (2000).

1.6. Conclusions

In this chapter the problem statement was given, stating that the crash rate for young novice drivers between 18-24 years of age in The Netherlands is five times higher than the rate of experienced drivers, with 23% of the serious crashes involving young drivers. Problems with *speed adaptation* and *hazard detection* have been reported as main causes for young drivers' accident involvement, together with their undeveloped cognitive skills. Meanwhile, ADAS have been designed to help drivers in difficult and risky driving tasks. Given these facts, the research objective was set: to examine the perception of learner drivers towards ADAS and their introduction to drivers' training and testing. The used methodology, including literature research, questionnaire development and interviews, has been announced. Finally, the scientific relevance of this work has been explained through the limited literature that is found focusing on the effects ADAS could have on learner and novice drivers.

State of the art

Having formulated the research objective, an overview of the existing literature is required in order to find supporting knowledge on the respective work in this field. In the meantime, the reasons why the topic of the present study is chosen are illustrated in a more detailed way. As already mentioned, both the accident rates of young people and the ADAS are issues which have risen a lot of discussions. At this point the relation of the two subjects is examined, together with the need of introducing Intelligent Transportation Systems (ITS) in driving education procedures.

The first part of the literature research presents the significance of traffic safety by briefly presenting the current situation on road crashes and the core contributing factors. The second part depicts a number of aspects of the driving risks, characteristics and training of young candidate and novice drivers, since they are found to rank first in road fatalities. Meanwhile, the human factor is considered to be the most influential one in causing road crashes, thus human behaviour while driving has to be studied. Next, the fundamental concepts of drivers' training and testing are described, followed by the currently applied training and testing methods. In the fourth part, the introduction of the ADAS in the automotive industry is discussed, together with the reported driver behaviour issues that have risen because of the latter and require special attention. Last but not least, a brief look in the necessity and the means of integrating ADAS into driver training practices is given, since it comprises one of the core aims of this study.

2.1. Traffic Safety facts

Road traffic crashes are considered to be one of the most crucial problems in today's civilized society. The number of people being killed in road accidents has reached 1.2 million per year, while the injuries exceed 50 million for the same period of time (WHO, 2013). Relative forecasts indicate that these facts will increase by about 65% over the coming 20 years, unless super-effective strategies and measures are put into practice.

Nevertheless, the prevention of crashes, which is necessary for the elimination of the traffic accidents, calls for the recognition of the factors that contribute to a crash. Traffic is the outcome of interaction three components, being road users, vehicles and road infrastructure. In this relation, human is conceived as the fundamental element, since the majority of accidents prove to be a result of human error.

Based on the aforementioned factors, the policies and measures to counteract the radical development of road accidents can be divided into three different categories:

1. Changing human behaviour policies
2. Vehicle-related measures
3. Road infrastructure related measures

All three approaches contain a variety of both active and passive measures. Behaviour related practices, involving enforcement, education and driving instructions, mostly belong to active measures, while in vehicle related measures a balance between the types of actions is found. On the one hand, passive components refer to car body structures, seatbelts and airbags, whereas active components are related to ADAS that continuously assist the driver in primary and secondary tasks as well as in avoiding accidents in critical situations (Lu, Wevers, & Van Der Heijden, 2005).

The nature of countermeasures that are undertaken differs in each situation, since both the type of driver (age, gender, experience) and the function, aim and impact of each assisting device together with the type of driving environment determine the category of strategies to be implemented. The latter concepts are discussed in the following sections.

2.2. Young Novice Drivers

Novice drivers are the group of road users running the highest accident risk. According to Drummond (1989), in most of Western countries novice drivers between 18 and 20 years rank first in road fatalities and injuries, while road crashes have been established as the main cause of fatality for young people between 15 and 29 years in high income countries (Pedan, McGee, & Krug, 2002). Based on SWOV fact sheet (2012), the risk of getting involved in a crash for these ages is more than five times as high per kilometre as it is for drivers 30-59 years of age. Specifically, the crash rate reaches a peak immediately after being allowed to drive unaccompanied just after the driving test is succeeded, followed by a rapid decrease in the following years. In addition, the younger the novice driver, the higher the crash rate at the start of the driving career.

2.2.1. Risk increasing factors

There are several differences in the factors of accident causation that distinguish young drivers from older ones. Turetschek (2006) ranks by importance the main causes of accidents, in which badly adapted speed, failure in giving right of way, mistakes in keeping distance and problems with turning movements are included (Engstrom, Gregersen, Hernetkoski, Keskinen, & Nyberg, 2003). Whelan et al. (2004) proved that newly licenced drivers focus more on vehicles in the adjacent lanes than in their own lane, resulting in rear-end collisions. Another problem related to this category of drivers is the lack of experience to recognize the type of road (Fuller, 2005; Tronsmoen, 2008) and thereby induce adequate behaviour as well as easily detect risks and hazards and properly react to them (McKnight & McKnight, 2003). According to Deery (2000), the required time for the development of risk assessment skills and the detection of hazards is longer for young novice drivers when compared to drivers with ages of experience. In such cases, the causation of an accident is often attributed to the effort of young drivers in collecting relevant visual information during driving, especially when driving in complex and demanding situations (Crundall & Underwood, 1998). Based on Pollatsek et al. (2006), the latter failures can be explained through two areas, a structural and an informational one. On the one hand, less experienced drivers have less skills related to the mechanics of driving which reduce their abilities to pay attention to the whole road instead of some parts of it. On the other hand, failures in risk and hazard perception and detection might be outcomes of their inability to realise where they should be concentrated on in order to avoid risks.

With regard to traffic violations, young drivers are often found to be involved in traffic injuries and fatalities caused by alcohol use and non-usage of seat belt. Moreover, most of the novice drivers' accidents are reported during the evening and night hours as well as during the weekends, while they are often found to be distracted from the presence of other passengers in the vehicle (Kelly & Nielson, 2005).

It cannot be denied that experienced drivers are also involved in crashes because of failing to scan the roadway, control their speed and maintain their attention. Nonetheless, it is reported that newly-licenced drivers face at least some of these failures more often than experienced drivers (Chan, Pradhan, Pollatsek, Knodler, & Fisher, 2010).

2.2.2. Driving Behaviour

As in all domains of life, during driving humans behave according to their decisions and the expected outcomes of the latter. Being based on that, they tend to perceive certain situations as less risky than they actually are. Thus, they use their subjective view in order to deal with the objective risks. Meanwhile, people tend to delegate the responsibilities of their behaviour to the assistance systems they use. For instance, fast driving is more feasible and easier when the Adaptive Cruise Control is turned on and the system takes care of the distance with the preceding vehicle. However, the reduction of the reaction time can reach certain levels. In relevance with the latter, drivers tend to generalise their behaviour. In terms of speeding, people who drive fast on motorways usually behave in the same manner on other types of roads, like in urban environments. An important cause of such behaviour is the fact that the negative consequences of risky actions are almost never apparent. The hidden negative impacts of risky behaviour also lead to conflicts between motives. To elaborate more, novice drivers, who are very prone to this phenomenon, do not seem to recognise the need for driving slowly for traffic safety reasons, since they attempt to reach a destination in the minimum possible time (Turetschek C. , 2006).

Comparing candidate or novice drivers to experienced drivers, it is seen that the risk of getting involved in an accident is still high after the first year of driving. Although basic skills, like shifting gears, may be acquired at a high level, it usually takes a longer period of time to automatize the latter. As a result, the lack of perfection of drivers on these skills cause inability to sufficiently attend and control other tasks, such as hazard perception. Young drivers have been also found more prone to attentional capture because of the longer time they spend on fixations, when dealing with demanding situations (Crundall & Underwood, 1998). In other words, young drivers confront the problem of spare attentional capacity, which is the difference between the demanded by the task cognitive resources and the resources that are available to use for a task (Kahneman, 1973). Having less spare cognitive capacity, novice drivers are less capable of focusing on the surrounding environment when driving, while experienced drivers have been found to react fast to peripheral targets. Thus, the involvement of young drivers in hazards and accidents can be partly attributed to the amount of spare attentional capacity to the respective drivers' category (Patten, Kircher, Östlund, Nilsson, & Svenson, 2006).

Besides the attentional capacity, the visual search mechanism of inexperienced drivers has also proved to be insufficient compared to older drivers. While the latter group adjusts its eye scanning movements to the road conditions, the former one is ineffectively flexible in scanning the demands of the different road segments (Mourant & Rockwell, 1972; Crundall & Underwood, 1998; Kass, Cole, & Stanny, 2007). Driving simulator experiments have shown that young drivers' scanning abilities develop through time and experience, resulting in increased awareness of risky situations (Brown & Groeger, 1988; Underwood, Chapman, Brocklehurst, Underwood, & Crundall, 2003; Pollatsek, Fisher, & Pradhan, 2006).

Even in case of successful hazard detection, inexperienced drivers are susceptible to underestimate the posed risks. Underestimating the risks, together with a tendency for acceptance of greater risks lead to the choice of aberrant driving behaviour by young people (Matthews & Moran, 1986). Following this, novice drivers consider themselves as better skilled compared to their peers or other experienced drivers, resulting in failures caused by such overconfidence (Lee, 2007).

Elaborating more on hazard detection and risk perception, the driving problem of young drivers can be represented by two core factors, being age and experience (Deery, 2000). On the one hand, the ranking of novice drivers in the accidents charts is explained through their age related habits and their willingness to take risks. In accordance to that, their driving performance is highly relevant to the role the car plays in their life and the meaning it has to them, while their risk involvement can be considered as a consequence of their recent independence from family and school. On the other hand, inexperienced drivers' driving skills are inferior to that of the experienced ones, with hazard recognition, control of attention and time distribution being the most crucial ones (Gusfield, 1991).

The differentiation between age and experience leads to the respective distinction between driving style and driving experience (Deery & Love, 1996). Although driving skills are usually improved through training, there are always subject to a number of limitations in specific parts of the driving task, such as the reaction time to hazardous situations in traffic. The decision making process and traits are associated with the driving style, meaning the way in which people drive, which is the result of driving habits developing over time. The choice of speed and distance headway are examples of driving style components (Deery, 2000). The different preferences of drivers might influence the way in which the drivers adopt and interact with the vehicle technology, which is available to match their driving purposes and motivation as well as their driving style. According to Hoedemaeker (1999), whenever driver assistance systems contradict or aggravate drivers' needs, the anticipated acceptance of them is lower or false, possibly leading to dangerous reactions in risky conditions.

Despite their distinct separation, the relation between age and experience significantly affects the driver's safety level. Hence, the tendency of young inexperienced drivers for risky driving behaviour can be explained through their lack of experience and their low levels of driving skills.

As far as hazards are concerned, experience is considered to be a greater influence on the development of the necessary skills. Using visual information collection methods, Mayhew and Simpson (1995), reckoned that young drivers are found to have a smaller range of horizontal scanning of their surrounding environment when compared to drivers with more years of experience. The latter means that novice drivers usually look closer to the front of the vehicle, while reducing the frequency with which they check their mirrors. In addition, the detection of objects on the road segment is often poor and the peripheral vision is less efficient from that of the experienced drivers. Equally important for the difficulty in hazard detection is the fact that inexperienced drivers spend time focusing on stationary objects, whereas the fixation of older drivers is mostly done on moving objects.

According to Milech, Glencross and Hartley (1989), novice drivers also differ from the experienced in the way they perceive conditions and incidents. On the one hand, drivers with experience display a holistic perception of events, while novices display fragmentary and independent of context perception of incidents. For instance, one common characteristic among different situations is sufficient for novice drivers to perceive all situations sharing that characteristic as hazardous. Nevertheless, situations are judged based on various characteristics by experienced drivers, determining the extent of a potential risk (Benda & Hoyos, 1983). Following the latter, it is seen that experienced drivers have the ability to quickly absorb information and recognize danger, as a result of perceiving situations holistically which is generated by the reorganisation of knowledge and develops with experience (Milech, Glencross, & Hartley, 1989).

However, long latencies in hazard perception do not mean that novice drivers are slower than the experienced ones in other parts of the driving task. Reaction times increase by ageing (Deary & Der, 2005). Since experienced drivers are generally older than novice drivers, they have longer reaction times. Based on the study of Quimby and Watts (1981), drivers younger than 25 years old were found to have faster reaction times for simple manoeuvres and choices than experienced drivers. Summala (1987) as well as McKenna and Crick (1991) verify the latter study's findings, while showing that novices are more susceptible to miss existing hazards and it takes longer for them to detect the perceived hazards. Gaining experience through practice, drivers familiarise with hazards and start relating different types of hazards to certain parts of the traffic system (Brown & Groeger, 1998). Nonetheless, reaction times of some older and more experienced drivers may be shorter than the ones of young novice drivers, who have not yet developed elaborated mental representations. Detailed mental representations provide drivers the ability to identify latent hazards as the road and traffic environment develops (Norman & Shallice, 1986; Vlakveld, et al., 2011).

However, the shorter reaction times of young drivers might not be a result of hazard perception skills only, but also an outcome of differences of risk acceptance among different groups of drivers. Because of higher level of cautiousness, older and thus more experienced drivers may react earlier than young drivers, for instance by pressing their brake pedal faster. Either being a result of hazard perception or a result of risk acceptance, it has been proved that better developed schemata are a more probable explanation for shorter reaction times among the group of experienced drivers (Vlakveld, 2014).

Concluding on hazard perception, various studies were led to the fact that there is no significant difference between reaction times of novice and experienced drivers, since in some cases experienced drivers did react faster in more complex latent hazards (Sagberg & Bjørnskau, 2006) but in other cases there was no difference in the risk ratings of hazard scenes between different experience groups of drivers (Wallis & Horswill).

Referring to risks, the subjective perception of them together with hazard detection plays a crucial role in driver's safety (Gregersen N. P., 1996). Risk based theories use the subjective experience of risk as a core element in their explanation of accident causation and involvement. Specifically, perception and acceptance of risks or failures in these actions are used to illustrate the relationship between driving style and accident involvement. In accordance, it has been exhibited that the level of risk perception in traffic hazards is associated with the respective crash records, since both the driver's evaluation of risks and their self-assessed ability to handle such situations positively contribute to the creation of an accident (Groeger & Brown, 1989). In the meantime, several studies have proved that although drivers experience subjective levels of risk, their experience might not represent and reflect the real road conditions (Taylor, 1964; Colbourn, 1978). For instance, young male drivers evaluated risk as of lower level, while they held the biggest responsibility for the situation, while suggesting that they regarded themselves more able to tackle similar situations than other drivers, peers or not (Brown & Copeman, 1975).

Comparing novice and experienced drivers regarding risks, it is claimed that young drivers assess lower risk levels in certain types of manoeuvres, like short headway adaptation. Such behaviour might be attributed to experience related factors, age related ones or both (Deery, 2000).

Another point of difference because of age and experience is found in the impact of passengers' presence. Although passengers' existence in the car positively contributes to the driver's performance in case of experienced drivers, this protective effect is reversed for young drivers, especially when passengers are people of the same age (Vollrath, Meilinger, & Krüger, 2002). To be more specific, teen passengers can have a damaging impact on both the driver's performance and attitude, since they have the ability to affect all types of incidents, ranging from the basic driving tasks to challenging risk taking behaviour (Williams, 2003). So, peer influence, incorrect confidence, and reduced situation awareness lead young drivers into situations in which their weak skills leave insufficient capacity for adjustment to situations of high demand (Lee, 2007).

Finally, driver behaviour changes when driving assistance systems are used. To begin with, the acceptance of the system is considered to have major importance, since the system cannot be used properly when drivers do not accept its way of usage and operation. Thus, it is necessary to figure out the attitude of the drivers, and particularly the novice ones, towards those systems. A number of different studies have examined different aspects of drivers' behaviour during the use of driving assistance systems. Results from the study of Young et al. (2003) depicted that the most accepted assisting technologies among young novice drivers are the seat belt use reminder together with the Alcohol interlock. In the same study, Fatigue warning, Intelligent Speed Adaptation (ISA) as well as the Lane departure warning system are considered as the least appreciated systems. Compared to Young et al. (2003), Mitsopoulos et al. (2003) showed that the acceptance of ISA is sufficiently high for people at the same ages. Moreover, differences in acceptance of the systems have been found between different driving environments. In general, it can be concluded that systems with a warning character are more widely accepted and respected than intervening systems, thus they are expected to be more effective (Turetschek, 2006).

2.2.3. Drivers' Training

Candidate drivers' training procedure is based and structured on studies focused on human needs, responses and interactions towards and during driving. Drivers' training has received a lot of alterations throughout the last decades, aiming to adjust to the new traffic conditions and the technological developments, which have created a new era in the domain of safe driving. Recognising the need of unceasing development of the training methods, it is crucial to gain knowledge on the fundamental parts of the latter. At this point, the vital parts of the driving training context are given, briefly illustrating the two most rudimentary and widely applied standpoints.

The driving task – basic interpretation

The driving task has been illustrated by various ways in the past. According to a number of studies (Allen, Lumenfeld, & Alexander, 1971; Summala, 1996; Pöysti, Rajalin, & Summala, 2005), driving can be depicted as a control task comprising of three levels (Figure 2). A collapse in one of the levels propagates to the other levels.

To elaborate more, the operational stage refers to the driver's ability to sustain the desired speed and lane position, thus it includes the basics tasks of driving. The operational level is followed by the tactical control of the vehicle, where the driver has to set the appropriate speed, detect and react to hazards as well as operate the necessary manoeuvres. The strategic level, being the last one, is related with more long term decisions, such as destination and route choice. It is seen that failures in one level spread to failures in the other levels, providing an explanation of why young novice drivers are overrepresented in car accidents (Lee, 2007).

The driving task – GDE matrix

Meanwhile, the European project GADGET has described the driving task in the same way (Van der Molen & Botticher, 1988), while adding another level in the GDE (Goals for Driver Education) matrix (Peräaho, Keskinen, & Hatakka, 2003). The uppermost level is known as "Goals for life and skills for living". Although no driving tasks are included in this level, driver characteristics such as personality, group identification, age, etc. are used as the influential components of drivers' performance at lower levels. Specifically, the general attitude and action of a person towards planning can influence themselves in their strategic decisions, which might further have effects on the tactical and operational level. Moreover, the matrix focuses on the fact that that the driver should know the way in which incorrect and absent information and skills result to enlarged risk (Brezillon & Tijus, 2007; Lang, et al., 2007).

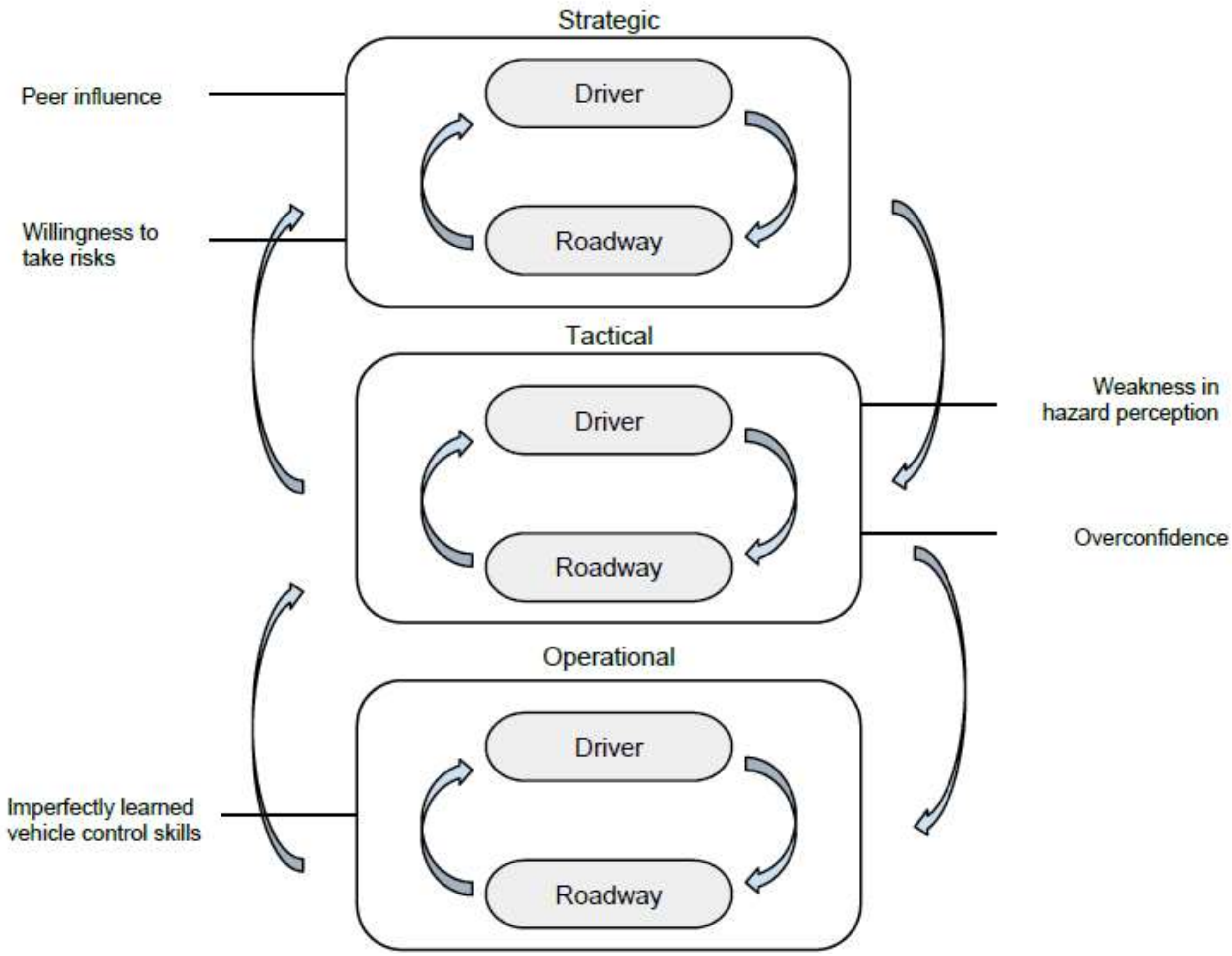


Figure 2. A three-level control illustration of the factors reducing road safety at each level of driving control (Lee, 2007)

Nevertheless, the European projects that have been focusing on novice drivers and training procedures, like the aforementioned GADGET and TRAINER, have emphasized vehicle control skills and obedience to traffic rules. Main components of drivers' performance, such as their willingness to take risks, which adequately explain the accident patterns of young people, are overlooked or are not clearly defined in the content of the latter projects. Therefore, personal attitudes, risk seeking, situational awareness and self-evaluation skills are still to be studied further and taken into account in driving training procedures (Maycock, 2001; Lang, et al., 2007).

Following the above mentioned points, driver training presents deficiencies in its aim to provide safe and efficient participation in traffic. Since the psychological principles that influence the effectiveness of training are not considered and driver training has not been appropriately structured in accordance with cognitive

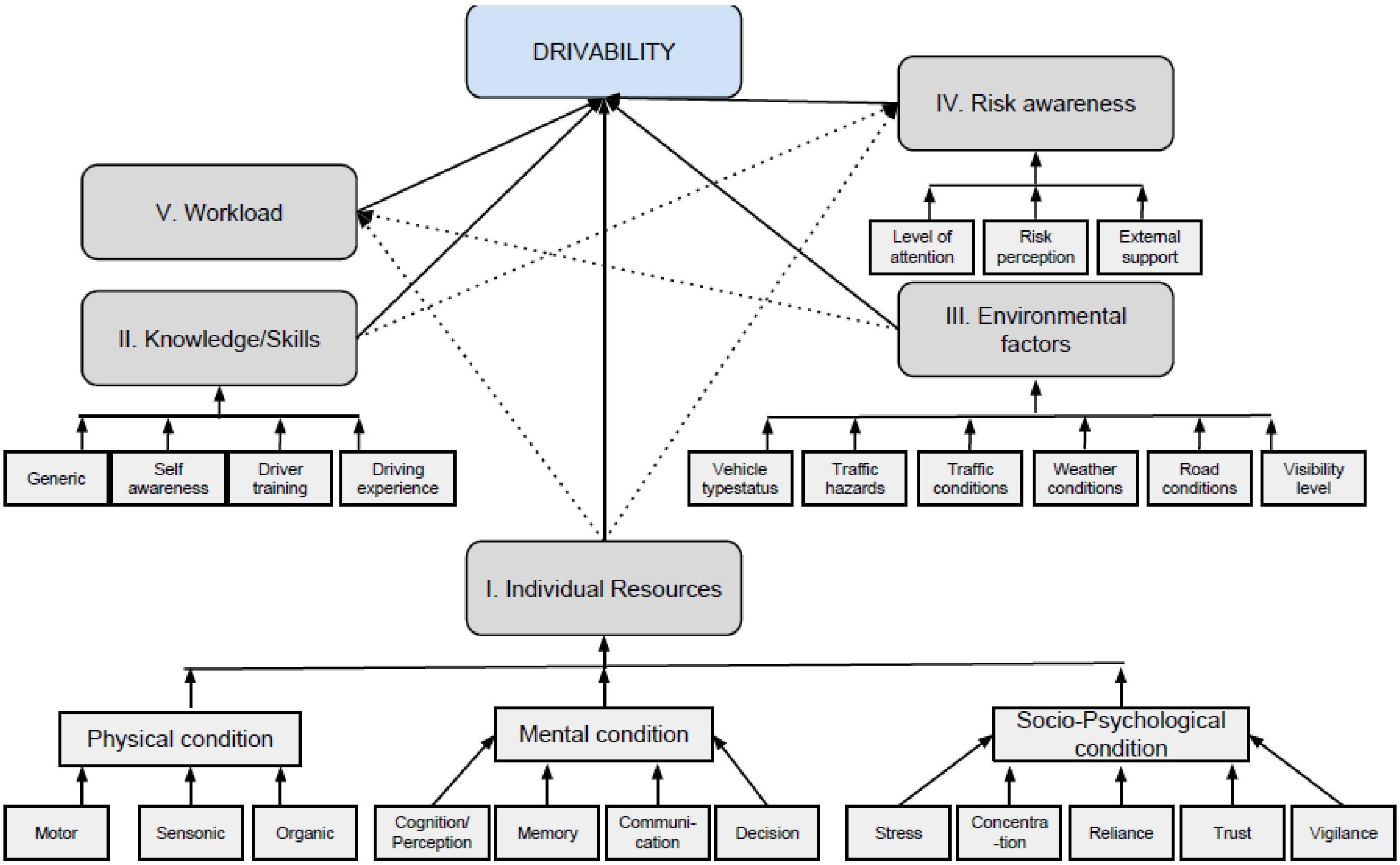


Figure 3. Contributing to the driving ability (DRIVABILITY) factors (Bekiaris, Amditis, & Panou, 2003).

psychological concepts, driving training practice has not been quick enough to incorporate the research results in the respective domain (Groeger & Rothengatter, 1998).

It cannot be denied that the systematic training of such skills in practical training is challenging for a variety of reasons, such as the limited involvement of the instructor in dynamic traffic situations, the increased risk of the rest of the road users etc. (Lang, et al., 2007). Hence, realistic, interactive in-car systems are required that make the drivers aware of both their abilities and their road environments' limitations, feedback and risk compensation processes. Their use in driving training practice might enhance the drivers' cognitive perception of the advanced driving tasks included in the third and fourth level of the driving matrices mentioned before. The introduction of Advanced Driver Assistance Systems into driving practice would aspire the comprehensive integration of basic and advanced driving tasks (Bekiaris, Amditis, & Panou, 2003), taking into account all environmental and psychological factors affecting the driver while performing (Figure 3).

Trends in drivers' training and testing

A variety of attempts have been made during the last 20 years in drivers' training and testing, aiming at the reduction of the novice drivers' accident risk. All of the changes have taken the form of countermeasures to address the two main causes of novice drivers' difficulties and inabilities, being their lack of experience and their undeveloped cognitive skills. The most important of them have been summarized in the CIECA report (2007) as such:

1. Basic changes to the pre-test practice structure, like setting a threshold for the minimum hours of driving practice before taking the practical driving test (e.g. Victoria, Australia: 120 hours). Another example is the introduction of a minimum learning period of 3, 6 or even 12 months before the final test can be taken (e.g. GDL countries, Belgium and Ireland). Additionally, setting a lower minimum age for the start of drivers' training, while maintaining the licensing age, has taken place in several countries, like Sweden. The purpose was to encourage more on-road driving practice.

2. Enhancement of the quality in drivers' training in terms of structure, methods and content. A lot of research, especially related to the GDE matrix, has emphasized on higher order skills, like self-assessment and insight of the impact of attitudes and motivation on drivers' behaviour. Based on that, a compulsory "2nd phase" of training has been introduced by several countries (e.g. Finland, Luxembourg, Austria, Switzerland and Estonia) for the first few months of unaccompanied driving, in order address the aforementioned issues (CIECA, 2007).

   Another well-known and widely applied idea is the Graduated Driver Licensing (GDL), which has been introduced to enhance the road safety of young drivers (Shope & Molnar, 2003; Williams, 2006). As far as Europe is concerned, the acquisition of high levels of cognitive skills is closely associated with increased levels of practice. Although several countries have been allowing private practice as a way of preparing for the driving test, the view of enhancing novice drivers' experience before driving unaccompanied has been actually encouraged only in a few countries. GDL improves young drivers' safety levels by eliminating the exposure to hazardous situations, while providing a classified introduction to them (Twisk & Stacey, 2007). Its protection to novice drivers is also achieved through reducing their exposure to night time driving, alcohol and unaccompanied driving. In this way, challenging traffic situations are gradually tackled by the inexperienced drivers (Lee, 2007).

   Besides Europe, GDL has been used as key road safety initiative in the U.S, Canada and Israel (Lotan & Toledo, 2007). Considering that the required for the driver skills cannot be learned at one time, graduated driver education has been established to complement GDL on theoretical basis. Guidelines and instructions should be provided to the candidate driver over a longer period of time, since the student displays lack sufficient cognitive capacity to adopt certain concepts in the initial stages of the training procedure. Moreover, the interest for post-licensing training programs, including computer-based instructions, simulator-based training etc., has been increasing in Europe, Australia and the U.S. but it has to be noted that such training takes place independently from both the driving training for beginners and the GDL (Lonero, 2008).

3. Alterations to the driving test, e.g. extending the duration of driving during the practical test to gain more realistic insight into the candidates" driving skills. Moreover, countries, like the UK and Australia, have established PC-based hazard perception testing.
4. Most innovations have been observed in the establishment of probationary periods, with constraints and stricter conditions for novice drivers in the first period of unaccompanied driving period after licence acquisition. Examples of measures that have been implemented are:

   - Low (or even zero) blood alcohol levels (e.g. Austria, Germany, The Netherlands, Israel)
   - Speed limitations (e.g. Lithuania)
   - Obligatory accompanied driving during night (e.g. Croatia, Israel)

- Ban of night or weekend driving (several GDL jurisdictions, e.g. the U.S)
- Prohibition of mobile phone use while driving (e.g., Australia)

Beyond the probationary periods, certain countries, such as Germany and The Netherlands, have introduced post-test accompanied driving. This option refers to the ability to take the driving test earlier than usual (e.g. 17 instead of 18 years), while being obliged to drive being accompanied until the driver's 18th birthday (CIECA, 2007).

Drivers' training and testing in the Netherlands

Figure 4 presents the drivers' training and testing procedures applied in The Netherlands in a nutshell. Drivers' training begins with a theoretical part, which can be conducted in a supervised or independent way. In the first case, learner drivers can choose to attend theory classes, whereas in the second case they can gain the necessary knowledge by learning the necessary theory independently. Approximately 30% of the candidate drivers choose to attend theory classes. As for the practical training, being the only permissible form of training in real traffic, is also conducted on a voluntary basis. Besides practical training in real driving environments, driving simulation training consists of another option for practice. With regard to testing, the final exam consists of a knowledge test and a driving test, before which the candidate drivers are able to fill in an optional learner self-assessment. After the acquisition of the driving licence (minimum age 17 years), the

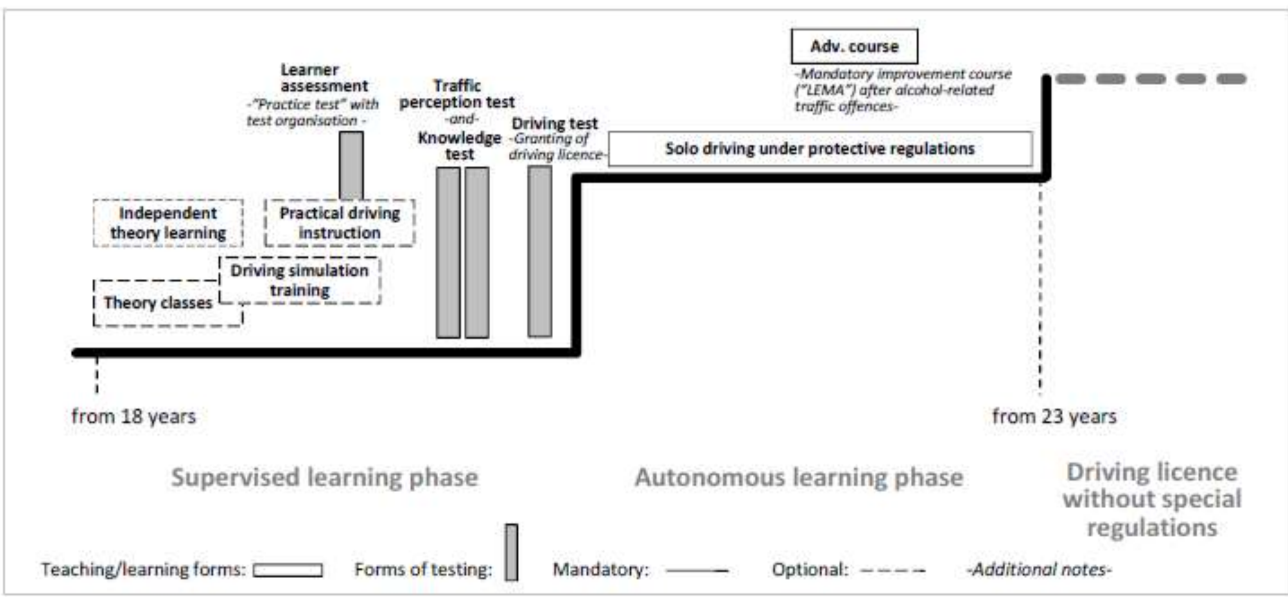


Figure 4. Schematic representation of drivers' training and testing in The Netherlands (Genschow, Sturzbecher, & Willmes-Lenz, 2014).

driver is allowed to drive solo but under protective restrictions (e.g. total alcohol prohibition) for the first five years. Finally, a voluntary test every ten years is recommended to the drivers in order to have up to date traffic related knowledge (Genschow, Sturzbecher, & Willmes-Lenz, 2014).

Curriculum

Theoretical training methods include presentations, written and oral progress evaluation, discussions, draft tests as well as demonstrations by the instructor. Regarding learning material, traditional text books, slides, videos, simulated driving scenarios and computer-based/online training programs are used.

"Driver Training Stepwise" or "Rijopleiding in Stappen" – "RIS" is a popular way of transferring driving knowledge during practical training. It consists of a type of training-highly relevant with the GDE matrix concept, where the learning process is divided into distinct modules (39 driving tasks in total) and provides continuous assessment for the drivers' learning success. The four existing modules comprise "Vehicle operation and vehicle control", "Mastering simple driving manoeuvres and traffic situations", "Complex vehicle operation and control of complex driving manoeuvres and traffic situations" and "Safe and responsible traffic participation". The achievement of learning objectives is examined by the driving instructor once each module is completed, while at the end of the third module an external driving test examiner conducts the exam. Although practical driving instruction is not mandatory, learner drivers are found to attend 40-50 driving lessons on average. Participants in this programme also have the opportunity to attend driving safety training on a special practice ground, like slippery roads. Besides the content of practical training, the typical methods of driving classes included guided by the instructor driving on basic and flexible routes in real traffic conditions, practical demonstrations by the instructor and independent driving, meaning driving to a certain destination without detailed guidance. Finally, approximately 15% of the learner drivers choose to attend driving simulation training, which is offered by commercial driving schools (Genschow, Sturzbecher, & Willmes-Lenz, 2014).

Driving test

The driving test in The Netherlands consists of 2 parts, theoretical (divided into *traffic perception* test and *knowledge* test) and practical tests. During the theoretical exam, the candidate drivers undertake a computer assisted test, where the questions are given in the form of photographs of traffic situations (information from mirrors, turn indicators and speedometer is given to the candidate). Knowing these, the candidate has to choose between three possible answers: "Apply the brakes", "Take foot of the accelerator" or "Do nothing". The practical test takes place in real traffic conditions. Before it starts, the candidate driver submits a completed self-assessment to the driving test examiner, which will be used after the test is finished to compare with the test results. During the test, two of the following basic driving manoeuvres are examined: "Turning the vehicle to face the other way", "Parking" and "Braking accurately to a stop" (Genschow, Sturzbecher, & Willmes-Lenz, 2014).

Further development

Attempting to keep the training and testing of the drivers in line with the traffic safety needs and trends, the Dutch authorities have been introducing several concepts in the educational procedure, with accompanied driving being one of the last innovations. Specifically, in 2011, a new option of accompanied driving was introduced in The Netherlands in the form of a six years experiment. Based on this concept, learner drivers choose to obtain their driving licence in the traditional or the accompanied way. The accompanied driving option or "2toDrive" provides the opportunity to start learning at an earlier age, 16 years for the theoretical driving and 16.5 years for the practical driving lessons. The respective driving exam can be taken by drivers who are 17 or older. After succeeding in the exam, novice drivers are only allowed to drive if accompanied by an experienced driver. Drivers are allowed to drive solo when they reach 18 years old. It has to be noted that the traditional way of taking the driving exam at the age of 18 and start driving solo directly is still also possible. After six years of experimenting (2017), the Dutch government will make a decision on whether or not the law about the acquisition of the driving licence needs to be changed permanently. The decision will be based on experiences and an effect evaluation (van Schagen & Wijlhuizen, 2015).

Given the structure of the existing methods, the possibility of introducing ADAS into training and testing of the drivers has been considered both by the authorities and CBR (Dutch Driving Testing Organisation). Specifically, the initiative of CBR refers to the introduction of ADAS systems to "Category B" driving test at a voluntary level from 1st January 2016. ADAS has been permitted in testing of professional drivers for a long time.

2.3. Advanced Driver Assistance Systems (ADAS)

As already mentioned, safety problems of young inexperienced drivers are largely accredited to inappropriate or insufficient driving performance. Therefore, enhancing vehicle-driving behaviour seems to be one of the most promising paths to achieve an ultimate level of safety. Apart from education and behaviour enforcement by traffic police, a variety of systems based on electronics, the role of which is to undertake actions in case of sub-optimal driving behaviour, are established and implemented. Such systems are broadly known as Advanced Driver Assistance Systems (ADAS).

The development of ADAS systems can be illustrated through a lot of projects and initiatives that have been proposed and implemented in the European Union and not only there. Starting from Prometheus, various manufacturers and institutes carried out a number of projects, intending to find practical solutions to traffic problems in urban areas. Prometheus was followed by the DRIVE (Dedicated Road Infrastructure for Vehicle safety in Europe) initiative, in terms of which a substantial number of projects handled both practical and major issues. An eminent example of the latter is GIDS (Generic Intelligent Driver Support), which consists of the most significant projects of DRIVE 1 (Michon, 1993). To be more specific, the project's scope was determining the needs and design standards for a category of intelligent driver assistance systems in such a way that they follow the information needs and capabilities in driving performance of drivers. The initiative referred to a class of systems that would assist the driver in a range of tasks, from detection and evaluation of traffic hazards to provision of guidance based on the driver's ability to tackle with the latter (Brookhuis, De Waard, & Janssen, 2001). Considering young novice drivers, another European project, called RESPONSE, was launched in 2001. The project was considered to be the most endangered user group of ADAS among the other European initiatives (Becker, et al., 2004).

The current range of ADAS is wide for both lateral and longitudinal control (Figure 5), starting from systems supporting the driver in one specific driving task, such as proper distance keeping or blind spot obstacle warning to highly progressive systems where the drivers' basic tasks like steering, throttling and braking tasks are fully automated (Marchau, Van der Heijden, & Molin, 2005).

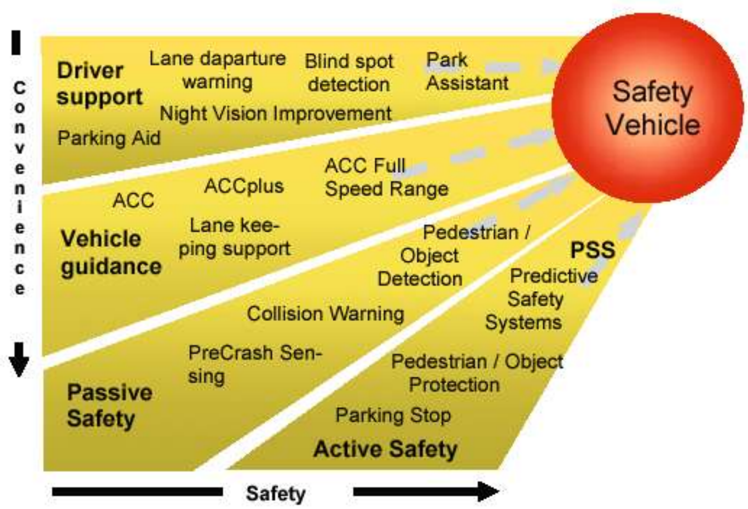


Figure 5. Range of ADAS.

Increasingly, vehicles are being equipped with ADAS including GPS and navigation systems, sensor suites as well as control systems that assist people in driving safely. Such systems may use biometric technology so as to identify the characteristics of individual drivers and create a history of their driving performance in order to measure short and long-term fluctuations in drivers' performance (Turetschek C. , 2006). Each type of ADAS aims to enhance and assist a specific characteristic of the driving performance, whose absence or deficiency would probably have negative consequences. Although young drivers might take advantage of ADAS that is developed to meet the general public needs, more remarkable benefits are expected by modifying this technology in such a way that it fulfils specific needs of young drivers.

Nevertheless, as all systems entering the market, ADAS have both positive and negative aspects. Despite the fact that they have been developed to lessen the number of road crashes and lead to a higher level of traffic safety, implications in the way of perception, adoption and reaction to them as well as failures of the mechanisms can lead to adverse results (Zwahlen, Adams, & DeBals, 1988; Saad, 2004; Dragutinovic, Brookhuis, Hagenzieker, & Marchau, 2005). To begin with, the delivery of information might lead to the driver's distraction from traffic. Moreover, depending on the level of behavioural adaptation to the system, the driver may lose awareness of the traffic situations, thus overlook hazards and fail in reacting properly.

Most of the research on the impact of ADAS has been conducted for drivers of all ages (Rudin-Brown & Parker, 2004) or older drivers (Tsugawa, 2006; Davidse, Hagenzieker, van Wolffelaar, & Brouwer, 2009; Rakotonirainy & Steinhardt, 2009). Thus, almost no literature emphasizing on the effects of ADAS systems on the driving performance of candidate and novice drivers has been found. In general it can be assumed that such systems could have a beneficial role on young inexperienced drivers, since they would attempt to compensate for their lack of experience (Chaloupka, Risser, Antoniades, Lehner, & Praschl, 1998). The introduction of any type of driver assistance system requires the knowledge of the consequences of system's operation. Thus, the causes of the effects and such failures have to be detected and dealt with.

There are several differences between introducing a new system into vehicles and the proper application and use of it. Firstly, drivers get no training on the use of a new system, since in most of the cases, the training on the system only consists of reading the user manual provided with the purchase of a new car. Secondly, the success of an ADAS design not only depends on the way the complexity is implemented technically but also on the extent to which this complexity is effectively hidden from the driver. Finally, the success of a system, determined by the correct use of it and its positive effects, highly depends on the freedom it leaves to the driver to perform the rest of the driving tasks. It is seen that it would be irrational to require ADAS to have absolutely no risk. Instead, it would be much more sensible to anticipate a risk "as low as possible", meaning that the higher or more unacceptable the risk, the more attention should be given to reducing it by improving driving behaviour and performance (Bekiaris & Stevens, 2005).

The selection of certain ADAS for further examination stems from two different components. The first component refers to the type of drivers under study, meaning their driving behaviour, their needs and preferences while performing their driving tasks as well as their inabilities to successfully face sudden events or risky situations.

Concerning the overpresentation in accidents of this group of drivers, there are very specific reasons for which young drivers deal with a higher risk of getting involved in road accidents (Turetschek C. , 2006). As described in the previous section, according to Underwood et al. (2002), their visual search is characterized inefficient and inexperienced, while they confront problems in speed adjustment and in adopting an appropriate distance headway in different driving conditions (Clarke, Ward, & Truman, 2005). Specifically, novice drivers have more possibilities in failing to appropriately react to traffic signs and variability in road geometry, for which speed management is necessary (Chan, Pradhan, Pollatsek, Knodler, & Fisher, 2010). Moreover, their risk assessment skills are considered very few at the moment they acquire the driving licence and the ability to detect and evaluate potential hazards takes long to develop (Vlakveld, 2014). To elaborate more, young drivers are usually found to scan less broadly from side to side and particularly in lane changing situations (Mourant & Rockwell, 1972). Meanwhile, their eye movements are found to be less widely spaced compared to the experienced drivers (Crundall & Underwood, 1998). Inexperienced drivers have also less probabilities to make successive fixations on objects in the peripheral environment (Underwood, Chapman, Brocklehurst, Underwood, & Crundall, 2003). Finally, they are not only found to underestimate hazard risks but to overestimate their abilities in overcoming a hazard (Deery, 2000).

Based on the category of drivers that are first ranked in accident involvement as well as on the currently available ADAS, two certain ADAS have been chosen to take part in the present study, being Adaptive Cruise Control (ACC) and Blind Spot Detection system (BSD). A brief description of the systems is given below.

2.3.1. Adaptive Cruise Control (ACC) system

Adaptive Cruise Control belongs to the ADAS that aim to support longitudinal behaviour of the vehicle and the driver. It differs from Cruise Control (CC), since its main goal is to maintain a safe distance from the preceding vehicle by adjusting the vehicle speed, while the cruise control adjusts the throttle to keep a constant speed that is chosen by the driver.

The system was first introduced in order to provide comfort to the driver while driving on highways, by adopting speed and distance to selected values, but it is considered to be a great help for novice drivers who have not developed the required skills yet. To be more specific, by providing automation to two parts of the driving task, being the control of the headway and the speed, ACC is expected to lessen driver stress and human failures (Stanton & Marsden, 1996). This is achieved by setting free the amount of visual, cognitive and physical resources that are needed to fulfil the respective tasks when having full responsibility. Accordingly, ACC is expected to reduce the number of strong accelerations and decelerations, promote speed harmonisation as well as improve merging behaviour. Finally, Chira-Chavala and Yoo (1994), claim that the appropriate use of ACC is able to decrease tailgating, thus reducing both the number and the severity of rear-end accidents (Rudin-Brown & Parker, 2004).

The most widely applied method to exploit the latter benefits of ACC is radar systems. Radar proves to be the best standard sensor, since options such as video, laser, and ultrasound have shown deficiencies in cases of bad weather conditions, in which they are needed most (Strohm, Bloecher, Schneider, & Wenger, 2005). Long range radar (LRR) or short range radar (SRR) systems as well as a combination of those are used in order to expand ACC system's aims from driver comfort to driver's safety.

Long range radar (77-81 GHz) systems provide information about the traffic conditions occurring in front of the vehicle, aiming to achieve a quick reaction to changing traffic conditions by accelerating and breaking (Wenger, 2005). Specifically, the system warns the driver for following the leading vehicle in a distance smaller than the least safe one or automatically maintains a safe distance to it. Meanwhile, the set cruise speed and the safety distance are controlled by activating brake or accelerator (Valldorf, 2005).

Figure 6 illustrates the standard function of the LRR ACC system. When no vehicle is detected in a safe distance in front of the own vehicle, the latter travels at the predetermined speed, which has been set by the driver. In case a vehicle is identified in the road ahead, the speed is automatically adapted in such a way that the pre-set safety gap between the own and the preceding vehicle is sustained. Furthermore, in case of fast and hazardous approach of the driver to the leading vehicle, an additional warning is given to the driver.

Finally, when the leading vehicles leave the road segment in front of the own vehicle, the latter accelerates to the previously set speed (Valldorf, 2005).

ACC systems operating with LRR are mostly used on highways and carriageways, being activated at speeds of 30km/h to 200km/h or more. Typically, LRR ACC systems are placed in the radiator grille or in the front bumper, working in a band of 77 GHz. At speeds below 30 km/h the systems switches off with a warning signal to the driver (Wenger, 2005). The driver can dominate the ACC system at any time by actuating the accelerator or with a short initiation of the brake.

Besides LRR, short range radar technologies have entered the area of ACC systems, mostly being applied for expanding the system's capabilities. SRR sensors are used for the stop-and-go operation of the ACC as well as for its expansion to pre-crash warning or changing lanes assistance devices.

Combining the use of LRR and SSR, valuable data for advanced driver assistance systems is provided. In this case (Figure 6), two types of radar systems are joined in order to monitor the traffic conditions ahead of the vehicle. A short range radar, usually based on 24 GHz technology, operates together with a long range 77 GHz cruise control system. As a result, the LLR tracks three motorway lanes over a 150 metres distance and an angle of nine (9) degrees, whereas the SSR monitors the area just in front of the vehicle, reaching 30 metres, by using an angle of 80 degrees (Wenger, 2005).

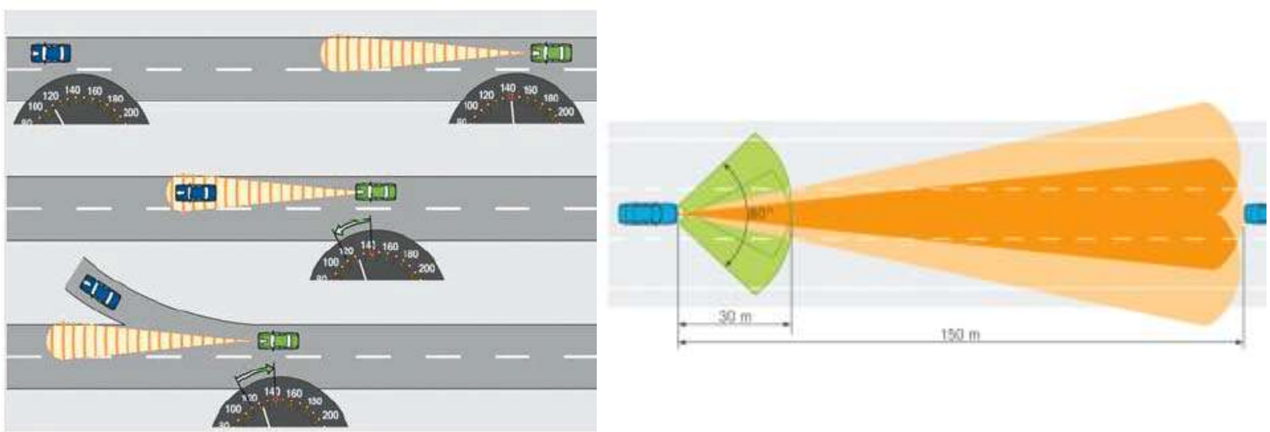


Figure 6. Left: Standard function of ACC (LRR), Right: Combination of LRR and SRR.

Despite its beneficial influence, a few problems might arise because of using ACC. According to Rudin-Brown and Parker (2004), drivers displayed improved performance in secondary tasks when driving with ACC but their reaction time in cases of traffic hazards increased. Specifically, drivers were found to fail in detecting and reacting to critical driving conditions because of not paying attention to the primary driving task (Smiley, 2000; Brown, 2001). Moreover, ACC drivers' attention was found to shift away (Cho, Nam, & Lee, 2006). Furthermore, despite the fact that ACC is expected to reduce hard accelerations and decelerations, it has been reported that drivers tend to brake more often and harder than needed (Sayer, Fancher, Bareket, & Johnson, 1995). In addition, as a result of undertaking basic driving tasks, the use of ACC leads to reduction of mental workload, thereby the attentional resources available to the driver decrease. Hence, there is less capability to perceive relevant cues in the surrounding environment which might be damaging to driving (Schleicher & Gelau, 2011). As for the perceived value of the system by its users, drivers consider that they put less effort in driving when using ACC than when the system is unavailable (Hoedemaeker & Brookhuis, 1998). Finally, Young and Stanton (2007) reckon that in cases of the system's failure in speed adaptation, the response times of drivers becomes longer compared to similar cases with no use of ACC.

Summarizing, besides its positive impact on obedience to speed limits and increased headways from the preceding cars, ACC has been subject to a number of accusations concerning the situation awareness levels of the drivers using it. As described above, based on driver reports, they have difficulties in keeping the levels of situation awareness stable, leading to extended reaction times in risky and hazardous traffic situations. Moreover, engagement in secondary tasks, distraction and the reduction of attentional resources as a result of the decreased workload, are the rest of the main reported impacts of ACC on driving behaviour.

Taking the latter into account together with the fact that two of the main causes of accidents involving young inexperienced drivers is speed and distance adaptation (Turetschek, 2006), in this thesis their performance is further examined with ACC, which directly aims to resolve this type of problems.

Table 1. ACC technologies and features.

		Features			
Types of ACC systems	**Automotive suppliers**	**Information about the traffic conditions ahead**	**Stop and go function**	**Adverse weather conditions**	**Environment**
Radar (LRR)	Nissan, BMW, Volkswagen, Audi, Mercedes-Benz,Mazda, Ford, Volvo	✓		✓	Urban-Rural-Highway
Radar (SSR)	Volkswagen, Audi, Mercedes-Benz, BMW,Mazda, Ford, Volvo	✓	✓	✓	Urban-Rural-Highway
Laser	Toyota/Lexus	✓			Urban-Rural-Highway
Ultrasonic	Volkswagen	✓			Urban
Camera	Subaru, Volkswagen, Peugeot	✓			Urban-Rural-Highway

2.3.2. Blind Spot Detection (BSD) system

Blind spots consist of areas that cannot be seen by the driver from the back mirrors (Chen & Chen, 2009). Blind spot areas usually refer to the rear quarter blind spots, which are found in the rear of the vehicle in both sides (Lindgren & Chen, 2006; Mahapatra, Kumar, Khurana, & Mahajan, 2008). The biggest blind spot areas appear at the rear and right-hand side of the vehicle in case the drivers sits on the left-hand side and vice versa. In the meantime, other areas at the lower parts in the front and back of the vehicle can also be considered as blind spots (Figure 7). These areas are not visible from the driver's position due to the shape of the vehicle. For instance, such blind spots become larger when calculated for a truck driver (Ehlgen, Pajdla, & Ammon, 2008). Moreover, vehicles in the adjacent lanes can be a part of the blind spots, thus making it very difficult or even impossible for the driver to see them only using the car's available mirrors. Finally, blind spots might arise in the right or the left side of the vehicle because of incidents or conditions that hinder the driver's vision for the respective sides (Mahapatra, Kumar, Khurana, & Mahajan, 2008).

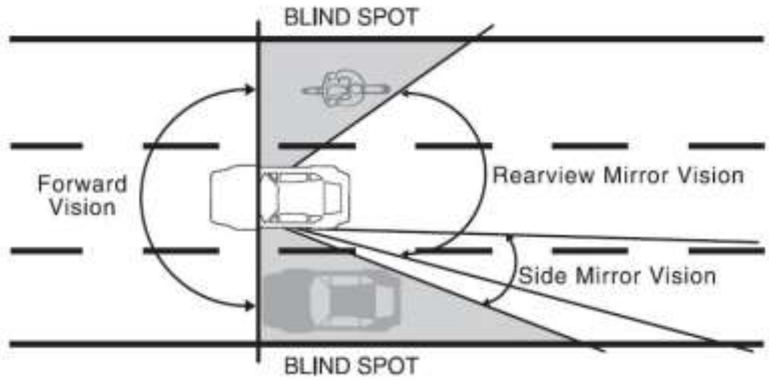


Figure 7. Main Blind Spot areas (Mahapatra, Kumar, Khurana, & Mahajan, 2008).

Considering the difficulty of drivers to detect vehicles in the vehicles' blind spots (Lang, et al., 2007), there is a certain need to enhance safety around all types of vehicles. The Blind Spot Detection system aims in gathering information about objects and obstacles in blind spots of the vehicle's driver. Specifically, the system identifies whether a vehicle is present in the so-called "blind spot" area when the vehicle performs a lane change or overtaking manoeuvres (Lang, et al., 2007). A variety of methods has been developed throughout the last decades in order to help drivers avoiding blind spot cause collisions.

Depending on the system's mechanism, the way the data is obtained may differ from infrared light techniques (Patent No. US7049945 B2, 2006) to cameras (Patent No. US6859148 B2, 2005) (Table 2).To obtain the required information the distance between the vehicle and the object, the speed of the object and the identity of the identified object have to be measured.

To begin with, the placement of extra mirrors and wide angle lenses is the simplest applied method. The installation of such devices aims in broadening the driver's range of view. However, despite the method's simplicity, continuous alertness is still one of the driver's main responsibilities, while the blind spot areas are not totally reduced (Matuszyk, Zelinsky, Nilsson, & Rilbe, 2004). In addition, in cases where additional mirrors are placed into trucks, areas of the truck are magnified in different ways. As a consequence, although some objects are found to be next to the truck, they only occupy a small part of the mirror's area and cannot be clearly observable (Ehlgen, Pajdla, & Ammon, 2008).

A second approach for estimating the distance of an approaching vehicle is the use of radar sensors, which collect information from the surrounding road environment, translate it into quantitative data which is being processed, resulting to a warning to the driver in case a hazard or a collision is approaching (Matuszyk, Zelinsky, Nilsson, & Rilbe, 2004). To be more specific, the radar uses either an ultrasonic distance detection system or an infrared distance detection radar to estimate the distance (Chen & Chen, 2009). In the first stage, when an object is detected, radio waves are spread and received at receiver-end of the sensors, while in the second stage of the system, the radio waves activate the circuit, the output of which is displayed by glowing LED's and audible signals (Mahapatra, Kumar, Khurana, & Mahajan, 2008). In certain cases, the detection of the object's-vehicle's shape is also possible (Chen & Chen, 2009). However, several system's drawbacks have been reported. Specifically, the low angular resolution of the range sensors is considered as the system's core disadvantage (Matuszyk, Zelinsky, Nilsson, & Rilbe, 2004), while they provide a smaller view of the surrounding area. The range and the covered area of the blind spots is highly dependent on the number of the vehicular radars installed. Finally, such radars have restricted detection distance, increasing the difficulty of detecting a moving vehicle in a large area (Chen & Chen, 2009).

Another type of sensor offering higher angular resolution is the laser scanner. Nevertheless, due to the fact that laser range sensors are able to detect objects only in a thin two-dimensional plane, their use in this application is quite limited (Matuszyk, Zelinsky, Nilsson, & Rilbe, 2004).

As far as ultrasonic sensors are concerned, on the one hand, this category of sensors has been advantageous in terms of cost-efficiency. On the other hand, a lot of factors have contributed to its limited use. The system's sensitivity to external instabilities such as specific environmental conditions (e.g. rain, wind) has been hindering the use of the sensor to high-speed applications (Magori, 1989; Magori, 1994). Another issue raised in the use of ultrasonic sensors is the small amount of information that is included in the signal given to the drivers. Compared to more expensive sensor systems, like radar or lidar, which offer a sufficient angular resolution, ultrasonic sensors usually have a huge aperture. As a result, the difficulty is distinguishing the location of a sound (Wang, Bebis, & Miller, 2005; Mirus, et al., 2012).

Given the deficiencies of the aforementioned methods, developments with other directions have taken place in order to detect moving obstacles. Matuszyk et al. (2004) suggested a different approach for monitoring vehicle blind spots, called computer vision. In their study, stereo panoramic vision has proved to be able to create disparity maps from which objects can be separated. According to the study's results, a stereo panoramic sensor can be used to reliably estimate the location of a vehicle with perfect angular accuracy in the direction of the azimuth. Finally, this kind of sensor owns the benefit of providing higher angular resolution and sensitivity than the other driver assistance systems.

Image or vision based methods consist another widely applied vehicle detection system. In contrast to the previously described sensors, cameras are cheap passive devices operating with no beams or waves. Given that, they are more suitable for mass production in the automotive industry and substantial application on roads and highways (Sotelo & Barriga, 2008).

In vision based systems, cameras are installed on both sides of the vehicle attempting to gather images of blind spots. A display device allows the driver to watch the images of the blind spots. A variety of detection and tracking technologies for image based detection system development have been found in literature. The latter refer to motion information (Techmer, 2004; Wang & Chen, 2005; Zhu, Comaniciu, Pellkofer, & Koehler, 2006), knowledge based (Tsai, Hsieh, & Fan, 2005) as well as optical flow (Wang, Bebis, & Miller, 2005) methods.

To elaborate on the differences between the latter techniques, knowledge based ways implement colour and edge information so as to identify approaching moving vehicles from a single image (Tsai, Hsieh, & Fan, 2005). On the other hand, motion information methods use a series of images in order to achieve vehicle detections, while employing homogeneous optical flow has been used to detect overtaking vehicle, providing more robust results than camera shocks and vibrations (Wang, Bebis, & Miller, 2005). Sotelo et al. (2007), elaborate on the way a vehicle is detected with optical flow analysis. Any object whose front part looks like the frontal part of a vehicle is considered to be one. In this way, a big enough object in the image that produces optical flow in the direction of the system equipped vehicle and has a frontal part similar to the previously described one, is validated as car entering the blind spot. As for the vehicle's position, the image is analysed and the position in it is computed and tracked with the help of a Kalman filter. Vehicle tracking carries on until the vehicle disappears, leading to an alarm signal that informs the driver that a vehicle has entered the blind spot.

Given the fact that these three technologies require the consumption of a huge number of resources to process the needed images, Chen and Chen (2009) have proposed a new method. The method includes the transfer of two dimensional road data into one dimension lane information through the use of the estimation of the image entropy, followed by a differentiation process which determines the vehicle's position. Afterwards, the position of a moving object is determined by the data of two lanes which is taken from images of time series. Based on their experiment, the authors claim that the accuracy of the system reaches more than 90%, while the mean distance for the warning area is approximately 8 metres. Thus, the results present a system which is satisfactory enough as well as a perfect algorithm for the detection of an approaching vehicle from an imaging system. Hence, the technology is becoming broadly applied both for its low cost and the wide area of vision.

Having collected the necessary data, control of the vehicle is influenced by an audio or visual warning device or a steering wheel control device. In other cases, a controller is coupled to the indicator. The former creates a size signal and position signal for a rear-approaching vehicle. The controller activates an indicator when a rear-approaching vehicle enters a blind spot in accordance to the size signal and position signal (Patent No. US6859148 B2, 2005).

Table 2. BSD technologies and features

		Features		
Types of BSD systems	**Automotive suppliers**	**High coverage of blind spot**	**Adverse weather conditions**	**System warnings**
Extra mirrors	Audi, Ford, Volvo, Cadillac, Toyota, Subaru, BMW, Mercedes-Benz, Kia, Mazda, Volkswagen			
Ultrasonic		Dependent on the number of radar sensors	Ultrasonic: problems in high speeds	Limited
Radar		✓	✓	✓
Image/Vision based		✓		✓
Computer vision		✓	✓	NA
Image entropy		✓		✓

In contrast with ACC, BSD is applied for the lateral control of the vehicle and may also result in undesirable events in case of the system's malfunctions or due to inappropriate driver response. The probabilities for that increase when the system has to be used by drivers who have not totally developed their tactical and strategic driving skills, like young novice drivers.

The choice of BSD in the current work has been made taking into account that besides speed and distance adaptation, young drivers lack the experience and the cognitive skills to perceive the surrounding hazards (McKnight & McKnight, 2003). Thus, their reaction and behaviour regarding the use of a blind spot detection system will be tested and studied.

2.4. Driver Behaviour issues concerning ADAS

As already mentioned, most of the research on the impact of ADAS has been conducted for drivers of all ages or older drivers, whereas almost no literature focusing on the effects of a failure of ADAS systems on the driving performance of candidate and novice drivers has been found. Automation often disguises real complexity with apparent simplicity (Woods, 1994), which may be especially treacherous for young drivers for whom vehicle automation may rise overconfidence in their driving abilities.

The investigation of the successful introduction of the advanced driver assistance systems in the automotive industry and the area of traffic safety has reported that ADAS can hinder traffic safety in case users do not correctly understand their function. Current driver assistance systems display a number of limitations for several reasons, like sensor issues or defects in sensor processing. Hence, drivers should have sufficient knowledge of each technology's capabilities.

With regard to the ACC system, the system is designed to provide support to the driver rather than dealing with critical situations, thus the driver's role remains active during the route (Nilsson, 1995). Considering traffic safety, although the ACC system has a clear relevant aim by maintaining a safe distance from the preceding vehicle, it has to be noted that it cannot handle all situation dependent factors. In other words, the driver has to be prepared in advance to take the responsibility and control of the vehicle in situations where the latter cannot deal with the traffic situation. Severe risks can arise if the user is unable to properly perceive and react to the situation (Larsson, 2012).

According to Larsson (2012), drivers have to take control of the vehicle in three types of situations. To begin with, there are situations that cannot be dealt with by the system, so the driver has to be able to understand the warning of the system and respond to the ongoing conditions. Secondly, the driver has to be able to correctly monitor and perceive the surrounding traffic conditions and risks in cases where the system identifies situations towards which it is incapable to react and does not notify the driver (Nilsson, 1995). The latter is considered a matter of great significance since, according to Nilsson (1995), drivers anticipate the system's intervention even if they expect that the system's limitations will prevent its activation. Finally, there are cases where the system collapses, resulting in totally failing to meet its initial aims and the driver's needs. Under such circumstances, the driver needs to be able to identify the system's failure and overtake the responsibility (Stanton, Young, & McCaulder, 1997). De Waard et al. (1999) claimed that drivers' role should not be passive towards the system in order to quickly react to potential failures of the latter and reclaim control. In addition, they reckoned that in highly automated situations the system functionality has to be very clearly communicated to the operators.

Besides real failures of the system, experienced drivers might perceive the non-anticipated operation and activation of the system as a failure as well. To elaborate more, during a field operational test in the Netherlands, it was found that the fact that ACC does not allow very short headways is considered to be a type of the system's failure and leads to less use of the system in congested traffic where short gaps are necessary for the queues. The same study also reported prior deactivation of the system in order for the drivers to avoid the operation of the system in a way different than intended by them. Moreover, drivers in the same study took control of the vehicle by braking hard straightaway because the system failed to break the time they considered that it should have acted (Viti, Hoogendoorn, Alkim, & Bootsma, 2008).

Mode errors consist another type of communication issues, which increase the complexity of the situation where drivers recognise the need to take responsibility. Such errors are generated due to the failures in the driver's understanding and familiarity of the system. Specifically, the user acts in a certain way believing that the system is in one mode while it is in the other (Sarter, 2008). The complexity levels increase more when the system has more than one functions, which are not transparently delivered to the user (Stanton & Marsden, 1996). Hence, improper understanding of the system state may lead the operator in acting so false that the system's state is worsened instead of being improved. Referring to ACC, mode errors are translated into the surprise of the drivers by the actions of the system that may lead to inappropriate reaction.

In addition, a number of system limitations based on drivers' reports are mentioned in the study of Larsson (2012). The radar loss of contact issues in front of sharp curves are considered to be the most common deficiency of the ACC system. Besides that, the system was found to lose radar contact in roundabouts as well as when being overtaken or when larger vehicles were apparent in the adjacent lane. Apart from losing contact, the system started to accelerate again in sharp curves and decelerate in improper moments like overtaking on the fly. Based on what this study's respondents claimed, "*The speed goes down just as I am about to overtake*".

Taking everything into consideration, Norman (2007) suggests that the problem of advanced in car systems, and particularly ACC, does not lie on over-automation but it is rather due to the fact that incorrect feedback is given, followed by insufficient interaction with the system. Instead of providing continuous feedback, automated systems deliver signals and messages in case of obstacle/hazard detection. Thus, there is a lack of communication in parts of the system's operation that is not caught by the drivers, who are, consequently, left "out of the loop". Together with the latter, overreliance is considered by Stanton and Marsden (1996) as another cause of the risks related to such systems. According to the authors, a long period of successful performance of a system leads to drivers being dependent on the system even in situations where the functional limits of the system do not allow it to take control of the task. As a result, the system's user displays a late reaction to the traffic conditions which is most of the times the beginning of an adverse situation.

Finally, experiments have proved that the longer the use of the systems the higher the awareness of the system's limitations is. Considering that awareness increases with practice and the fact that ACC requires intermittent reactions of the driver, it could be stated that this type of assistance is preferred to a system with unceasing feedback. In this way, users are prepared for unanticipated situations in which taking control over the system is required (Larsson, 2012).

Learning of the system as well as the situations where intervention is required are main driver's responsibilities. Since the user's acquaintance with the system requires an extended period of practice, it is important to find out whether familiarising with the system can already start as a part of the driver's training. In this way, drivers will already have a certain perception of the system's usefulness and their need for it before using it in real traffic conditions.

As far as the way of learning the system is concerned, Hoffmann and Mortimer (1996) stated that a functional representation of the system's abilities and deficiencies would generate precise and reliable expectations for its use. It would also benefit drivers in reacting faster, since the small number of hints that is given in cases of failures usually leads to delayed responses of the former. Therefore, a representation of ACC behaviour may improve understanding of the system, promote more effective monitoring as well as encourage more suitable dependence on it.

With regard to the Blind Spot Detection system, the recent introduction of the system in the industry together with its limited use compared to the ACC system, results in finding almost no studies for reported defects and failures of the system. Although having great potential in improving drivers' and passengers' safety, they have limitations the drivers should be aware of in order to exploit the system's benefits instead of producing the adverse result. That is the reason why a learning curve should be established, showing the way to get the best benefit from the system.

Having examined several conditions in order to evaluate the system, the latter was not only found to effectively perform in various situations but also to fail in other uncovered scenarios. Delayed warnings seem to be the most common defect of the system, while drivers mentioned that the blind spot monitoring systems in their cars could hardly detect the fast moving vehicles in very demanding traffic situations, such as when merging into a heavy traffic loaded highway. In this case, the system's alerts were delivered too late or not delivered at all. The same applied for motorcycle detection, meaning that high speed motorcycles were detected 26% later than passenger vehicles. Finally, drivers' statements include complaints about warnings similar with alerts of other advanced driver assistance systems that might increase the levels of workload and confusion instead of assisting the driver (Mohn, 2014).

According to the Foundation for Traffic Safety (2014), more than 35% of the respondents in their study on Blind Spot Detection and Monitoring system stated that the cameras used for the identification of vehicles in the blind spot failed to cover the entire area behind the vehicle. In addition to that, back-up cameras were reported to turn off if the vehicle was travelling faster than a certain speed. Therefore, drivers should keep an active role, checking the rear view mirrors instead of over relying on the system.

To conclude, it can be seen that there are several aspects of both systems that render them as extremely risky in certain traffic situations. The latter implies that users should be adequately informed and practiced for such incidents before deciding to use the system. One way of implementing that is introducing the systems in the main parts of driving training and testing. However, in order to achieve successful delivery of knowledge, the relationship between training methods and human needs has to be clearly understood together with an in-depth understanding of the belief of drivers towards this innovation.

2.5. ADAS contribution to traffic safety, flow and environment

A number of studies have been devoted on the expected contribution of the ACC and BSD systems into drivers' safety, traffic flow and the environment. Especially the evaluation of the safety effects is a key indicator of the overall assessment of a system. The goal of the safety impact evaluation is to estimate the potential safety effects a system could have in case it was installed in a higher number of vehicles. In such an assessment, "Safety impact" is translated into changes in crash numbers and associated injury and fatal accidents (Benmimoun, Aust, Faber, Saint Pierre, & Zlocki, 2011).

It has to be noted that the existing and anticipated impact of the systems apply for drivers of different age and experiences, thus they are not novice or learner driver directed. In addition, the BSD related literature found was very limited compared to the ACC one. The following paragraphs elaborate on the impacts of the systems in different areas.

ACC impact on traffic safety, traffic flow and environment

To begin with the *impact of ACC system on drivers' safety*, the results of several studies are shown below:

1. The number of injury accidents in EU27 countries is expected to decrease by **2.2-5.8% on highways**, followed by a reduction of **0.47%-0.65%** and **0.14%** in **rural** and **urban** environments respectively. The results are based on two field operational studies in Sweden and Germany (Malta, et al., 2012).
2. ACC with automatic braking functionality was estimated to lead in the following reductions for accidents with speeds higher than 60km/h: **7% in the number of fatal accidents** and **4% in the number of injury accidents**. For accidents happening across all speeds, the respective anticipated reduction was larger, 12% and 25%. Anderson et al. (2011), computed the reduction by analysing police reported crash data in New South Wales for a 10 year period.
3. Benminoun et al. (2013) analysed the effect of ACC and FCW on safety and environment. The impact on safety was determined by calculating the average time headways between vehicles, which increased by 16% in highways. The number of critical time-headways (less than 0.5 s) dropped by 73%, while the number of harsh braking events decreased by approximately 70%.
4. The systems impact on drivers' safety has been investigated through insurance claims, using data sets of insurance companies in USA. According to Moore and Zuby (2013), ACC together with Forward Collision Warning (FCW) was found to statistically significantly decrease the frequency of **collision**

insurance claims by 7%, while reducing **property damage liability claims** by approximately **15%**. The frequency of injury claims also dropped, with **bodily injury liability claims** being reduced by **16%**.

5. In a Dutch field test, the **number of accidents reduced by 8%** when vehicles were equipped with ACC and Lane Departure Warning system (Reinhardt & Kompfner, 2007).

As for the *ACC system's contribution in environmental issues*, the main findings are summarised in the following studies:

1. Benminoun et al. (2013) analysed the effect of ACC and FCW on safety and environment. Fuel consumption declined by **3% on highways** for equipped vehicles. Given the high usage rate (50%) in the study, ACC was likely to reduce fuel consumption of passenger cars by 1.37% on highways. The results are based on a field operational test, involving 100 passenger cars, a three month baseline period and a nine month treatment period.
2. After 5-10% reduction of CO_2 emissions being reported for standard Cruise Control, the respective reported decrease for ACC was **0.5-5% in CO_2 emissions** (Klunder, et al., 2009).
3. According to Reinhardt and Kompfner (2007), who conducted a field operational test, ACC reduced emissions up to 60% in certain situations, whereas emissions generally dropped by **up to 10%** when driving with ACC and Lane Departure Warning system.

Regarding its *impact on traffic flow,* ACC has been found to allow uniform headways and constant speeds to be maintained between vehicle platoons, which form important components of congestion reduction. ACC has managed to maintain a steady-state flow, thus leading to significant congestion drop (Hardy & Fenner, 2015). The system's impact on throughput because of its homogenizing effect has been considerably higher in congested situations (high traffic volumes) and more positive effects are expected when 100% of drivers are equipped with the system and always keep it on (Klunder, Li, & Minderhoud, 2009).

To conclude on the anticipated impact of ACC on different areas, the system has proved to be very promising in terms of traffic safety improvement, emissions reduction and traffic flow harmonisation. The reduction in crashes because of the use of the system can reach 6% depending on the road environment, decreasing fatalities by up to 7%. With regard to the environment impact of the BSD system, it has already proved to enable emissions up to 10%. Finally, the system has high potential for traffic flow harmonisation and congestion reduction. Nonetheless, most of the studies have examined the impact of ACC when operating with FCW system. This has to be taken into account before conclusions for its predicted impact are made.

BSD impact on traffic safety

The *BSD system's contribution in drivers' safety* can be seen through the following results:

1. According to Jermakian (2011), the BSD system could **prevent approximately 7% of all crashes**, whereas it could prevent 393 fatal accidents and 20.000 injury accidents per year in USA. The estimates stem from databases of accidents reported by the police which were identified and could have been avoided or mitigated. However, the study focused on the analysis of the potential the system has to prevent accidents but has not investigated the system's effectiveness.
2. The BSD system was found to decrease the frequency of injury claims from insurance companies. The reduction was around **4% for bodily injury liability**, **26.5% for medical payments** and approximately **7% for personal injury protection**. Nonetheless, it has to be noted that these reductions were not statistically significant (Highway Loss Data Institute, 2012a).

3. **5% of truck involving crashes** could be prevented (Kingsley, 2009).

Summarising the existing studies, it can be seen that the BSD system and its expected impact on traffic safety has been examined less than the ACC system. Given that the use of the BSD system could prevent an important number of crashes in the USA, similar considerations could be made for Europe. This can be verified by the reduction in the claims done to insurance companies, which can be used to predict the anticipated impact of the system under certain assumptions, like the width of vehicle fleet occupied with the system.

2.6. Introducing ADAS to drivers' training

Being active in a training environment, people have the opportunity to learn new facts and skills without a lot of effort (Säljö, 2000). Therefore, it is considered of major importance that training environments are designed in a way that trainees are made to gain skills and knowledge as close as possible to their actual performance environment. In case there is an incongruity between the training environment and the real world, the required skills, which are supposed to be acquired during training, might not be transferred or transferred in an incorrect way, possibly leading to misunderstanding and ineffectiveness (Turoff, 2002).

Aiming to attain higher levels of traffic safety, a number of different alterations have taken place worldwide in the domain of drivers' education and training throughout the years, most of which have attempted to take integrate training procedures with real driving parameters (Lonero, 2008). At a European level, drivers' education has been addressed as a fundamental part of road safety policy. However, the focus on driver education of beginners has been kept at low levels. Similarly to Canada and the U.S., driver education displays huge differences among European countries. (Gregersen, 1994).

Despite the fact that such policies and current drivers' training and testing methods have proved to be very efficient in increasing safety levels, their advantages might be restricted because of the limited character of the intervention. For instance, through GDL drivers' exposure to dangerous and risky situations is reduced but this does not relate to restrictions with more special nature, since only aggregate guidelines are given to drivers for hazard avoidance (Ferguson, 2003). In addition, the post-licensing training programs have not been evaluated yet (Lonero, 2008). Finally, in cases where accompanied practice has been implemented, its effects have been assessed with mixed results (Sagberg, 2000).

Extending the currently applied and proven for their success in enhancing road safety methods is possibly the most effective way to tune technology for young inexperienced drivers. ADAS offer more precise ways of controlling hazards exposure as well as handling the involvement in highly demanding driving situations (Twisk & Stacey, 2007). Thus, a favourable approach to fitting ADAS to the needs of young drivers is to use technology to enhance GDL or even to imitate the benefits of an adult passenger. Meanwhile, although new technologies have entered the market in order to support young novice drivers, in recent experiments regarding the impact of ADAS on road safety, young drivers are not included as a specific target group.

Taking into account that the current technological developments in the ADAS area have the potential for eliminating the crash rates of young inexperienced drivers, there is a variety of aspects that should be considered in the future training curricula. To begin with, safe and easy interaction between individuals and ADAS has to be assured, meaning that the driver should be able to understand the background and the fundamental features of an ADAS so as to be able to adopt to the development and improvement of the ADAS interfaces which are becoming better and better. Specifically, the content of the training should be such that it enables the young driver to react safely to all input interfaces and properly perceive all the ADAS interventions. Secondly, training should educate drivers in dealing with system failures, from recognising it to tackling it. Finally, an advisability aspect should be also included, including the basic principles for ADAS operation together with not only the ideal scenarios for each type of ADAS but also the critical situations where reduced ADAS functionality is anticipated, like incorrect or delayed alarms (Lang, et al., 2007).

To conclude, it can be seen that there is a basis on which the ADAS systems can be integrated with the driver training practices worldwide and in The Netherlands specifically. Future ADAS related attempts to advance the way in which hazard perception training is introduced to training and testing, by both learners and instructors are considered to lead to more significant reductions in reported accidents (Emmerson, 2008). Moreover, upgrading the driving test means focusing on the higher levels of the GDE-matrix which are directed to driver profile and risk awareness. The part of the practical test on independent driving could be a possible way of integrating elements from the higher levels into the driving test. Thus, learner drivers' perception and decision about using (or not) in-car assistance systems to improve their higher order and planning and decision skills can be tested in the practical driving exam (Vissers, Mesken, Roelofsz, & Claesen, 2008). However, the impact of these systems on young drivers has to be identified and understood in depth in order to determine the means of this integration. The following chapter presents the methodological approach, with which the human-system interaction will be analysed to fulfil the purposes of the present report.

2.7. Conclusions

In this chapter the existing research on several areas has been reviewed. Starting from the traffic safety facts, in most of developed countries novice drivers between 18 and 20 years rank first in road fatalities and injuries. The risk increasing factors for novice drivers' high crash involvement, are mostly related with bad adaption of speed, failure in giving right of way and inability in keeping proper distance. Their lack of experience to recognize the type of road and thereby induce adequate behaviour or detect hazards and react to them are also contributing to high risk. With regard to these, the causation of an accident is often attributed to the effort of young drivers in collecting relevant visual information during driving, especially when driving in complex situations.

Next, driving behaviour of novices was researched both individually and compared to experienced drivers. The lack of perfection of drivers on basic skills, like shifting gears, cause inability to properly attend and control higher order tasks, such as hazard perception. Often, the ranking of novice drivers in the accidents charts is explained through their age related habits, their willingness to take risks or to underestimate them. Compared to experienced drivers, novices are more prone to attentional capture because of the longer time they spend on fixations, when dealing with demanding situations. Having less spare cognitive capacity, they are less capable of focusing on the surrounding environment when driving, while experienced drivers are fast in reacting to peripheral targets and in adjusting their eye scanning movements to the road conditions. The differentiation between *age* and *experience* also relates to the distinction between driving style and driving experience. Drivers with experience are found to display a holistic perception of events, while novices display fragmentary perception of incidents. As for the influence of ADAS on drivers' behaviour, systems with a warning character are more widely accepted and respected than intervening systems, thus they are expected to be more effective.

Regarding drivers' training, driving is depicted as a three level control task. The GDE matrix adds another level, known as "Goals for life and skills for living". Various attempts have been made in drivers' training and testing, aiming at the reduction of the novice drivers' accident risk. They involved: basic changes to the *pre-test practice structure,* improvement of the *quality in drivers' training*, changes in the *driving test*, introduction of *probationary periods*. As for driver's training and testing in the Netherlands: RIS is a popular way of transferring driving knowledge during practical training.

Next, a description of the ACC and BSD system took place, followed by a review of driver behaviour issues regarding ADAS. Most of them are related to inappropriate interaction with the system due to systems' failure and non-anticipated operation. Delayed warnings and incapability to scan and adopt to the road conditions have been reported as the main causes of problematic interaction with the systems. An overview of the main advantages of the ACC and BSD on safety, traffic flow and environment has been given. ACC is estimated to be able to reduce fatalities by up to 7% and decrease emissions up to 10%. It also has high potential for traffic flow harmonisation and congestion reduction. The BSD system is also estimated to be able to prevent an important number of crashes in the USA, so similar considerations could be made for Europe. The introduction of the systems in training and testing is seen as an option with great potential. Upgrading the driving test means focusing on the higher levels of the GDE-matrix which are directed to driver profile and risk awareness can be assisted with the use of ADAS. In this way, learner drivers' perception and decision about using (or not) in-car assistance systems to improve their higher order and planning and decision skills can be tested in the practical driving exam.

Methodological approach

This chapter focuses on the discrete steps that have been followed in order to answer the main research question mentioned in Chapter 1. The methodology used is based on the state of the art studies that have been found in this domain. According to both the literature review (Hoedemaeker & Brookhuis, 1998; Ohno, 2001; Zheng & McDonald, 2005; Larsson, 2012) and the needs of the present study, the proposed methodology consists of the development of a questionnaire and the organisation of interviews, the output of which is used as input in for the data analysis, described in the next chapter. To be more specific, a multi-content questionnaire is used, each part of which aims to collect different types of data. This is followed by the organisation of interviews, which intends to get more insight on specific parts of the questionnaire and especially on questions that resulted in diverse answers of the participants. More information on the procedure is described in the following paragraphs.

3.1. Participants

The selection of the participants is highly associated with the aim of the study and the anticipated results to analyse. Two groups of participants were recruited for this study, classified as learner drivers and experienced drivers. In order to acquire a representative sample, at least sixty (60) participants from each group were needed.

To begin with the first group, students of driving schools have been recruited. Participants in this category should be driving students who have already started the part of the practical driving training. Recruiting students at an earlier stage of training is considered unnecessary, since participants need to be familiar both with the vehicle and the driving environment. Concerning the age of the participants, attempts were made to limit the age range from 18 to 28 years old, thus avoiding learners above that age.

In addition to the first group, a second group of experienced drivers took part in the experiment. A certain range of ages has not been set for the second group of participants. However, the latter should consist of people who have acquired their driving licence at least 5 years ago and they drive regularly. The results of the experienced drivers would be used to examine the extent to which driving experience plays a role in the perceptions and reactions of drivers towards driving assistance systems.

Given the fact that the developed questionnaire is in English language, homogeneity in the groups of participants has been considered a factor of major importance, especially concerning the educational level and background. This aimed in preventing misinterpretation of the survey's content due to lack of understanding of the language. Although this is not a close representation of reality, in order to reduce the chances of having wrongly answered the questionnaires, the recruitment has taken place mostly among English speaking TU Delft university students and staff. Since the required number of learner drivers could not be collected in the university, other sources have been found and are mentioned below.

The recruitment of participants has been carried out with the following ways.

- Announcements in different locations in CITG and EWI faculties and Central Library building of TU Delft;
- Announcement in screens from the Service Desk in CITG faculty building and De Haagse Hogeschool (located in TU Delft campus);
- Online questionnaire distribution in sports' groups, student associations, faculty groups and in social media group pages;
- Online questionnaire distribution in social media pages of *TeamAlert* organisation. The organisations action is related to raising the awareness of young drivers' responsibility in traffic. This is achieved through original campaigns and road safety projects, some of which are funded from the Ministry of Infrastructure and Environment. TeamAlert interacts with young people between 12 and 24 years, offering educational projects for people up to 18 years and informational ones for people between 16 and 24 (http://www.teamalert.nl/home/);
- The recruitment of learner drivers, has also been conducted outside TU Delft. Learner drivers have been recruited with the assistance of CBR (Centraal Bureau Rijvaardigheid), the Driving Test Organization in the Netherlands. The general purpose of the study has been described by CBR to a number of driving schools, the owners of which agreed to communicate the need to their students and deliver the questionnaire.

Since both parts of the experiment, meaning the questionnaire and the interviews, required time and some attempt, people have been motivated to participate by offering a small reward. A lottery has been organised for the people who filled in the questionnaire, offering 60 € each to two winners, while bonus cards of a value of 10 € each, have been given to learner drivers of the interviews.

3.2. Questionnaire

The main goal of this study is to examine driver performance and behaviour at a conceptual basis. Hence, the developed questionnaire is used as the core source for data collection. As will be described in detail below, the questionnaire consists of four different parts:

(1) drivers' driving profile;

(2) drivers' attitude towards stressful situations;

(3) drivers' reflection towards the Blind Spot Detection system; and

(4) drivers' reflection on towards the Adaptive Cruise Control system.

In this way, the driving profile of the participants is clearly defined, while providing the opportunity to compare the general driving attitude of the drivers with their stated driving performance as given in the last section of the questionnaire. Before elaborating on the design and the construction of the questionnaire, a short introduction for the need and necessity of self-reports is given, explaining the reasons why this method of data collection is used.

3.2.1. The need for self-reports

The need for a questionnaire can be verified in several studies. According to Timmermans (1982) and Louvière (1988), individual preferences and behavioural choices are the result of an individual's cognitive decision-making process. This behaviour is based on the subjective perception and evaluation of a number of existing choice alternatives in terms of their physical, functional and socio-economic attributes, based on which humans create personal structures of preferences.

People often occupy themselves with tasks, aiming to develop themselves and reach specific aims through these by gaining skills. Setting goals and selecting ways that lead to their achievement is very associated with a person's belief about their ability to attain desired outcomes (Bandura, 1986). Hence, human's perception on their abilities might have a significant effect on the type of activity they decide to undertake. This can also be applied in the driving task, where drivers mostly engage themselves in tasks they feel confident they can carry out. For instance, exceeding the speed limit is usually followed by the belief that the driver is able to confront and overcome the relevant hazards. However, overconfidence leads to altered perception of risks as well as evaluation of one's abilities, which itself may considerably reduce traffic safety levels (Matthews & Moran, 1986). Referring to the previous example, an overconfident driver does not usually seek for information about their performance even in case they exceed the speed limits, which might have serious impact on road safety. Therefore, it is crucial that drivers assess their abilities as accurately as possible (Deery, 2000).

Most of the studies examining drivers' behaviour have emphasized the issue of driver's self-estimation, attitudes and risk, hazard and traffic safety perceptions. This is usually achieved through self-reporting surveys, in which participants assess their driving behaviour and habits as well as their attitudes and perceptions towards risks, law obedience and traffic safety. Having the advantage of gathering large amounts of data in a cost-beneficial way, such questionnaires have been widely applied to numerous studies related to several aspects of driving behaviour, like aggressive driving (Parker, Lajunen, & Stradling, 1998; Lajunen, Parker, & Stradling, 1998; Ulleberg & Rundmo, 2002; Iversen, 2004; Maxwell, Grant, & Lipkin), impact of alcohol and drug use and driving behaviour (Caetano & Clark, 2000; Begg & Langley, 2004) as well as the effect of socio-economic characteristics and parental influence on drivers' behaviour (Yagil, 1998; Golias & Karlaftis, 2001; Boyce & Geller, 2002).

Given the fact that self-reporting has been extensively used over the years, several methods and forms of questionnaires have been constructed to acquire information on the drivers' actions, attitudes and beliefs towards traffic. The questionnaires, which usually consist of set of questions in a very controlled written form, can be generally divided into three categories. In the first type of questionnaires, participants are asked to describe their actual behaviour after having driven in real driving environments or in simulated ones (Gregersen & Berg, 1994), while in the second group of questionnaires drivers are given questions about their general beliefs and tendencies in different driving situations (Reason, Manstead, Stradling, Baxter, & Campbell, 1990; Taubman-Ben-Ari, 2008). The third type of questionnaire comprises of a set of questions on socio-demographic and socio-economic characteristics and it usually forms the first part of every questionnaire. Questions might differ among the questionnaires, depending on the survey's aim and the respondent's social background relevance to it.

The present questionnaire is a combination of the categories described above. Specifically, the participants are asked to fill in two different types of questions, related to their perception about themselves as drivers and their implied behaviour if driving with ADAS. As far as the first group of questions is concerned, the questionnaire has been constructed after conducting literature research in the domain of driver behaviour studies and advanced driver assistance systems. Concerning the second group, the structure and the content of the questionnaire has been created based on the scope of the study, thus it is not directly taken from an existing source.

The following paragraphs define the structure and the reasoning behind the construction of the questionnaire used as the experimental tool of this work. Beginning from the first group of questions, which highly depend on the existing work in the relevant field, the reasoning of choosing specific inventories and factors is given by presenting the state of the art. Having chosen the theoretical content of the survey, the description of the practical section, which focuses on the use of the Adaptive Cruise Control and the Blind Spot Detection system, takes place.

3.2.2. Overview of widely applied driver related questionnaires

The selection of a questionnaire for a certain study is highly associated with the purpose of the study as well as the drivers' population of interest. Before elaborating on the questionnaire used in the present report, it is considered necessary to provide an overview of the most widely applied questionnaires that have been found in literature. An illustration of their aim and structure provides a clear explanation for the underlying reasons of choosing the final questionnaire.

Driving Behaviour Questionnaire (DBQ) (Reason, Manstead, Stradling, Baxter, & Campbell, 1990). The Manchester Driver Behaviour Questionnaire—DBQ is undoubtedly one of the most widely used methods for examining the relationship between self-reported driving behaviour and road accidents' participation. Despite the fact that the first questionnaire was constructed to investigate aberrant behaviour on the road through two specific types of driving behaviour, being errors and violations, recent forms of this questionnaire include four or five sub-scales (Gras, et al., 2006). According to Reason et al. (1990), such deviant driving behaviour is analysed through slips, lapses, mistakes and two types of violations, unintended and deliberate ones.

To elaborate more on each sub-scale, errors (slips) consist of situations like failing to notice road signs or other road users, missing turns or switching on wrong mechanisms. Lapses refer to incidents that occur due to lack of attention while driving or memory failures, such as having no clear impression of the road segment just travelled. Mistakes are related to failures due to wrong perception of the traffic conditions while driving, like underestimating the speed of an oncoming vehicle while overtaking. Finally, violations are distinguished in two separate categories, being intended and unintended violations. Deviations from correct driving behaviour such as exceeding the speed limit, dangerous car-following behaviour or forgetting to arrange tax and insurance payments refer to unintended violations. On the other hand, intended violations are usually expressed through aggressive ways both towards other drivers and road users. Examples of such incidents vary between being impatient towards slow drivers to making bad-mannered gestures at other drivers (Özkan & Lajunen, 2005; Freeman, Wishart, Davey, Rowland, & Williams, 2009; Sucha, Sramkova, & Risser, 2014).

The DBQ is not only accepted for its psychometric properties but also for the consistency among its findings (Albert, 2011). Specifically, research in which the DBQ was used on private car drivers, has produced fairly constant findings in terms of the given factor structure (Gras, et al., 2006). The latter has been proved by the questionnaire's application in different countries and populations, such as studies in the UK (Parker, Reason, Manstead, & Stradling, 1995), Sweden (Aberg & Rimmo, 1998), Greece (Kontogiannis, Kossiavelou, & Marmaras, 2002), Finland and the Netherlands (Lajunen, Parker, & Summala, 1999), China (Xie & Parker, 2002) and Turkey (Sümer, Ayvaşik, Er, & Özkan, 2001; Özkan & Lajunen, 2005).

Driving Style Questionnaire (DSQ) (French, West, Elander, & Wilding, 1993). The DSQ analyses behaviours of drivers that have proved to be related to accident involvement or risky driving behaviour, like speeding, short headways and traffic violations. Cognitions and attitudes that are considered to be straight associated to driving decision-making, such as feelings of control and risk taking during driving are also investigated in it (Taubman-Ben-Ari, Mikulincer, & Gillath, 2004). The DSQ, which is composed of six driving style dimensions (speed, calmness, social resistance, focus, planning and deviance), has been used by Hoedemaeker and Brookhuis (1998) to evaluate driver behaviour towards new technologies. To be more specific, the study focused on examining behavioural adaptation and acceptance of the driver to adaptive cruise control and the outcomes showed that self-reported differences in driving style are good predictors of the participants' actual driving style as performed in a driving simulator (Hoedemaeker & Brookhuis, 1998; Albert, 2011).

Driver Behaviour Inventory (DBI) (Gulian, Matthews, Glendon, Davies, & Debney, 1989; Glendon, et al., 1993). DBI, which consists of forty (40) items of driver stress assessment, has been used as a measure of drivers' stress level. Based on this method, drivers are affected by various types of anxiety and stress, thus not only related to driving. Therefore, Gulian et al. (1989) have introduced the term driver stress instead of driving stress and their method is considered to be a valid, robust and consistent measure of driver stress used in various studies (Hennessy & Wiesenthal, 1997; Matthews, Tsuda, Xin, & Ozeki, 1999). The questionnaire includes six factors, named Driving Aggression, Dislike of driving, Alertness, Irritation when overtaken, Overtaking tension and the General Stress Scale.

Driver Stress Inventory (DSI) (Matthews, Desmond, Joyner, Carcary, & Gilliland, 1996). For more than ten years, the aforementioned DBI has been tested in various studies focusing mainly on measures of personality, attitude and stress. Based on the results of these studies as well as on the fact that DBI items mainly tackled stress symptoms or outcomes, whereas the rising theory of driver stress focuses on the importance of cognitions, the DBI was revised, resulting in the DSI. The new questionnaire on driver stress includes five factors, being Driving aggression, Dislike of driving, Fatigue Proneness, Thrill Seeking and Hazard Monitoring instead of Alertness. As mentioned above, the Overtaking factors are deleted.

The Dundee Stress State Questionnaire (DSSQ). The DSSQ is another method of measuring the drivers' stress levels. It consists of multiple scales of stress, being anger, concentration, control and confidence, hedonic tone, motivation, self-esteem, self-focused attention, task-irrelevant interference, task-related interference and tense arousal. The existence of such list of scales is chosen in order to serve as a way of organising the order of the analysis. The questionnaire has been used in several driving behaviour studies, like the one of Stanton and Young (2005) and Matthews et al. (2005).

Lifestyle questionnaire (Gregersen & Berg, 1994). Questionnaires with lifestyle related content have been used in several studies, either using the original version or a modified one (Chliaoutakis, Darviri, & Demakakos, 1999). Gregersen and Berg (1994) applied the Lifestyle Questionnaire to three thousand young people not only to clarify the specific lifestyle profiles among young drivers but also to investigate the existing associations between lifestyle and accidents caused by young novice drivers. According to them, there are two reasons why such knowledge can prove to be beneficial, being theoretical and practical. On the one hand, the level of association between accidents and lifestyle is examined. On the other hand, the opportunity for a practical basis for traffic safety measures and strategies is given. In other words, if high-risk groups can be defined in terms of lifestyle, recognising the groups to which attention has to be paid will be both easier and more direct.

With regard to the questionnaire's content, the lifestyle is organised in three levels, being a level of basic values, a level of attitudes as well as a level of actions. All levels have four dimensions, in which values are described as material, esthetic, ethical, and metaphysical. The questionnaire includes actions like sports, reading, driving, style, political and social commitment, alcohol and drugs etc.

Multidimensional Driving Style Inventory (MDSI) (Taubman-Ben-Ari, Mikulincer, & Gillath, 2004)**.** Elander et al. (1993) referred to driving style as the way drivers choose to drive or drive by habit, meaning driving speed, headways, cautiousness and confidence. Despite the importance of driving style as well as the fact that driving style is considered to be affected by attitudes towards driving, general needs and standards, there is no common agreement for its conceptualization and measurement.

Given the various aspects of driving that have been addressed in different studies (Gulian, Matthews, Glendon, Davies, & Debney, 1989; Reason, Manstead, Stradling, Baxter, & Campbell, 1990; Glendon, et al., 1993; French, West, Elander, & Wilding, 1993; Furnham & Saipe, 1993), Taubman et al. (2004) integrated the complex nature of the driving style into a single multidimensional formulation of driving style. Their hypothesis considers that the different scales can be combined into four general aspects, being reckless and careless driving style, anxious driving style, angry and hostile driving style as well as patient and careful driving style. The reckless and careless driving style characterizes persons with preference for high speeds, car races, driving intoxicated etc. The anxious driving style illustrates feelings of attentiveness and pressure, while the angry and hostile driving style relates to feelings like annoyance, temper, and aggressive actions during driving. Finally, the patient and careful driving style corresponds to the well-balanced driving style, meaning attention, patience, law obedience etc., which has not been studied in depth before. The study's findings communicate that the eight factors under study significantly predict self-reports of participation in car accidents and breaking of traffic rules.

Risky Behaviour and Perception Questionnaires (Rundmo & Iversen, 2004; Ivers, et al., 2009)**.** According to Deery (2000), young novice drivers are considered to perceive risks in traffic differently than other groups of drivers. To be more specific, they perceive relatively low levels of risk compared to older or experienced drivers. Ivers et al. (2009) used a questionnaire to analyse risky driving behaviours and risk perceptions of young drivers who had a new driving licence, while determining the relation between the risk perception and crash risk.

Another type of risk perception survey was performed by Rundmo and Iversen (2004), who developed a questionnaire containing eight indicators of risk perception. This questionnaire aims to measure various characteristics of perceived risk, like probability evaluations referring to traffic accidents and anxiety or concern. Since the cognitive or belief-based element of risk perception, such as the assessment of the probability of an accident, has to be differentiated from emotion-based reactions that appear when imagining or being exposed a risky situation, the respondents are also asked to assess the frequency with which they think about traffic related hazards and are concerned about them.

The Driver Self-Image Inventory and the Driving Self-Efficacy Questionnaire (Taubman-Ben-Ari, 2008)**.** The main threats to youngsters' health lie under their own risky behaviour. According to Cooper et al. (1998), individual or social goal-directed behaviour can contribute in the generation of motivations, including motivations for risky behaviour. The two questionnaires have been developed to discover the motivations for driving as well as the relation of motivation with careless driving among young drivers. On the one hand, the Driving Self-Efficacy Questionnaire investigates the relation of self-esteem and risk-taking behaviour. While high self-esteem behaviour is associated with such behaviour in order to serve intrinsic growth needs, low self-esteem might raise risk exposure in order to please extrinsic needs, like creating a positive image for the eyes of others. On the other hand, the Driver Self-Image Inventory addresses the drivers' perception of their self-image, consisting of ideas and cognitions people have about themselves and prove to direct their driving behaviour (Markus & Wurf, 1987).

The Driving Costs and Benefits Questionnaire (Taubman-Ben-Ari, 2008)**.** One's involvement in risky behaviour is most of the times a result of considering the benefits and costs of their actions (Caffray & Schneider, 2000). With regard to the components the youngsters consider as beneficial, the acquisition of adult status, the increase of self-esteem, control and self-confidence as well as the experience of thrill and sensation are representative examples. Moreover, according to Donovan et al. (1988) and Gregersen and Bjurulf (1996), drivers get involved in risky situations in order to increase their personal efficacy, test their limits and even differentiate among the genders. As far as the costs of such behaviour are concerned, the drawbacks of risky actions vary from confronting their parents to social costs like failure and getting humiliated.

It has to be noted that young people's awareness of the benefits is a better predictor for their participation in risky situations when compared to their perception of costs. This is supposed to happen due to adolescent egocentrism, leading to emphasising on the advantages of risky behaviour. Finally, the fact that the benefits are mostly experienced by the drivers themselves, while the costs are known through others, plays a crucial role in their tendencies (Parsons, Halkitis, Bimbi, & Borkowski, 2000).

Taking all the above mentioned points into account, Taubman (2008) developed the Driving Costs and Benefits Questionnaire in order to examine the motivations found in this type of thinking. To examine the subjective perceptions of the costs and benefits of driving, the final questionnaire consists of two scales, for the benefits and the costs respectively, including twenty-one (21) items each.

3.2.3. Questionnaire design - The conceptual part

The questionnaire used in the current study comprises a combination of two different questionnaires that have been found to suit and serve the purposes of this study, being the DSI (Driver Stress Inventory) and the Driver Self-Image Inventory. As already mentioned, the selection or development of a written survey depends on the drivers' group of interest. Therefore, although the research conducted in this domain has been broad enough to overview a wide range of existing questionnaires, the stage of the selection has been narrowed, focusing on surveys that have been created or used for young people and have potential to be used for older and experienced drivers as well. Another important criteria in the selection of the questionnaire is related to its validity. The overviewed surveys have been examined in terms of validity and range of application as well as checked in relation to their outcomes.

In case that only a part of a questionnaire is considered relevant to a certain study (some of the factors), then all the items related to these factors should be considered in order to assure the validity and the correct application of it.

Since the aim of this study is highly related to traffic safety implications because of young drivers' behaviour and relevance to Advanced Driver Assistance Systems, the study is focused on the underlying reasons of aberrant driving behaviour and the attitude and stress of young drivers towards different situations in traffic. Deviant driving behaviour as well as increased levels of stress relate to hazard and accident risk that can be attributed to the exposure to traumatic life events (Selzer & Vinokur, 1974). Similarly, personality factors that are allied with stress tendencies like depression can be related with risky behaviour and crash involvement (Beirness, 1993).

Under certain circumstances, both stress-increasing factors and personality factors (Figure 8) cooperate to bias cognitive stress procedures, which consist of assessment processes related to the evaluation of personal skills and decisions needed to manage demanding situations. Cognitive stress processes usually lead to two different types of outcomes. On the one hand, such processes have subjective results such as concern, irritation and fatigue, while on the other hand, the outcomes are performance related, meaning changes in speed, impairment of psychomotor control etc. Both types of results prove to be more harmful to safety when cognitive processing is significantly biased, particularly in cases where this biased processing maintains maladaptive responses to specific kinds of demand (Matthews G. , 2002).

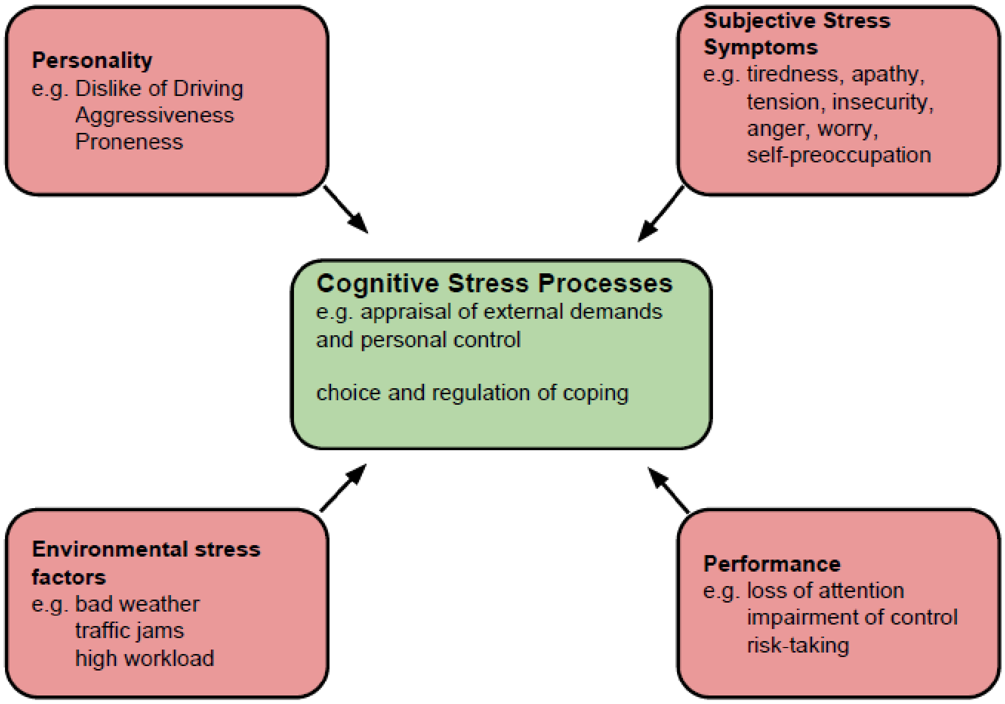


Figure 8. A transactional framework for driver stress (Matthews G. , 2002).

Based on both the aforementioned discussion and criteria, the final choice is a result of "reductio ad absurdum", meaning that all the stated questionnaires have been examined and those considered irrelevant or presented problems with some of the questions in the needed factors have been discarded (Table 3).

The DBI is considered to cover different aspects of driver behaviour, while focusing mostly on aggressiveness and stress. Gulian et al. (1988) have developed a questionnaire, aiming to identify and measure psychological elements of driver stress and some of the variables which influence and predict it. The use of this questionnaire in the current study would attempt to analyse the personality and motivational factors that are assumed to mediate driver stress. Nevertheless, the absence of information about the original questionnaire and the measuring scales it comprises of, has led to its replacement by the DSI, which is an updated and more comprehensive version of the DBI.

The DSI consists of forty one (41) questions in total, which can be further categorised into five factors. Given the content of the latter, only three of them are included in the final questionnaire, being Dislike of Driving, Thrill-seeking and Hazard monitoring. Aggression and Fatigue proneness are considered less relevant to the thesis' context and are, therefore, discarded.

Table 3. Summarised advantages and disadvantages of the inventories regarding the present study.

<table>
<tr><th>Questionnaire</th><th>Advantage</th><th>Disadvantage</th></tr>
<tr><td>Driver Behaviour Questionnaire (DBQ)</td><td>• applied to young and experienced drivers</td><td>• some driving experience needed
• learner drivers answers would be based on assumptions and hypothesis</td></tr>
<tr><td>Driver Style Questionnaire (DSQ)</td><td>• already used in similar studies
• content related to the present study</td><td rowspan="4">• whole factors cannot be used because of containing irrelevant to the study items
• some driving experience needed</td></tr>
<tr><td>The Dundee Stress State Questionnaire (DSSQ)</td><td rowspan="2">• content related to the present study</td></tr>
<tr><td>Lifestyle Questionnaire</td></tr>
<tr><td>Multidimensional Driving Style Inventory (MDSI)</td><td>• driving style related
• content highly related to the present study</td></tr>
<tr><td>Driver Behaviour Inventory (DBI)</td><td>• stress related</td><td>• absence of the original questionnaire and measuring scales</td></tr>
<tr><td>Driver Stress Inventory (DSI)</td><td>• updated version of DBI
• stress related
• 3/5 factors highly related to the study
• no experience needed</td><td>-</td></tr>
<tr><td>`Risky Behaviour and Perception Questionnaires</td><td>• interesting aspects for young novice drivers</td><td>• no direct connection with the needs of the present study</td></tr>
<tr><td>Driver Self-Image Inventory</td><td>• driver profile identification
• already used for novice drivers
• no experience needed</td><td>-</td></tr>
<tr><td>Driver Self-Efficacy Questionnaire</td><td>• already used for novice drivers</td><td>• not significantly important for the present study</td></tr>
</table>

Finally, the Driver Self-Image Inventory has been selected. The selection offers the opportunity to identify the relation between the type of drivers and their attitude towards the ADAS. It relates to the drivers' perception of themselves as drivers. Self-image contains elements such as ideas and attitudes of people regarding themselves, based on which their behaviour in different circumstances is determined (Markus & Wurf, 1987). Since individuals may perceive themselves in a different way in various cases and aspects of their life, including this set of questions in the survey is considered appropriate.

As already mentioned, the Driver Self-Image Inventory, which was developed and used together with two other questionnaires in order to evaluate the motivational aspects of driving and their significance for explaining variations in reckless driving behaviours and cognitions, aims to tap the subjective aspects of self-image as a driver. Consisting of fifteen items, it reflects drivers' current perceptions, both positive and negative, of themselves as drivers, on which participants have to reflect through a six-point scale ranging from "not at all" (1) to "very much" (6) (Taubman-Ben-Ari, 2008). The hypothesis is that cautious and courteous drivers are expected to be lower in the ranking of reckless driving and express higher need for assistance systems, while the confident and impulsive drivers not only are anticipated to score higher in the ranking of aberrant driving behaviour but also display a smaller need for assistance.

It is seen that each of the chosen questionnaires has been developed and used for the examination of the reasons of deviant driving behaviour, while focusing on different aspects of it. The integration of them into one questionnaire attempts to investigate non-overlapping domains of driving behaviour, while providing the opportunity to test the correlations between the components and characteristics included in the different questionnaires.

The final questionnaire consists of four groups of questions, three of which use a rating scale and the other being demographic questions. A rating structure has been preferred to a ranking one, since it indicates the strength of the preference for an alternative. Instead, a ranking scale shows no more than which alternative is preferred to another. The choice of a rating scale has also been made for statistical reasons, since it belongs to an interval measurement level, while the ranking scale is considered to be ordinal data (Oppewal & Timmermans, 1992). Finally, rating tasks are more easily delivered and defined than ranking tasks in written questionnaires (Marchau, Wiethoff, Penttinen, & Molin, 2001). The use of such scales becomes clearer in the following paragraph, where the description of the last part of the first and the fourth part of the questionnaire is made.

The questionnaires are presented in Appendix I.

3.2.4. Questionnaire design – The video based part

Having acquired data related to the participants' attitude towards driving as well as their perception of themselves as drivers as described in section 3.2.3, input related to their perception regarding the two examined ADAS systems: adaptive cruise control and blind spot detection system is needed.

Advantages of video-based questionnaires

The use of videos in conducting a questionnaire has proved to have several advantages. From a cognitive psychology's standpoint, when asked to answer a question, the respondent has to encrypt the given question into a mental representation which works as an indication of memory reclamation and decision making (Tourangeau, Rips, & Rasinski, 2000). In case the participant's mental representation deviates from the questioner's, the question might be misinterpreted, wrongly answered and considered invalid (Conrad, Couper, Tourangeau, & Peytchev, 2006).

According to Graesser et al. (2006), a common method of reducing the probability that this happens is inserting hyperlinked definitions for the core concepts of certain questions so as to clarify the query to the respondents. Nevertheless, there is still the chance that respondents do not seek for clarification even if they need it. In addition, such definitions are not always short enough to attract the respondent's attention and increase their willingness to read them thoroughly. As a result, the likelihood of appropriately responding to the questionnaire is diminished (Lind, Schober, & Conrad, 2001).

Chien and Chang (2012), developed and animation based questionnaire in order to visualize key concepts included in their questionnaire examining the student's perceptions of a technology-enhanced learning environment. According to them, the students were expected to directly perceive the external images of the meaning of the question from the animation video instead of creating their own internal visual images. In this way, the individual differences in perception of certain concepts would be controlled, resulting in a reduced probability of misunderstanding the questions by the respondents.

With regard to transport related surveys, Howard and Dai (2014) explored peoples' view on self-driving cars in Berkeley (CA) through the use of a questionnaire and a video. After two sections of demographic and driver profile questions, the participants were shown a video related to self-driving cars. Taking into account that such technologies are quite new and not clearly understood, the use of a video was considered critical for the respondents to understand the way the self-driving car works. Afterwards, participants were asked a number of questions related to their perception of self-driving cars.

The use of videos in the present questionnaire

Given the fact that the use of videos provides the aforementioned advantages as well as the fact that it is a method that has been successfully applied in previous studies, the idea of using videos that display the concept, operation and use of ACC and BSD has been adopted as the closest realistic way to achieve the collection of data showing the reflection of drivers to their experience from driving with ADAS systems. Figure 9 presents snapshots of the videos presented to the questionnaire participants.

Figure 9. Images from the used videos. Left: ACC (https://www.youtube.com/watch?v=RDSZWFV7qFk), right: BSD (https://www.youtube.com/watch?v=NfK9Rm2ShRw)

Following the behavioural part of the questionnaire (sections 2 and 3), the last part of the survey, which is divided into two sub-sections, is devoted to the opinion of drivers towards the examined ADAS. The two understudy systems are presented in sequence. The Blind Spot Detection system comprises the first sub-section, followed by the second one on Adaptive Cruise Control system.

To begin with the first sub-section, a few queries related with the driver's familiarity with the system are introduced in the form of both rating (Vagias, 2006) and open-ended questions. After the introductory questions, a video is shown to the participants, describing the concept of the BSD system. The video consists of a combination of different videos available by automotive companies on *YouTube* search engine. The selected video had to fulfil certain requirements, like including information on the general aim of the system, operation of it, appropriate use by the driver and a variety of traffic situations the system applies to as well as being short enough to not weary the participant (approximately 3 minutes). Advertising parts of the videos have been discarded.

The first set of the next questions aims to test the participants' understanding on the video. Therefore, a repetition of the introductory questions takes place. In this way, the differences between the answers before and after the video are investigated and the value of the video in explaining the system is tested. The next series of questions emphasize on the expected usefulness and expected ease of use of the system under specific traffic situations. The respondents' willingness to use the system in different road environments is also asked. The question aims to figure out the types of road environment where drivers have most difficulty driving and in which of these conditions potential assistance would be more than accepted. Finally, few questions on the participants' opinion for the introduction of the system to drivers' training and testing are given. Although the latter questions are given in a rating scale, further explanation for each answer was required through open-ended questions in order to gain deeper understanding on the need of drivers for an innovation like that.

As far as the second sub-section of the survey is concerned, its structure and content is similar to the previous, replacing the BSD video with the ACC one. A number of sub-questions are also changed to adopt to the operation of the different system.

It has to be mentioned that a different survey corresponds to each group of participants. Although 95% of the survey is exactly the same for both groups, minor differences are found in the first part of the questionnaire that relates to demographic information and driving experience of the participants (Kyriakidis, Happee, & De Winter, 2014). To be more specific, participants are asked to respond to questions related to their driving experience, being years of having the driving licence, frequency of driving, kilometres driven per year and number of accidents they have been involved in during the last 6 months. These questions are absent from the learner drivers version of the survey, where the only question that differs asks about the number of hours of professional driving training the respondents have attended (Appendix I).

3.2.5. Pilot study

The distribution of the questionnaire to the recruited participants requires its prior testing. Despite the fact that the conceptual part of the survey, as described above, has the advantage of being validated, the video based section needed to be tested. The main issues of the video based section were associated with the satisfactory explanation of the systems by the videos, the added value of certain questions to the study as well as the willingness of the respondents to answer open-ended questions.

To test the last part of the questionnaire, a pilot study, for which a small number of participants (5 experienced and 5 learner drivers) was required, was organised. The whole procedure, including recruitment, data collection and brief data analysis lasted one week.

Concerning the responses (Appendix II), 80% of the experienced drivers were found willing to answer the open-ended questions, while 100% of the learners submitted a fully completed questionnaire. According to the majority of the respondents, the used videos were found satisfactory in explaining the operation and use of the system, thus the value of the main tool of the questionnaire has been verified. Furthermore, despite the small size of the sample, the responses displayed variation not only among the groups but also among the respondents within the same group. Taking this variation into account, additional open-ended explanatory questions were added in the questions regarding training and testing of the systems. Finally, the initial form included the question "What is shown in the video?" after the introduction of the videos for BSD and ACC system. However, the respective responses did not add any value to the purpose of the survey since the participants narrated in detail what they have seen in the video. The existence of the repeated introductory questions proved to be sufficient enough to understand whether the participant understood the system's aim and use.

3.2.6. The final questionnaire

The final questionnaire comprises of four main sections given in the following order:

1. Demographic questions
2. Driver Self-Image Inventory
3. Driver Stress Inventory
4. Video-based ADAS related part
    a) Blind Spot Detection system
    b) Adaptive Cruise Control system

A short introduction is given prior to the abovementioned sections, depicting the general scope of the study as well as the rights of the participants. The final version of the questionnaires can be found in Appendix I.

3.3. Interviews

An in-depth interview is "*a qualitative research technique that involves conducting intensive individual interviews with a small number of respondents to explore their perspectives on a particular idea, program, or situation*" (Boyce & Neale, 2006).

Another definition of a qualitative research interview is given by Kavale (1983), who summarises the scope of an interview by claiming that "*the purpose is to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena*".

3.3.1. The need for interviews

Individual or group interviews have been widely employed in empirical studies, mainly emphasizing in health and social domains. Recent examples consist of the study of Lankshear (1993), who used group discussions to examine the student nurses' opinions on assessment, the study of Butler (1996) aiming to investigate public health nurses' perceptions of their role as well as the work of Cowles (1996) that was directed to tap the way people from different cultural background experienced grief. With regard to transport related research, Jain and Lyons (2008) have established focus groups to examine the perception of travel time as a gift for the individuals, while Hine and Scott (2000) report the results from several group interviews including both public transport users and car users being undertaken for a Scottish study on interchange and travel choice. Such interviews were also used to measure social and behavioural implications due to the lack of public transport as well as the social benefits related with enhancing services (Currie, et al., 2009).

Considering questionnaire based studies, like the present one, interviews have been employed to provide in depth understanding and expand the knowledge acquired by the survey (Hyland, Bott, Singh, & Kenyon, 1994; Fowler Jr, 2013), proving to have several advantages both for the researcher and the participants. To begin with, the primary advantage of in-depth interviews is that the opportunity they provide to acquire more detailed information than other data collection methods, like questionnaires. They also offer a relaxed atmosphere, since people usually feel more comfortable having a personal conversation about their considerations compare to filling out a survey. In other words, interviewing may encourage a higher degree of freedom in the way opinions are expressed compared to other methods of data collection (Butler, 1996). Finally, the researcher gains the advantage of more honest and comprehensive answers as a result of the security and safety feeling delivered to the participants. In other words, not feeling obliged to answer all the questions (Peters, 1993; Vaughn, Schumm, & Sinagub, 1996), participants focus to the points they are mostly considered about, thus expressing complete and clear views that could not have been in depth answered in the questionnaire.

With regard to the methodological approach of the current study, the establishment of interviews comprises an attempt to gain deeper knowledge on certain parts of the questionnaire as well as to acquire further explanations on the presented differences between the groups' answers as well as the deviations within the same individual's responses.

3.3.2. Organisation and content

The acquisition of concise and valuable information implies careful organization and set up of the group interviews. Taking into account the reasons why interviews are necessary for the present work, all stages of the procedure are highly associated with the content and the responses of the questionnaire introduced above.

To begin with the interviews participants, they comprise learner drivers only, since the focus of the research is directed to this category of drivers and the outcomes of the study will mainly affect them and their descendants. Thus, a thorough look at the responses of the relevant group has taken place in order to figure out which questions gathered the most interest in terms of driver attitude towards the system answers. Participants whose answers largely differentiated from the rest of the respondents have been distinguished and after gathering people with clear deviations in their answers, the recruitment of the participants for the interviews started. The aim of this filtering is to point out learner drivers with different driver profiles and diverse views towards the understudy technologies. The latter is an indispensable element for a vivid conversation undertaken during an interview, where different aspects of a topic have to be presented. The recruitment of the participants has been carried out by personally contacting the respondents of the questionnaire who had provided their contact details as an indication of willingness to be part of the interviews.

Since differences within the same person's responses have been reported, special attention has been given to such incidents by formulating questions for the interview which would ask the respondent to elaborate on the reasons that led to this type of answers. Finally, given the significance and scope of the study for the driver education and testing, a section of the core questions is straight related with the introduction of the systems in training and testing.

The organization of the interview and its content has followed the guidelines of research studies that have been conducted in this field, including both conceptual and practical assets (Basch, 1987; Morgan, 1997; Morgan, 1997; Kidd & Parshall, 2000). A protocol has been prepared prior to the interview meetings, containing the guidelines and the main questions, so as to contribute to the success of the meetings. Finally, a consent form has been distributed to the participants in order to express their willingness to participate in the study as well as to be aware of their right to leave the procedure at their own will. The relevant documents are found in Appendix III.

3.4. Data Analysis Methodology

Following the design of the questionnaires and the interviews, an adequate methodology (Figure 10) for the data analysis has to be developed, given the type of data that is collected, the research questions that need to be answered, as well as the type of statistical tools that are available. First, an examination of the research questions and the research hypothesis is made. Second, a short overview of the widely applied statistical tests and analysis takes place. Based on these, a selection of appropriate methodology and statistical tools for this study is made. Having chosen the data analysis methodology, the data preparation procedure is explained, aiming to clarify any issues in the data that might affect the type of test to be used.

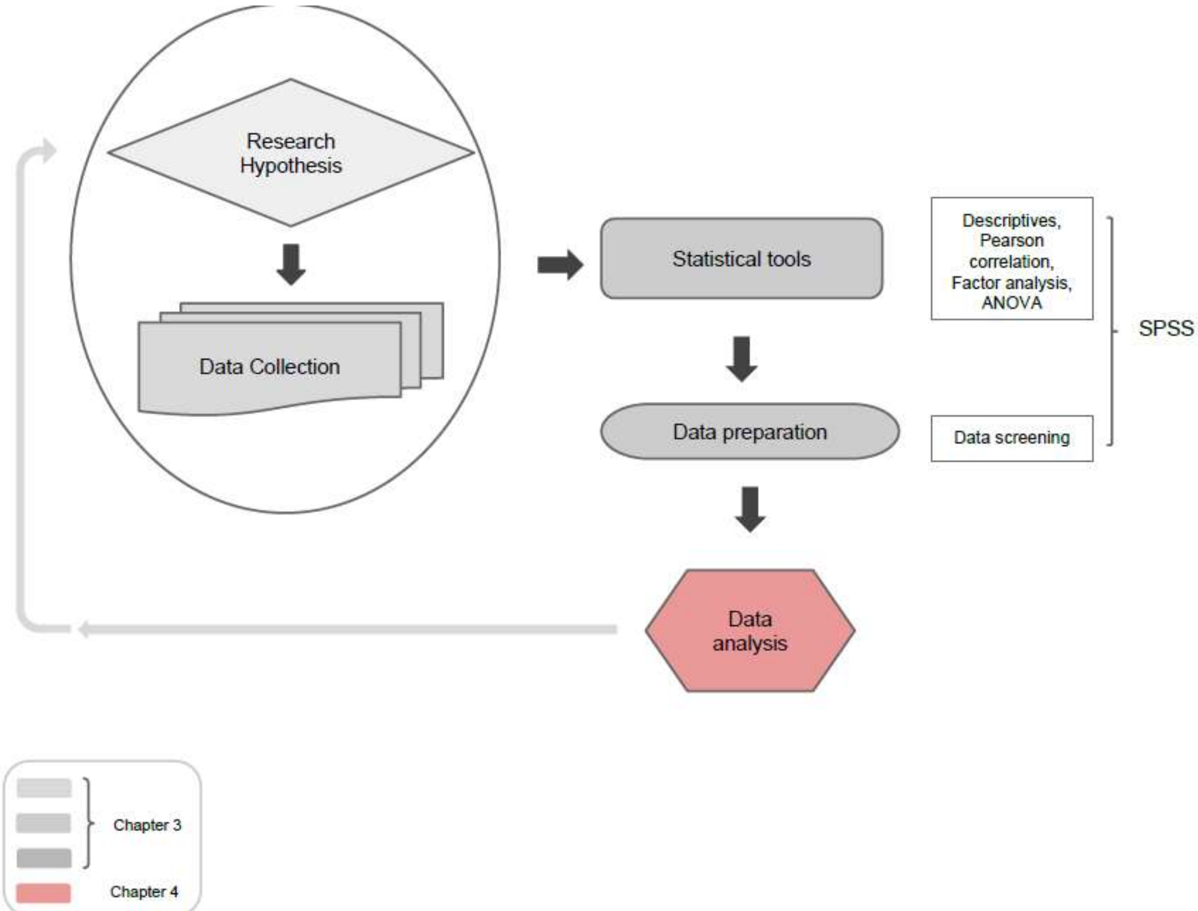


Figure 10. Data Analysis Methodology

3.4.1. Research questions and hypothesis

As mentioned in Chapter 1, the aim of this study is to examine the perspective of young learner drivers towards the Blind Spot Detection system and Adaptive Cruise Control system as well as the introduction of the systems to drivers' training and testing. This has been used as the basis for forming the research question or, in other words, the research hypothesis of the present study, where a new category of drivers is investigated. Thus, the research hypothesis can be written in the following way:

"Young learner drivers have a positive attitude towards Blind Spot Detection system and Adaptive Cruise Control as well as for their introduction in the drivers' training and testing".

Beyond the main research question, a number of sub-questions have been presented, trying to answer the former one. Based on both the literature research findings and the sub-questions, a set of null hypotheses are formed and will be used as the basis for the data analysis and testing.

Briefly summarising Chapter 2, the BSD system is less familiar to drivers compared to the ACC system, which can be explained by the fact that the BSD is relatively newly introduced to the automotive market in comparison with ACC. In addition, it was found that a number of accidents were caused not only because of system failures, but also due to drivers' overreliance on the systems and their tendency not to gain knowledge on the system they use. Furthermore, according to driver trainers and examiners, training drivers display worse driving performance when confronted with certain situations (e.g. being overtaken) or when having to perform specific tasks like overtaking or merging into traffic. Other findings have focused on the effect of the differences in the driving characteristics and driver self-perception on reckless driving. Specifically, previous studies have shown that drivers' cautious and courteous self-image were related to a lower rate of reckless driving, whereas confident and impulsive self-images corresponded to a higher rate of reckless driving. Finally, in view of the literature, experienced and novice drivers display differences in their attitude towards ADAS.

Consequently, the following null hypothesis are formulated:

H_0^a: There is no difference in learner drivers' perceived usefulness of the two systems (ACC, BSD) in specific driving tasks and situations (hazard monitoring, overtaking, etc.).

H_0^b: There is no difference in drivers' attitudes towards the introduction of BSD and ACC systems in driving training and testing among confident, courteous and impulsive drivers.

H_0^c: There is no difference in drivers' attitudes towards the introduction of BSD and ACC systems in driving training and testing between stressed and non-stressed drivers.

H_0^d: Driver's willingness to use the BSD and ACC system is the same in all driving environments (such as urban, rural roads and highways).

H_0^e: There is no difference between learner and experienced drivers in their knowledge about the ACC and BSD systems.

H_0^f: There is no difference between learner and experienced drivers in their perceived usefulness of the ACC and BSD systems.

H_0^g: There is no difference between learner and experienced drivers in their perceived ease of use of the ACC and BSD systems.

H_0^h: There is no difference between learner and experienced drivers in their acceptance of the ACC and BSD systems in training and testing.

Having transferred the scope of the study in the form of hypotheses, the next step is the selection of statistical tools to test these hypothesis. Such a selection depends on two components, the type of available data, and the existing statistical tools.

3.4.2. Overview of widely applied statistical tests

Depending on the type of data, raw or processed, the chosen methods of analysis differ considerably. A lot of research (Siegel, 1956; Sheskin, 2003) has been focusing on the advantages and disadvantages of several statistical techniques, concluding that it is crucial that the appropriate method is chosen so as to yield reliable and trustful results.

Parametric tests rely on the assumption of an existing normal distribution of the data, while no distribution assumptions exist for the non-parametric tests. Likert scale items comprise ordinal data that need to be analysed with non-parametric tests. However, after conducting factor analysis, which is elaborately described later, the data can be analysed using parametric statistical tests, since factor scores are interval data.

Table 4 presents a summary of the main differences between parametric and non-parametric tests, while providing the most widely applied tests for each category of data. As far as the type of tests used in the analysis of the present questionnaires, the Likert scale items of the two behavioural inventories and the

ADAS related part of the survey are firstly processed with factor analysis, giving a final score for each individual on each factor. Thus, they are further treated as interval or scale variables, for which parametric methods (Pearson correlation, t-test, ANOVA) are used.

Table 4. Overview of characteristics and tests for parametric and non-parametric data (Changing minds, 2015).

	Parametric	Non-Parametric
Assumed distribution	Normal	No assumption
Assumed variance	Homogeneous	No assumption
Typical data	Ratio or Interval	Ordinal or Nominal
Observations	Independent	Any
Usual central measure	Mean	Median/Mode
Benefits	More solid conclusions drawn	Simplicity; unaffected by outliers
Correlation Test	Pearson	Spearman
Independent measures, 2 groups	Independent-measures t-test	Mann-Whitney test
Independent measures > 2 groups	One way, independent-measures ANOVA	Kruskal-Wallis H test
Dependent measures, 2 measures	Dependent-measures t-test	Wilcoxon Signed-Rank test
Dependent measures> 2 measures	Repeated measures ANOVA	Friedman test

3.4.3. Selection of data analysis methods

Having carried out the data collection and having summarized the most widely applied statistical tests, the selected statistical analysis corresponding to each research question and sub-questions is made. The following tables depict the way of thinking before concluding on the methods of analysis. Table 5, Table 6 and Table 7 relate the study's questions with the null hypothesis as well as the type of involved variables. Table 8 summarizes all subjects that need to be analysed in order to answer the research questions. More than one subjects for analysis may correspond to one null hypothesis or one research question.

The type of variables in each analysis determine the group of methods that need to be examined so as to reach a final choice. Depending on the method employed, the role of the variables in it is presented. Finally, certain parts of the analysis require the use of more than one methods or tests in a sequence (main test and post-hoc tests).

Table 5. Hypothesis and variables in question "What is the need of the introduction of BSD and ACC systems in driving training and testing from learner drivers' perspective?".

Sub-question	**Question in Questionnaire**		**Null Hypothesis**	**Variables**	
	Experienced Driver Version	Learner Driver Version		Independent	Dependent
To which extent do learner drivers know about the systems and their operation?	10-12, 21-23	7-9, 18-20	-	Experienced-Learner	Knowledge about the systems
To which extent do learner drivers understand how the systems operate?	14, 15, 25, 26	11-13, 22, 23	-	-	-
How useful do drivers perceive the systems in different driving situations (hazards, overtaking, etc.)?	17, 27	14, 24	H_0^a	Different driving situations (e.g. overtaking, merging, collisions)	Perceived usefulness of the system
What are the differences in acceptance of the systems among different types of drivers?	8, 9, 20, 30	5, 6, 17, 27	H_0^b H_0^c	Types of drivers (e.g. confident, courteous, thrill seeking)	Acceptance in Training and Testing

Table 6. Hypothesis and variables in question "To which extent are learner drivers willing to use the systems?".

Sub-question	**Question in Questionnaire**		**Null Hypothesis**	**Variables**	
	Experienced Driver Version	Learner Driver Version		Independent	Dependent
In which traffic and road conditions are the drivers most willing to use the system?	19, 29	16, 26	H_0^d	Road conditions and environment	Willingness to use the system

Table 7. Hypothesis and variables in question "What are the differences between learner and experienced drivers in terms of usefulness, ease of use as well as training and testing of the systems?".

Question	Question in Questionnaire		Null Hypothesis	Variables	
	Experienced Driver Version	Learner Driver Version		Independent	Dependent
What are the differences between learner and experienced drivers in terms of knowledge of the systems?	10-12, 21-23	7-9, 18-20	H_0^e	Driver Category (Experienced drivers - Learner drivers)	Knowledge of the systems
What are the differences between learner and experienced drivers in their perceived usefulness of the systems?	17, 27	14, 24	H_0^f		Perceived usefulness
What are the differences between learner and experienced drivers in their perceived ease of use of the systems?	18, 28	15, 25	H_0^g		Perceived ease of use of the systems
What are the differences between learner and experienced drivers in their acceptance of the systems?	20, 30	17, 27	H_0^h		Acceptance of the systems in training and testing

Aiming to answer the null hypotheses H_0^b and H_0^c, the two behavioural inventories have been employed. Both the Driver Stress and the Driver Self-Image Inventory have taken part in previous transport related studies. Following their use in those studies, the items included in the inventories have been firstly analysed with Factor Analysis. In case of the Driver Stress Inventory, the use of this clustering method aimed in the transformation of the participants' raw answers into distinct kinds of driver stress (e.g. hazard or thrill-seeking related). With regard to the Driver Self-Image Inventory, Factor Analysis was necessary in order to gain meaningful information from it. Specifically, the separate items had to be grouped in such way that they would reflect discrete driver self-images. Achieving these "groupings", the inventories could be further used in statistical analysis.

Factor Analysis has been preferred over several other methods of grouping the Likert scale items. Using the results of the Factor Analysis of the original inventory was an option. However, the original factor loadings have not been found during literature research. In addition, the sample of this study represents a different part of the population, thus Factor Analysis would probably yield different results. A comparison between the two methods would assist in identifying which method to use, depending on the precision and reasonability of the outcomes, but this was not possible due to the absence of the loadings of the original analysis. Another "grouping" option was the calculation of the average scores of the respondents' answers, employing the factors of the original analysis. Nonetheless, the method of averaging does not take into account the importance (loadings/weights) of the items for a factor. Instead, it assumes equal loadings for all the items on a factor. Before being accepted or rejected, the method had to be investigated. Therefore, after conducting Factor Analysis for the two inventories, the method of averaging was employed, using the factors resulting from the factor analysis. Note that the factors of the original inventories were not used in order for a comparison to be feasible. Having computed individual scores in two different ways, a Pearson correlation analysis took place twice in order to identify the potential significance between the two inventories. The results of Pearson correlation have been used in order to compare the two methods of individual score extraction. The results not only displayed differences in terms of significance, but also in terms of reasonability. When the results of Factor Analysis results were used, the points of significance found between the two inventories were logical. Nevertheless, the correlation analysis when the averaging method results were used, resulted to some illogical significances, like significant positive correlations between courteous and impulsive drivers' self-images. Considering these results and the fact that it cannot be assumed that the items of an inventory load equally on a factor, Factor Analysis has been selected over the other methods.

A similar procedure has been applied in the ADAS related part of the questionnaire. As seen in Table 8, Factor Analysis has been used in order to tackle 8 questions in this part of the survey (4 questions for each system). Considering that each question comprises of several items highly related to it, one could reckon that each question represents a factor itself, thus Factor Analysis is redundant and other methods can be undertaken. Nonetheless, Factor Analysis has been conducted on each question separately. It has been preferred to other methods due to the way the factor scores are extracted. To be more specific, Factor Analysis in SPSS software provides three choices for the extraction of factor scores, being Regression, Bartlett's and Anderson-Rubin method. Compared to the "sum scores" method, these methods take the items' loadings on the factors into account. Thus, items with relatively low loading values are not given the same weight in the factor score as items with higher loading values (DiStefano, Zhu, & Mindrila, 2009). Although this problem is solved with the use of "weighted sum scores" method, Factor Analysis in SPSS has been preferred to it because of automatically providing the factor scores, saving time and avoiding potential mistakes. As far as the available in SPSS methods of factor score extraction, the widely applied method of Regression has been selected instead of the other two methods, since the latter did not have significant advantages over the former. In contrast with the simple weighted sum, beyond the correlation between the factors and between factors and observed variables (through loadings of the items), least squares regression considers the correlation among observed variables and the correlation among oblique factors (Tabachnick & Fidell, 2007).

H_0^a and H_0^d hypotheses testing obtains the use of a non-parametric test, since in both cases the dependent variable is ordinal. Friedman test, which is also called the 'method of ranks', is usually used instead of repeated measures Analysis of Variance, either due to the nature of data (data is not interval) or failure in meeting the assumptions required for the respective parametric test (Sheldon, Fillyaw, & Thompson, 1996). In the present analysis, Friedman test is used in order to check if there is a significant difference in the perceived usefulness of the BSD and ACC and the respondents' willingness to use the systems, when they are given different traffic situation and driving environment respectively. Given the fact that the repeated measures are more than two and Friedman test does not indicate where exactly the significance is found, post-hoc tests have to be made. Wilcoxon signed–rank test has been used, since it is the equivalent to the dependent t-test for non-parametric variables (Table 4). The pairs of variables under examination are shown in Table 8.

Aiming to find out the differences in the knowledge about the systems between learner and experienced drivers, Kruskal –Wallis H test has been applied. The method is chosen since the knowledge of the system is measured in an ordinal level instead of an interval one. Therefore, it has been preferred to ANOVA. The test has also been chosen over the Mann-Whitney test, being an expansion of it by providing the opportunity to test more than 2 groups. Nevertheless, the Mann-Whitney test is assumed to lead in the same conclusions when only 2 groups are examined.

Finally, Multivariate Analysis of Variance (MANOVA) has been used in order to test the rest of the hypotheses ($H_0^f - H_0^h$). ANOVA is a statistical tool that is used to test differences between two or more means. MANOVA is an extended version of Analysis of Variance (ANOVA), which considers more than one dependent variables. Being one of the most important parametric tests, the dependent variable should be measured in an interval level. In the current analysis, MANOVA is used to check if there is a significant difference for different aspects (Table 8) between the group of experienced and learner drivers. The test is applied for both systems simultaneously. The method would probably yield the same results with the independent t-test, since the only difference between the two tests is the ability of MANOVA to handle more than two groups. Although post-hoc tests (e.g. Tukey test) are available in case of significance, any significance found in the under study cases is not further analysed with post-hoc tests, since it is attributed to the two analysed groups.

The procedure followed for each test together with the results are given in detail in Chapter 4.

Table 8. Variables and methods for the different analysis subjects.

Subject of Analysis	Tested Variables	Type of variables	Step 1 of the Analysis	Use of variables in the analysis	Step 2 of the Analysis	Use of variables in the analysis
Driver Stress Inventory	28 items	Ordinal	Factor Analysis	Likert scale items (0=not at all, 10=very much)	-	-
Driver Self-Image Inventory	15 items	Ordinal	Factor Analysis	Likert scale items (1=not at all, 6=very much)	-	-
Perceived usefulness of the system	5 items (BSD) 4 items (ACC)	Ordinal	Factor Analysis	Likert scale items (1=strongly disagree, 5=strongly agree)	-	-
Ease of use of the system	3 items					
Acceptance of the system in training and testing	4 items					
H_0^a **(BSD)**	Driving situations (overtaking, collisions, merging)	Categorical	Friedman test	D. Safety Overtaking D. Performance Collisions Merging	Wilcoxon signed rank test (Post-hoc)	10 tested pairs: D. Safety with Overtaking/D. Performance/Collisions/Merging Overtaking with D. Performance/ Collisions/Merging D. Performance with Collisions/Merging Collisions with Merging
	Usefulness of the system (scale 1-5)	Ordinal		Likert scale items (1=strongly disagree, 5=strongly agree)		
H_0^a **(ACC)**	Driving situations (distance keeping, driving performance, collisions)	Categorical	Friedman test	D. Safety Distance keeping D. Performance Collisions	Wilcoxon signed rank test (Post-hoc)	6 tested pairs: D. Safety with Distance keeping/ D. Performance/Collisions Distance keeping with D. Performance/Collisions D. Performance with Collisions
	Usefulness of the system (scale 1-5)	Ordinal		Likert scale items (1=strongly disagree, 5=strongly agree)		
H_0^b H_0^c	"Confident Driver" "Courteous Driver" "Impulsive Driver" "Dislike of driving" "Hazard Monitoring" "Thrill-seeking"	Interval	Pearson correlation	X-axis	-	-
	Acceptance in training	Interval		Y-axis	-	-

	and testing					
H_0^d	Road conditions and environment	Categorical	Friedman test	Urban roads Rural roads Highway roads Congested roads	Wilcoxon signed rank test (Post-hoc)	6 tested pairs: Urban-Rural Urban-Highway Urban-Congested Rural-Highway Rural-Congested Highway-Congested
	Willingness to use the system (scale 1-5)	Ordinal		Likert scale items (1=strongly disagree, 5=strongly agree)		
H_0^e	Category of drivers (Learner Drivers - Experienced Drivers)	Categorical	Kruskal-Wallis H test	X_1-X_2	-	-
	Knowledge of the systems	Ordinal				
H_0^f	Category of drivers (Learner Drivers - Experienced Drivers)	Categorical	MANOVA	X_1-X_2	-	-
	Perceived usefulness	Interval				
H_0^g	Category of drivers (Learner Drivers - Experienced Drivers)	Categorical	MANOVA	X_1-X_2	-	-
	Perceived ease of use of the systems	Interval				
H_0^h	Category of drivers (Learner Drivers - Experienced Drivers)	Categorical	MANOVA	X_1-X_2	-	-
	Acceptance of the systems in training and testing	Interval				

3.4.4. Data preparation

Considering that the on-line questionnaire has been constructed and distributed through Google Docs, the responses have been delivered in two different EXCEL sheets, one for each questionnaire. EXCEL has been used in the preparation of the data for analysis, which implies coding of the questions and checking of missing data. In addition, it has been used as the main analytical tool in the examination of the first part of the questionnaire, being the analysis of the demographic background of the participants, as well as for the open-ended questions.

To begin with the data preparation, the initial database consisted of columns with long phrases in both questions and answers. As a first step the questions where shortened and coded in order to be easily used in further steps. Taking into account that most of the statistical analysis needed to be made in SPSS, the coding complied with the rules of the latter software. As far as the open-ended questions, the length of which varied depending on the type of question and the respondent, a categorization of them took place so that they could be handled quickly and easily. This type of analysis relates with the last part of the questionnaire and is given below.

Having finished with coding, the data was transferred to SPSS 20 software. Before the main analysis, data screening was considered necessary. Data screening refers to several checks of the data, like correct way of entering it to the database (e.g. out of range values), missing values and outliers existence and handling.

Firstly, frequency tables were extracted in order to find incorrectly entered data, displaying that out of range values did not exist in the data set. Secondly, the data base was searched for the identification of empty cells. Missing values check reported 141 (out of 7.920) empty cells, which correspond to unanswered questions. However, the way missing values are tackled is more important that their identification, since it might lead to a semantic reduction of data, thus create problems in the analysis. In order to deal with the absence of answers in certain questions, the reason of the missing data as well as the issues caused by that have to be clarified.

Missing values may be random or non-random. Values belonging in the first category might be a result of unintentionally not answering of questions by the subjects. Data entry mistakes might also account for random empty cells. On the other hand, non-random missing answers usually reflect the respondent's decision to not answer certain questions. Such a decision could result from the fact that a question causes confusion or that the given options of answers do not sufficiently cover the range of answers. Moreover, social desirability has to be considered as one of the reasons why specific questions are skipped, since some types of participants might feel reluctant in responding to various questions.

The missing values check took place both manually, by carefully looking at the respondents and the questions of missing answers, and by SPSS. EM (Expectation-Maximisation) estimation, which checks if the subjects with missing values are different than the subjects without missing values, resulted in the fact that the subjects with missing values displayed no significant difference ($p>0.05$) from the subjects without missing answers. Therefore, randomness is assumed for the missing data in both questionnaires.

With regard to the way of dealing with the missing values, three options are found available. The first option leaves the data as it is, meaning that the missing values are not replaced by other values while the answers of the respective respondents in the rest of the questions are also kept in the data set. The second and the third options relate with replacement of the empty cells with standard content (imputation) and the deletion of all the answers of the corresponding participants respectively. Taking into account that the number of missing values in the data base is small (1.8%), together with the fact that most of the missing values would be used together with others to create composites of items by averaging them together in a new variable, no special treatment for such values took place. Therefore, further decisions on the missing values had to be made in SPSS, which provides two types of data deletion. To be more specific, with *listwise* deletion subjects with missing values are not taken into account in the analysis. Since the disadvantage of loss of data might result in significant differences in the results, pairwise deletion had to be considered seriously. In this way, only the specific missing answers would be extracted from the analysis instead of the entire case so that all available data was included. However, considering that the sample of both groups remained sufficient even when listwise deletion was implemented, all types of tests conducted with this software employed listwise omission of data.

As far as the outliers are concerned, no extreme values have been extracted from the data set. The decision has been made based on two facts. To begin with, the existence of an answer which is considerably different from the rest of the data does not indicate an anomaly and does not set the value invalid. Therefore, there is no reason for it to be removed. Instead, such answers can be considered as part of research conducted in order to discover empirical reality. Throwing away certain data would mean arbitrarily rejecting answers under the assumption of them being not "normal". Choosing an answer, the participant gives a reflection of reality, thus taking the outlier away would be an opposition to the reasons why one conducts research.

Normality in data reflects the normal distribution of them. Such a probability distribution plots all values in a symmetrical way so that the majority of them is situated around the probability's mean. Generally, distributions tend to be normal as the sample increases in size, allowing the use of parametric tests under the assumption of normality.

In the present study, the type of data as delivered by the questionnaire consists of Likert scale answers, thus comprise ordinal variables. At a later stage, after statistical processes, the data can be treated as interval. According to Jamieson (2004), the suitable descriptive and inferential statistics vary for ordinal and interval variables. In case wrong statistical methods are used, the chances of being led to wrong conclusions rise (Norman G. , 2010). Thus, the data should be treated in a different way in each stage of the analysis. To elaborate more, raw answers in the Likert scale questions, considered to be ordinal data, belong to the wide group of non-parametric data. Since no distribution assumptions lay behind non parametric tests, Likert scale data have not been tested for normality.

The next step included a number of last modifications in the data. The latter included coding of the Likert scale answers and reverse coding of the certain questions. To begin with the coding, different answers were assigned to the Likert scale items in both questionnaires such as "strongly disagree" to "strongly agree" and "not at all" to "very much". For efficient use of the answers in calculations, values where assigned to each of the answers in the different scales. The lowest values referred to the negative answers, followed by a range of values which led to the highest value, thus the positive response.

Since some of the Likert scale items found in the inventories are reverse coded, meaning that there are both positively and negatively scored items for each scale. The items had to be recognised and reversed so that all questions had the same direction, being from negative to positive rating. In comparison with the Driver Self-Image Inventory, where all items were verified to have the same direction, three items in the DSI had to be reversed. More specifically, coding was reversed for the following items: "Do you think you have enough experience and training to deal with risky situations on the road safely?", "Do you feel confident in your ability to avoid an accident?", "When you pass another vehicle do you feel in command of the situation?". Based on the results of the real version of the DSI, all three items belong to the factor "Dislike of driving".

Therefore, their reversion has been done in such a way that the answer of the respondent means no sense of dislike of driving for the value 0 and high level of dislike of driving for the value 10.

Having conducted the prior preparation of the data set through the abovementioned steps, the main analysis was ready to start, as described in the following paragraphs.

3.4.5. Theoretical framework of factor analysis

Both the driving profile of drivers and the driving characteristics of them as reflected from the Driver Self-Image and the Driver Stress Inventory respectively had to be analysed and processed separately in order to add value to the next steps of the research (Figure 10). Further steps in the analysis aim to investigate the relation between driving profile and attitude towards ADAS, by examining the correlations of different types of drivers and their responses in the ADAS related part of the questionnaire.

The analysis of the first two inventories has taken place through factor analysis. Factor analysis aims to display a set of variables X_1, X_2...X_n as a series of latent variables, taking into account the uniqueness of a factor for each variable. The latent variables, also called common factors, consist of variables that demonstrate through correlations which variables relate to each other. According to the latter, correlated variables are items having one or more factors in common.

Factor analysis is used as an attempt to illustrate the results of the analysis in an efficient way, employing a small number of factors instead of a huge number of measurements. In addition, such a procedure enables the examination of variables that are hardly measured in a direct way. Considering the present study, factor analysis assists is verifying that the observed variables of the inventories in the questionnaire achieve to measure the same latent factor, thus they are able to reliably represent it.

To be more specific, the measured variables are presented as a system of linear functions of the latent factors as shown below.

$$X_1 = \alpha_{11}F_1 + \alpha_{12}F_2 + \alpha_{13}F_3 + \ldots + \alpha_{1m}F_m + \alpha_1 U_1$$

$$X_2 = \alpha_{21}F_1 + \alpha_{22}F_2 + \alpha_{23}F_3 + \ldots + \alpha_{2m}F_m + \alpha_2 U_2$$

$$\ldots$$

$$X_n = \alpha_{n1}F_1 + \alpha_{n2}F_2 + \alpha_{n3}F_3 + \ldots + \alpha_{nm}F_m + \alpha_n U_n \tag{1}$$

, where

X_i: the observed variables

F_j: the latent (common) factors

U_z: the unique factors

α_{ij}: coefficients

As already mentioned, factor analysis attempts to find which variables best represent specific factors. This is achieved by calculating the coefficients α_{ij}, which act in the same way as the coefficients in a regression equation. For instance, the effect of a one-unit increase in F_1 on variable X_1 is represented by α_{11}. Given that several variables load on a factor, the α_{ij} coefficients are called factor loadings. It has to be noted that in case there is no correlation between the factors, loadings depict the correlation between each variable and the corresponding factor.

Solving the aforementioned set of equations in a way that the factors are expressed as linear equations of the variables, the result illustrates the factor scores. As a consequence, a factor score is calculated for each subject (2).

$$F_1 = b_{11}X_1 + B_{12}X_2 + \ldots + b_{1n}X_n$$

$$F_2 = b_{21}X_1 + B_{22}X_2 + \ldots + b_{2n}X_n$$

$$\ldots$$

$$F_m = b_{m1}X_1 + b_{m2}X_2 + \ldots + b_{mn}X_n \qquad (2)$$

Factor analysis is one of the crucial components of the current study. Although both inventories (Matthews, Desmond, Joyner, Carcary, & Gilliland, 1996; Taubman-Ben-Ari, 2008) have been analysed through factor analysis previously, a number of facts requires a repetition of the analysis. To be more specific, the fact that the purpose of the study considerably differs from the original study as well as the differences in the type and size of used sample might yield significant differences in the results, thus the new outcome should be taken into consideration, affecting the direction of the analysis.

Given the theoretical background of factor analysis, the necessary steps of the entire factor score extraction procedure are presented for each inventory in Chapter 4.

3.5. Conclusions

In this chapter the employed research and data analysis methodology was given. Regarding research, the means for the development of a *multi-content online questionnaire* and *in-depth personal interviews* were presented. First, two groups, learner and experienced drivers, for recruitment were identified and the set of recruitment ways was listed. Second, the development of the present questionnaire, consisting of 3 main parts, was described. The 1st and 2nd part are related to drivers' behaviour, thus two behavioural inventories, the Driver Self-Image Inventory and the Driver Stress Inventory were selected among a great number of explored inventories, because of their relevance to the study and the type of participants. Each of the chosen questionnaires has been developed and used for the examination of different reasons of deviant driving behaviour, driver self-images and driver stressors. The integration of them into one questionnaire will investigate non-overlapping domains of driving behaviour. The 3rd part of the questionnaire was developed for the purposes of this study and was based on ADAS related videos. It was devoted to investigate the opinion of drivers towards the examined ADAS. The BSD and ACC systems were presented in sequence and a series of questions which emphasize on the *expected usefulness*, *ease of use*, *willingness to use* and the *introduction of the system to drivers' training and testing* were made to the participants. After a pilot study, the questionnaire was finalised. The questionnaire results study results will be used as input for the organisation of the in-depth personal interviews. Concerning data analysis, extensive research on the widely applied statistical analysis and tests have been done in order to employ the appropriate ones for the variables of this study. Both *parametric* and *non-parametric* tests have been chosen, while *factor analysis* has been one of the core methods of data analysis. Finally, the data preparation and the theoretical framework of factor analysis were presented.

Data collection and analysis

The current chapter presents all the steps of the data analysis, starting from the data collection set to the final results and conclusions drawn from it. First, the main parts of the analysis, including distribution analysis, factor analysis and correlation analysis are presented. Following, further statistical analysis is conducted to answer the research questions presented in Chapter 1.

4.1. The Data Set

The recruitment attempts described in the previous chapter resulted in the collection of 88 participants, comprised of both experienced (48) and learner (40) drivers from different geographical areas in and outside the Netherlands.

The sample of the experienced drivers, comprised of 48 drivers, included 31 men and 17 women with an age range from 20 to 53 (M=28.19, SD=7.59) and an average driving experience of about 10 years (M=9.85, SD=7.46). Half of the participants in this group use their private vehicles as main mode of transport, while walking/cycling and public transport are found to be the second (25%) and third (20.8%) preference respectively. More than 60% of the respondents claimed to drive 1 to 3 times per week, followed by 20.8% who drive every day. The rest of the participants also drive regularly (4 to 6 times per week). Finally, these drivers drove between 5001-10000 km per year on average, whereas none of the drivers has been involved in an accident in the last six months.

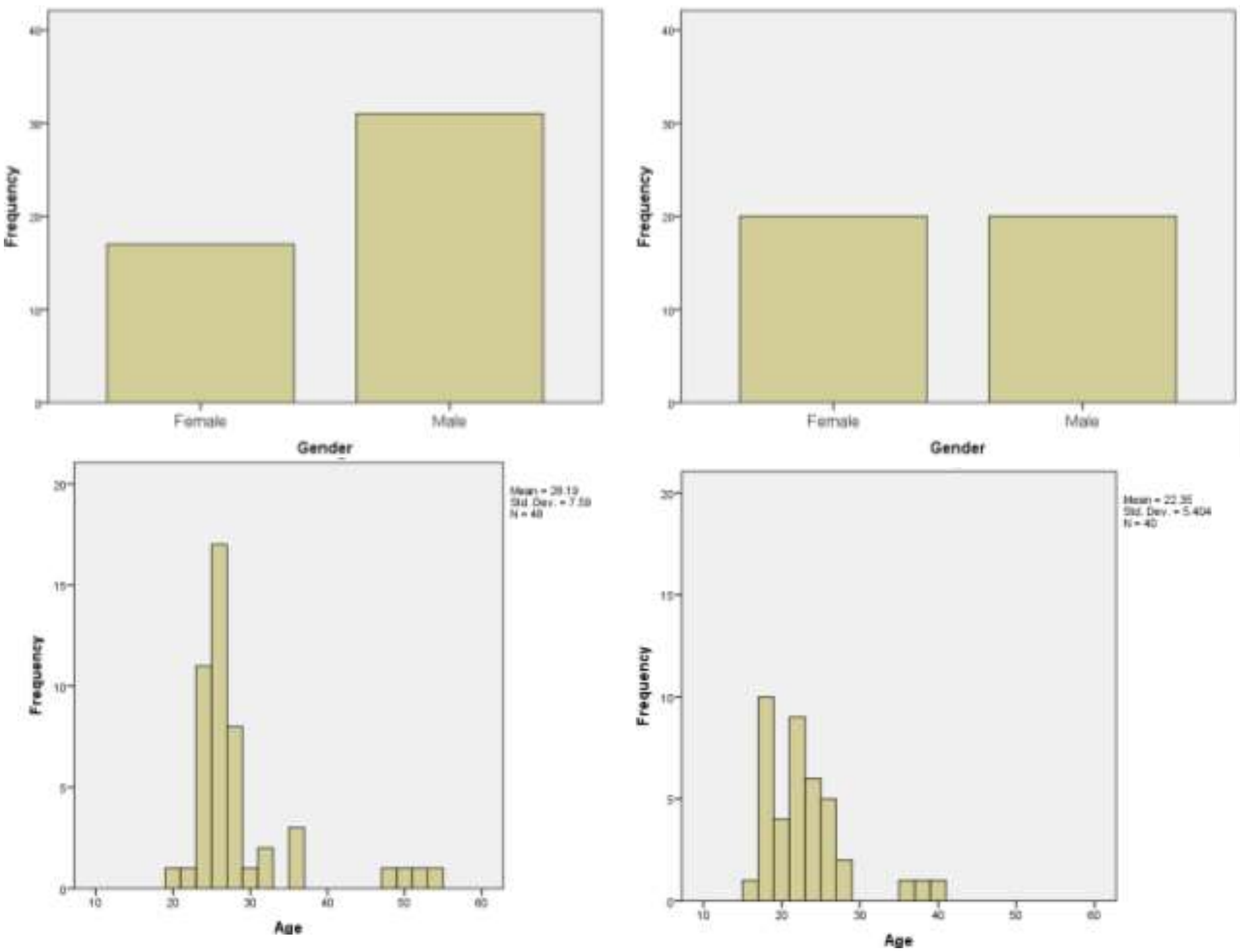
The sample of the learner drivers comprised of 40 people, 20 men and 20 women, with age from 16 to 40 (M=22.35, SD=5.4). Taking into account that the respondents of this group have not obtained their driving licence yet, walking/cycling is stated as the primary mode of transport (60%), followed by private vehicle (17.5%), public transport (12.5%) and motorcycle (5%). Finally, the average number of hours of driving classes was 36 (M=35.93, SD: 28.94).

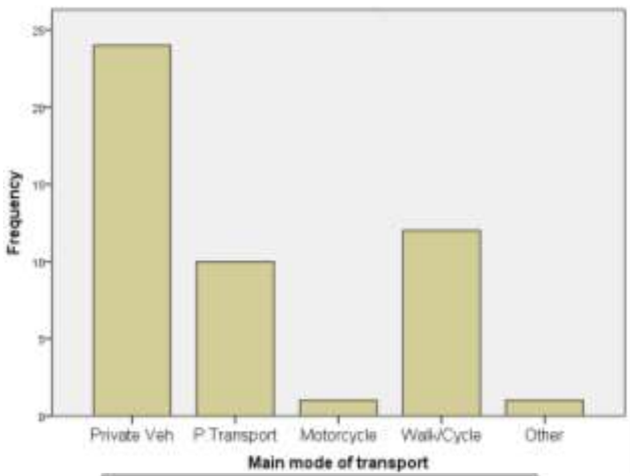
Almost all of the experienced drivers (first group) and half of the learner drivers (second group) were recruited from Delft University of Technology. The second half of the learner drivers were recruited from Driving Schools with the help of CBR. Having a similar educational background, approximately 67% of all the respondents have a very good understanding of English, while around 75% have a very good level in

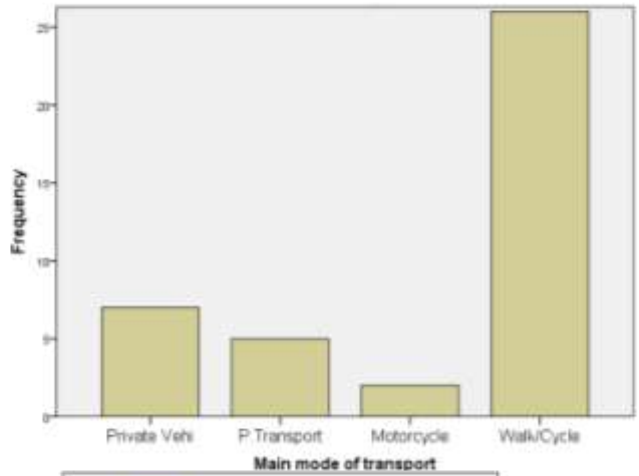
English listening comprehension. Only 2 of the respondents claimed to display poor English skills, which is considered a minor issue.

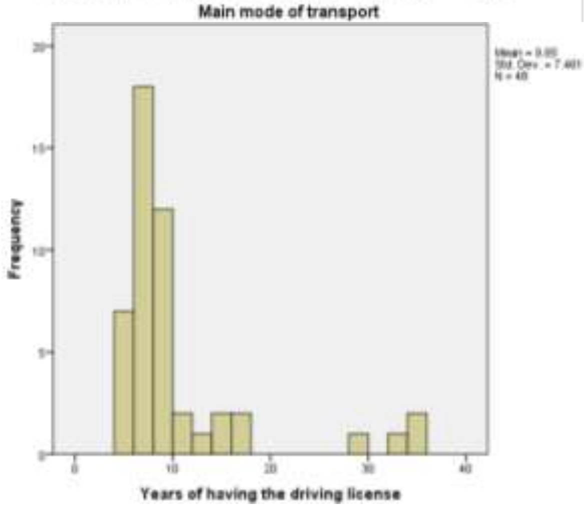
4.2. Demographic data analysis

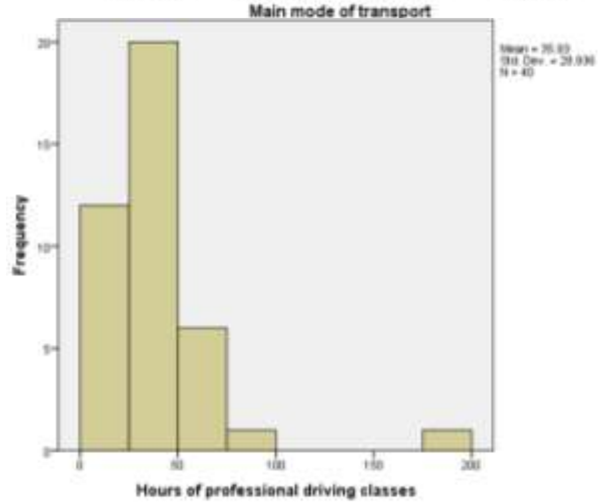
Figure 11 presents the distribution analysis of the participants' responses to the first part of the questionnaire which included questions regarding drivers' socio-demographic and driving experience related characteristics. The distribution analysis is based on the 88 drivers who participated in the study, divided into the two groups of the respondents. It has to be noted that driving experience related questions have been asked differently to the two groups, thus the content of the presented histograms does not match absolutely among the groups.

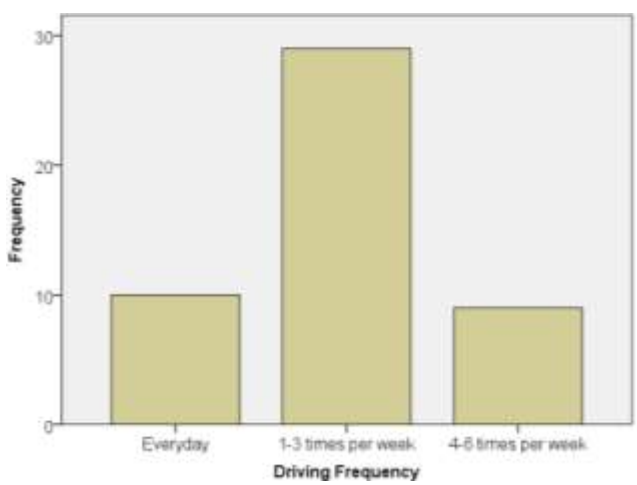



Frequency
Private Veh
P Transport
Motorcycle
Walk/Cycle
Other
Main mode of transport


Frequency
Private Vehi
P Transport
Motorcycle
Walk/Cycle
Main mode of transport


Frequency
Years of having the driving license


Frequency
Hours of professional driving classes


Frequency
Everyday
1-3 times per week
4-6 times per week
Driving Frequency

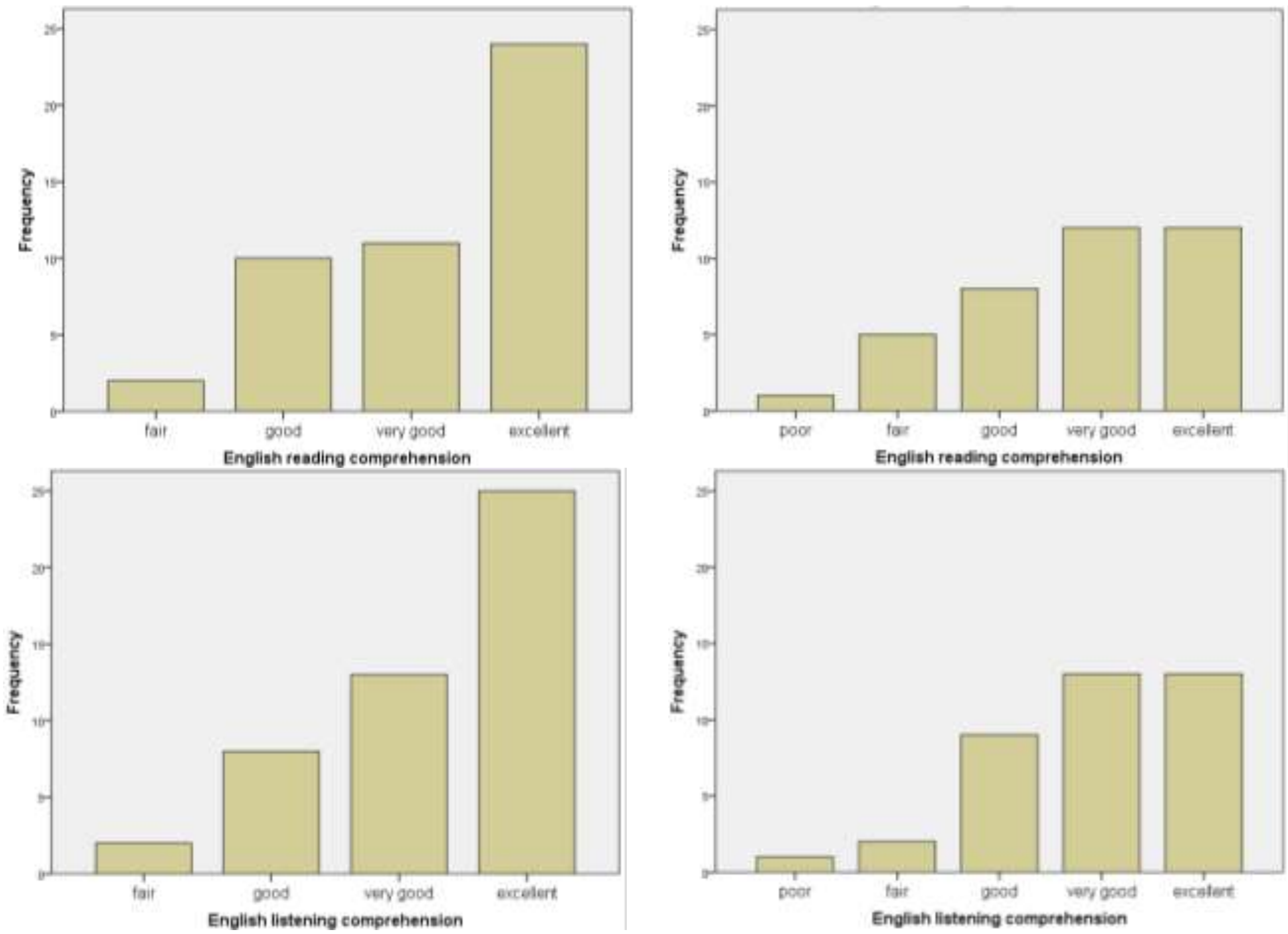


Figure 11. Distribution results. Comparison between experienced and learner drivers. Left: Experienced drivers, Right: Learner drivers.

4.3. Driving profile and drivers' characteristics analysis

The acquisition of knowledge about the profile of drivers that have taken part in the study is a crucial element when their attitude towards the ADAS is analysed, since one's driving attitude could explain their perception of ADAS. In the current study, the driver's profile is examined with the help of two behavioural inventories, the Driver Self-Image Inventory and the Driver Stress Inventory. As already mentioned, in order to include these two behavioural inventories in the next steps of the analysis, factor analysis is conducted. The following paragraphs describe the procedure of determining the individual scores on each of the extracted factors.

4.3.1. Driver Self-Image Inventory

As described in the previous chapter, the Driver Self-Image Inventory originally consists of 15 items, aiming to investigate the subjective views of self-image as a driver. In order to achieve this, the participants were asked to indicate to what extent each of the 15 adjectives (items) sufficiently describes their perception of themselves as a driver. The responses have been marked on a 6-point scale, ranging from 1 (not at all) to 6 (very much) (Taubman-Ben-Ari, 2010).

Reliability analysis

Reliability analysis comprises an indispensable asset of the factor analysis that has to be conducted so as to efficiently handle the Driver Self-Image Inventory. Being the first step of the factor extraction procedure, reliability analysis calculates the measures of internal consistency and adequacy of the sample so as to assess the value of each item of the inventory towards its inclusion in the set of variables that are going to take part in the factor analysis (Cronbach, 1951).

The Cronbach's alpha test is the first method used to assess the reliability of the available sample. The test provides an estimation of the consistency of the respondents' answers to the Likert-type scale. This is achieved by calculating the level of mean inter-correlation of the items, which is weighted by their variances. Reliability is depicted through Cronbach's alpha coefficient that ranges between 0 and 1. It has to be mentioned that the coefficient does not present a lower limit, since negative values can result from coding errors among the data. In the present analysis, the interpretation rule of George and Mallery (2001) for the reliability coefficient is used. According to the authors, a value of 0.5 sets the acceptance threshold, followed by a 0.7 value, being a sensible aim for sufficient internal consistency. Finally, coefficient values above 0.9 indicate proficient internal consistency (George & Mallery, 2001).

Cronbach's alpha formula is a function of the number of the inventory items and the average inter-correlation among the items. When the number of items increases, the value of the coefficient increases accordingly.

Considering the Driver Self-Image Inventory, the initial consistency of the 15 items is good, reflected by a Cronbach's alpha coefficient of 0.713. Further investigation of the individual items' consistency has taken place so as to assess the effect of each single item on the reliability coefficient. Table 9 illustrates the reliability results for the 15 items of the inventory. It can be seen that there are three items (nervous, rash and law-abiding) whose deletion would lead to a higher value of Cronbach's alpha.

After extraction of one item at a time and re-run of the reliability analysis, the best Cronbach's alpha reached was 0.844. However, this has been achieved with the extraction of five items, which are nervous, rash, risk-taker, law abiding, cautious. Given the fact that the deletion of the last five items would allow further analysis of only 2/3 of the 15-item inventory, such deletion had to be considered in comparison with other alternatives which may yield better results.

Since none of the items considerably decreased the reliability coefficient, the reliability test was decided to be terminated, keeping all the items for further analysis. Further evaluation on the deletion of some items has taken place in the next steps, under the conduction of the factor analysis.

Factor analysis

The factor analysis involved a variety of attempts and tests in order to examine each resulting set of factors both in terms of their content and validity as well as in comparison to the original Driver Self-Image Inventory results.

The Principal Axis Factoring method has been preferred to Principal Component Analysis (PCA), since PCA assumes that the factors are uncorrelated (orthogonal solution). It considers 0 unique variance for each of the examined items because each item's communality is thought to sum up to 1 over all factors. In addition, Principal Axis Factoring has been preferred over Maximum Likelihood, which is based on the assumption of multivariate normality of the variables. Finally, Alpha Factoring method has also been rejected since, in comparison to Principal Axis Factoring. Alpha Factoring establishes the number of factors in a different way from Principal Axis Factoring. To be more specific, instead of testing the statistical significance, the method retains only the alpha factors with positive generalisability/reliability (Kaiser & Caffrey, 1965).

Table 9. Cronbach's alpha results for the Driver Self-Image Inventory.

Item	Cronbach's alpha if item deleted
Cautious	0.706
Experienced	0.681
Nervous	0.787
Fast	0.672
Responsible	0.691
Considerate	0.679
Rash	0.737
Clear thinking	0.663
Self-confident	0.677
Polite	0.685
Law-abiding	0.715
Calm	0.674
Patient	0.695
Decisive	0.667
Risk-taker	0.712

The selection of Factor Analysis method was followed by the selection of the rotation method that needed to be employed for the easier and more reliable interpretation of the results, which is achieved by the creation of a simplified factor structure (Thurstone, 1944; Kaiser H. F., 1958). SPSS software provides a variety of rotation methods that can be divided into orthogonal and oblique rotation. In orthogonal rotation the new axes are orthogonal to each other, which means that they are independent, whereas in oblique rotation there is no requirement that the new axes are orthogonal to each other.

Although Taubman Ben-Ari (2008) used Varimax rotation to infer the extracted factors, which is the most widely applied orthogonal rotation, oblique rotation had to be undertaken. According to Tabachnick and Fiddell (2007), the best way to choose between orthogonal and oblique rotation is to perform oblique rotation asking for the desired number of factors while examining the correlations between them. Factor correlations lower than a threshold (<0.32) (Tabachnick & Fidell, 2007) mean that the solution is nearly orthogonal.

Direct Oblimin rotation was used, aiming to identify potential correlations between the extracted factors. The factor analysis contained a variety of options, from inclusion of all the items of the inventory to the deletion of the five items indicated for exclusion by the reliability analysis. The results of the factor analysis with oblique rotation are given in Table 10.

In most of the cases, the exclusion of items has led to correlated extracted factors. Correlations above the threshold 0.32 mean that there is at least 10% overlap in variance among the factors. Therefore there is enough variance to approve the use of an oblique solution and reject an orthogonal one.

Table 10. Results of Direct Oblimin rotation for the Driver Self-Image Inventory.

Deleted Items	Extracted Factors	Correlated factors
-	4	Factor 1- Factor 3 (0.351)
-	3	-
-	2	-
Nervous	4	Factor 1- Factor 3 (0.307)
Nervous	3	Factor 1- Factor 3 (0.381)
Nervous	2	-
nervous, rash	3	-
nervous, rash, risk-taker, law-abiding, cautious	3	Factor 1- Factor 2 (0.406) Factor 1- Factor 3 (0.361) Factor 2- Factor 3 (0.095)

However, the correlations have not been incredibly higher than the threshold. Moreover, the original Driver Self-Image Inventory analysis has resulted in the extraction of four uncorrelated factors and Varimax rotation has been used in the factor analysis (Taubman-Ben-Ari, 2008). For these reasons, Direct Oblimin rotation has been replaced by Varimax.

Several alternatives have been examined with Varimax rotation. To elaborate more, factor analysis has been conducted in two ways. Firstly, the analysis included all items of the inventory and gradually left out items which either reduced the Cronbach's alpha according to the reliability analysis or did not fulfil the requirements of the Kaiser-Meyer-Olkin (KMO) test at an individual item level. In the first case, the items that would lead to a higher alpha coefficient have been taken way. Nevertheless, the factor analysis resulted in the extraction of 2, 3 and 4 factor solutions which displayed a number of deficiencies in content and structure. All three solutions presented at least one factor which consisted of one or two items, thus the reliability of the result was downgraded (Raubenheimer, 2004). For the four factor solution, this can be attributed to the fact that the oblique rotation conducted before resulted in some correlations between factors. In this solution, two factors comprised of items that could be easily combined to represent one driver characteristic, thus one factor.

In the second case, the analysis was run including all items, followed by the removal of items that displayed a KMO value lower than 0.5 (Dziuban & Shirkey, 1974). High values of the KMO statistic point out that the correlation coefficients are rather large compared to the partial correlation coefficients, meaning that there are potential patterns of correlation in the data. Thus, factor analysis proves to be the proper method to use. On the contrary, when there are relatively large partial correlation coefficients compared to the correlation coefficients, then the data form disperse relationships. In this case, factor analysis is not the best statistical tool to use, since the under study variables are unable to form discrete factors. According to Kaiser (1974), a threshold of a KMO value of 0.5 indicates an acceptable level of correlation, followed by the adequate level of 0.7 value. An excellent level of correlation is, finally, interpreted by a value of 0.9 or more.

The individual KMO values for each item are displayed through the diagonal items of the Anti-Image Correlation matrix and are shown in Table 11.

Table 11. KMO test at item level.

Item	KMO	`Item	KMO
Experienced	0.780	Polite	0.772
Nervous	0.743	Law-abiding	0.574
Responsible	0.818	Calm	0.745
Fast	0.677	Patient	0.617
Considerate	0.813	Decisive	0.884
Rash	0.740	**Risk taking**	**0.487**
Clear-thinking	0.893	**Cautious**	**0.469**
Confident	0.903		

Since *cautious* KMO value was lower than *risk taking* value, it was excluded first from the variables. After re-running the analysis, all KMO values were above the 0.5 threshold, so only *cautious* has been removed from the inventory for the next steps of the analysis.

Besides KMO, Barlett's test of sphericity (Tobias & Carlson, 1969), tests the hypothesis that the correlation matrix is an identity matrix. If the test shows significance (Barlett's value higher than the alpha level), the null hypothesis that the matrix is an identity matrix is rejected, thus correlations exist within the data set and factor analysis can be implemented to the data.

The factor analysis resulted in 2, 3 and 4 factor solutions. Solutions with a larger number of factors could not be given since after several iterations, the communalities of the variables exceeded the maximum possible value. All solutions presented a Cronbach's alpha more than 0.7, meaning considerable internal consistency, whereas the overall KMO value rendered the sample adequate for factor analysis, with values above 0.7. Finally, Bartlett's test was highly significant in all solutions (p=0.000).

The selection of the number of factors has been achieved based on the Scree plot (Zhu & Ghodsi, 2006) and the use of the Ricolfi method of compromise measure. According to the Scree plot (Figure 12), 3 factors explain most of the variability, since the line starts to straighten after factor 3. Considering that the decision of the number of factors recovered is a subtle issue that has been researched a lot, the indications of the Scree plot needed to be tested with another method.

Ricolfi's method calculated the number of factors aiming for the best compromise between the adaptation and the efficiency of the solution. The adaptation of the solution is expressed as the percentage of cells of the correlation matrix, which yield a difference lower than 0.05 between the observed and reproduced correlations (3) (Ricolfi, 2002).

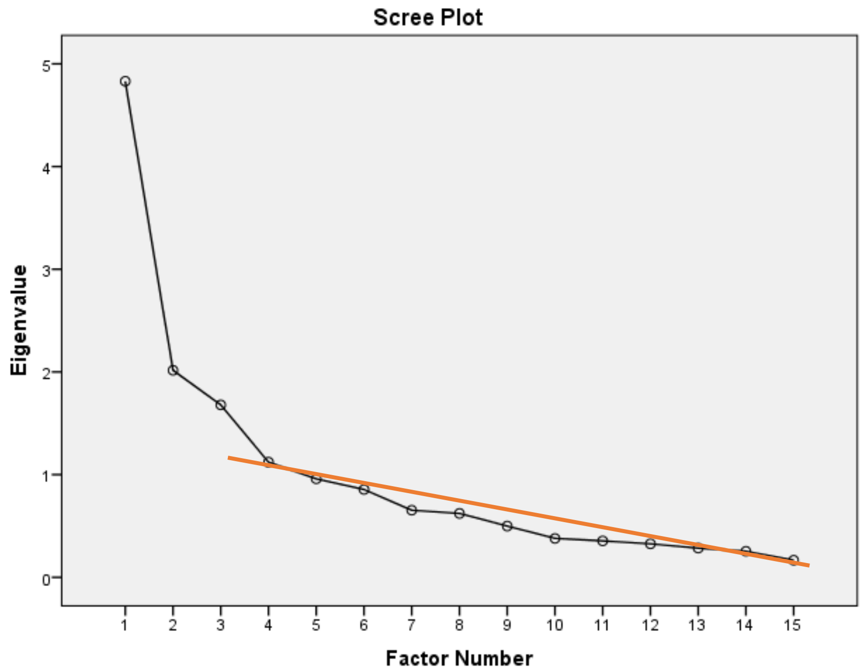


Figure 12. Scree plot of the Driver Self-Image Inventory (N=14)

$$a = 1 - \frac{\#\left(\left|r^2_{ij,obs} - r^2_{ij,repr}\right| > 0.05\right)}{m\frac{(m-1)}{2}} \tag{3}$$

, where

α: the adaptation

m: the number of items

$r^2_{ij,obs}$: the observed correlations

$r^2_{ij,repr}$: the correlations reproduced, calculated through the latent factors

The efficiency formula (4) is given as the ratio between the resulting solution which contains a certain number of degrees of freedom and the ideal solution, containing only one degree of freedom.

$$e = \frac{m\frac{m+1}{2} - \left[mf + f + f\frac{f-1}{2}\right] + f(f-1)}{m\frac{m+1}{2} - 1} \tag{4}$$

, where

e: the efficiency

m: the number of observed items

f: the number of latent factors

As already mentioned, several attempts were made in order to derive a solution under factor analysis with Varimax rotation (Table 12). In these attempts, the number of variables varied between 13 and 15, since one or 2 items from the inventory were removed, based on the previous factor analysis with oblique rotation.

With regard to the number of latent factors, this ranged from 2 to 4. The adaptation reached its maximum value when the solution consisted of 4 factors and only *nervous* was excluded from the inventory items, based on the suggestions of the reliability analysis. On the other hand, efficiency displayed the highest value when *cautious* was excluded from the inventory, based on the KMO test, and the solution comprised of 3 factors. Calculating the compromise measure by multiplying the adaptation and the efficiency values, the best solution was found to have 3 factors, the efficiency reached more than 60% and 29 (31%) of the non-redundant residuals had an absolute value smaller than 0.05. Ricolfi's method verified the Scree plots indications that the recovery of 3 factors best represents the Driver Self-Image Inventories content.

It has to be noted that the solution presented in the first row of Table 12 has been rejected for the reasons of content and structure explained above, although having the highest compromise measure value. Its efficiency is also relatively low compared to the final selection, which is given in bold.

Table 12. Compromise measure results for the Driver Self-Image Inventory.

Observed Variables (M)	# Factors (F)	Efficiency e	Adaptation a	Compromise Measure	Excluded items	Criterion for exclusion
14	4	0.490	0.868	0.426	Nervous	Cronbach's alpha
13	4	0.456	0.846	0.385	nervous, risk taker	Cronbach's alpha
13	3	0.578	0.718	0.415	nervous, risk taker	Cronbach's alpha
13	2	0.711	0.397	0.283	nervous, risk taker	Cronbach's alpha
14	**3**	**0.606**	**0.681**	**0.413**	Cautious	KMO
14	2	0.731	0.429	0.313	Cautious	KMO
13	3	0.578	0.705	0.407	cautious, risk taker	KMO

As seen in Table 13, the factor analysis resulted in three comprehensible and relevant driver self-image factors. Taking into account the inventory's designer, only factor loadings above 0.4 have been considered significant. Factor 1, explaining 31% of the variance, reflects a safe and confident way of driving. Factor 2, explaining 11% of the variance, reflects a controlled and socially adjusted way of driving. Although both factors are related to careful driving behaviour, the first one relates to a higher level of confidence, while the second one is related to more hesitant behaviour. On the other hand, the items of factor 3, explaining 7% of the variance, reveal a rather maladaptive and unstable way of driving. The three factors together explain 49% of the variance.

Table 13. Results of the rotated Factor Matrix. Driver Self-Image Inventory.

	Factor		
	1	2	3
confident	0.785		
nervous	-0.729		
clear-thinking	0.653		
experienced	0.632		0.430
decisive	0.605		
Patient		0.735	
Polite		0.679	
responsible	0.477	0.575	
Calm	0.551	0.561	
law-abiding			
Fast			0.685
risk taking			0.450
considerate			0.431
Rash	-0.400		0.422

Accordingly, the first factor can be named after the respective factor in the original inventory, gathering most of the characteristics of a "confident" driver (Cronbach's alpha = 0.827), while the second one illustrates a "courteous" driver's way of driving (Cronbach's alpha = 0.776). Despite the fact that the factors do not perfectly match the original version of the results (Taubman-Ben-Ari, 2008), most of the items loaded on the respective factors, whereas the rest of them are considered to meaningfully contribute to them. Items of factor 3, tapped the tendency of drivers to perceive themselves as "impulsive" drivers (Cronbach's alpha = 0.544). Each factor has at least three high loadings with valid content, which supported the choice of three factors instead of four, as selected in the studies of Taubman-Ben-Ari (2008, 2010).

Table 14. Interpretation of the different factors. Driver Self-Image Inventory.

Factor 1 "Confident driver"		Factor 2 " Courteous driver"		Factor 3 "Impulsive driver"	
Item	**Loading**	**Item**	**Loading**	**Item**	**Loading**
Confident	0.785	patient	0.735	fast	0.685
Experienced	0.632	polite	0.679	risk-taking	0.450
Decisive	0.605	calm	0.561	rash	0.431
clear-thinking	0.653	responsible	0.575	considerate	0.422
Nervous	-0.729				

The factor score covariance matrix, given in Table 15, confirms that the covariance values within the factors were sufficiently low so as not to consider correlations among the latent factors, and therefore not to implement oblique rotation techniques.

Table 15. Factor Score Covariance Matrix.

Factor	1	2	3
1	0.835	0.092	0.064
2	0.092	0.777	-0.017
3	0.064	0-.017	0.722

Extraction of factor scores

Scores were computed by averaging the items loading high on each factor, with higher scores reflecting a higher endorsement of each self-image.

Beyond the interpretation of the inventories items through comprehensive factors, factor analysis aims in the extractions of factor scores at the individual level. The Factor Score Coefficient Matrix (Table 16) has been calculated through Regression, which has been preferred to other choices of SPSS, being Barlett's and Anderson-Rubin's methods. As mentioned in the Chapter 3, Regression has been selected instead of the other two methods, since the latter did not have significant advantages over the former.

Table 16. Factor Score Coefficient Matrix. Driver Self-Image Inventory.

	Factor		
	Confident Driver	Courteous Driver	Impulsive Driver
Experienced	0.184	-0.135	0.184
Nervous	-0.266	0.153	0.127
Responsible	0.054	0.225	0.037
Fast	-0.040	0.034	0.365
Considerate	-0.017	0.070	0.174
Rash	-0.118	-0.050	0.263
dear-thinking	0.138	0.049	0.027
Confident	0.310	-0.102	-0.038
Polite	-0.132	0.315	0.100
law-abiding	-0.027	0.069	0.015
Calm	0.131	0.191	-0.111
Patient	-0.091	0.348	-0.137
Decisive	0.131	0.024	0.164
risk taking	-0.038	0.005	0.160

The Factor Score Coefficient Matrix defines the impact of each item to each factor. Having determined the latter, factor scores have been calculated in EXCEL for each respondent with the multiplication of two matrices. Specifically, the data matrix, including the responses of the participants to each variable, is multiplied with the Factor Score Coefficient Matrix. The resulting matrix has 88 rows and 3 columns, which equal the number of drivers and their reflection on the 3 factors. The individual factor scores represent the perception the drivers have about their driver self-image. Taking into account that the items are scaled from 1 (not at all) to 6 (very much), the values represent the extent to which a driver perceives themselves as confident, courteous and impulsive while driving (Appendix IV).

4.3.2. Driver Stress Inventory

The Driver Stress Inventory (DSI) consists of 28 items. The extraction of individual factor scores for this inventory has been more direct and less time-consuming compared to the Driver Self-Image Inventory, since the extracted factors almost absolutely matched the factors of the original analysis.

Reliability analysis

Initially, the reliability analysis resulted in a Cronbach's alpha value of 0.815, showing that there was more than sufficient consistency in the answers. Despite that, the extraction of 5 items would lead to a higher value, thus to improving the consistency. Table 17 presents the results of the first reliability analysis, which included all the inventory's items, highlighting the ones that have been finally removed, resulting in a Cronbach's alpha value of 0.838.

Table 17. Cronbach's alpha results for the Driver Stress Inventory.

Item	Cronbach's alpha if item deleted	Item	Cronbach's alpha if item deleted
Badweath	0.811	DifStretch	0.807
Breakdown	0.804	TenseUR	0.800
CornHspeed	0.813	AlertEff	0.810
WorryMist	0.801	RapAccel	0.805
RaceRisk	0.813	ConceMis	0.798
Rentcar	0.807	ParkCar	0.813
Frighten	0.805	AnxiPass	0.805
FastThril	0.802	HazaHard	0.808
SideChec	0.810	OTakeNer	0.805
WorthRis	0.813	**AheadRoa**	**0.817**
AdvPasse	0.812	**VehPass**	**0.826**
Adrenali	0.804	**NoSpeed**	**0.818**
HeavTraff	0.803	**AccAvoid**	**0.819**
HazaEffo	0.810	**ExTrRisk**	**0.820**

Factor analysis

The factor analysis for the DSI consisted of the same steps with the respective analysis for the Driver Self-Image Inventory. After the exclusion of the 5 aforementioned items in the reliability analysis, the KMO test demonstrated values higher than 0.5 for all the items, confirming that factor analysis is the appropriate method to use. An oblique rotation has been selected as the first way of analysis, intending to identify potential correlations among the extracted factors. Considering that no correlations were found when extracting 2, 3 or 4 factors and that in the original inventory the 28 items resulted in 3 uncorrelated factors, Varimax rotation was preferred. Later, both the Scree plot (Figure 13) and the Ricolfi calculations indicated that the 3-factor solution had the best compromise measure among the available solutions (Table 18).

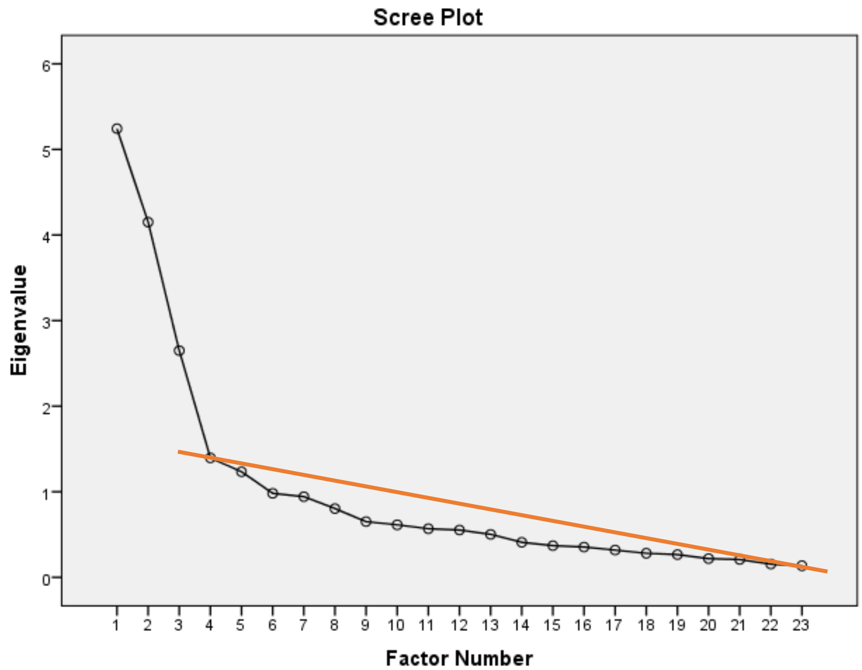


Figure 13. Scree plot for the Driver Stress Inventory (N=23).

Table 18. Compromise measure results for the Driver Stress Inventory.

Observed Variables (M)	# Factors (F)	Efficiency e	Adaptation a	Compromise Measure	Excluded items
23	4	0.676	0.684	0.462	VehPass, ExtrRisk, AccAvoid, AdvPass, NoSpeed
23	**3**	**0.753**	**0.632**	**0.476**	
23	2	0.833	0.379	0.316	

Table 19 provides the interpretation of the chosen number of factors. The first factor, consisting of 8 items of statements describing a driver who dislikes driving, is called "Dislike of Driving" (Cronbach's alpha=0.861), explaining 18% of the variance. It can be seen that the two last items included in this factor do not actually relate to its content and could be part of the other third and second factor. However, given the high loadings on the first factor, they have been considered to be part of it in contrast with the original results of the inventory. The second factor, explaining 15% of the variance, refers to causes of drivers' stress that are related to hazard monitoring. Therefore, it is named after the respective factor in the original inventory, being "Hazard Monitoring" (Cronbach's alpha=0.838). Items of factor 3 describe the drivers' stress caused by the drivers' tendency to seek for adventure while driving. Accordingly, the third factor is called "Thrill-seeking". Following the procedure employed for the Driver Self-Image Inventory, only items with loadings higher than 0.4 have been considered in each factor.

Finally, the Factor Score Coefficient Matrix, generated through Regression, has been multiplied with the Data Matrix in order to derive the individual factor scores. These scores explain in a quantitative way the levels of driver stress that are caused by each factor. In view of the scaling of the items (0-10), the higher the values of the Individual Factor Score matrix under a certain factor, the more this factor contributes in the creation of driving related stress. Hence, one or more stressors will be highly associated to each respondent, meaning that the driver is mostly affected by the factor with the highest value. The individual factor scores will be further used to investigate the impact of different types of driver stress on the drivers' attitude towards the BSD and ACC systems.

The tables with the results of each step can be found in Appendix IV.

Table 19. Interpretation of the different factors. Driver Stress Inventory.

Factor 1 "Dislike of driving"

Item	Loading
1. Does it worry you to drive in bad weather?	0.679
2. I am disturbed by thoughts of having an accident or the car breaking down	0.728
5. I find myself worrying about my mistakes and the things I do badly when driving	0.682
7. My driving would be worse than usual in an unfamiliar rental car	0.540
22. When driving on an unfamiliar road do you become more tense than usual?	0.745
27. I feel more anxious than usual when I have a passenger in the car	0.485
33. When you pass another vehicle do you feel tense or nervous?	0.695
37. Do you feel more anxious than usual when driving in heavy traffic?	0.609
8. I sometimes like to frighten myself a little while driving	*0.507*
25. If I make a minor mistake when driving, I feel it's something I should be concerned about	*0.470*

Factor 2 " Hazard Monitoring"

Item	Loading
10. I make a point of carefully checking every side road I pass for emerging vehicles	0.529
18. Do you usually make an effort to look for potential hazards when driving?	0.776
23. I make a special effort to be alert even on roads I know well	0.624
26. I always keep an eye on parked cars in case somebody gets out of them, or there are pedestrians behind them	0.671
29. I make an effort to see what's happening on the road a long way ahead of me	0.811
30. I try very hard to look out for hazards even when it's not strictly necessary	0.634
36. When I come to negotiate a difficult stretch of road, I am on the alert	0.557

Factor 3 "Thrill-seeking"

Item	Loading
6. I would like to risk my life as a racing driver	0.441
9. I get a real thrill out of driving fast	0.693
12. Do you think it is worthwhile taking risks on the road?	0.470
15. I like to raise my adrenaline levels while driving	0.566
24. I enjoy the sensation of accelerating rapidly	0.696
38. I enjoy cornering at high speed	0.793

4.4. ADAS related analysis

The participants have been asked to express their view regarding the usefulness, the ease of use as well as the training and testing of the systems by rating several relevant items from 1 (strongly disagree) to 5 (strongly agree). As seen in the questionnaire, this last set of questions is structured in such a way that each group of questions (items) can be considered as a set of items related to one factor. Following this, factor analysis was conducted on the parts of the questionnaire related to the usefulness, ease of use and training and testing of the systems – each represent a single factor. The results were compared to a more simple method of averaging the items related to each group, assuming equal loadings.

First, the analysis of the three groups of questions related to the usefulness, ease of use and the introduction of each system to driver's training and testing, assuming equal loadings of the sub-questions on the factor. Hence, averaging the answers of the sub-questions of each question would introduce the Individual Factor Score matrix for each factor for each system.

If the abovementioned assumption is rejected and the items do not load equally to the factor, a standard process is needed in order to derive the correct loadings. Although the factors are clearly formed as given in the questionnaire, factor analysis needs to be carried out for each group separately. In this way, the already described process of individual factor scores production is repeated. The only difference from the factor analysis conducted previously is that in this case one factor is extracted for each group of items representing usefulness, ease of use, and training and testing of the systems.

Both aforementioned methods were taken into consideration and based on the results, one of them was chosen. First, the generation of the individual scores was realized by calculating the average value of the given answers, which ranged from 1 (strongly disagree) to 5 (strongly agree). In a next stage, the result has been achieved with factor analysis. The two methods have been compared in terms of the content of the resulting matrix and the importance of the differences found. Although there were no huge differences in the result, the differences were identified in those cases where the respondent's score had an average value of 3 (neither agree nor disagree) in one of the methods, and a different score, 2 or 4 (disagree or agree), in the other one. Since the aim of the research is to obtain the drivers' beliefs towards the two ADAS in the clearest possible way, such deviations have to be avoided. In addition, compared to the averaging method, regression as a step of factor analysis assigns weights to the question's different sub-scales by taking the loadings on each factor into account. As a result, factor analysis has been selected for the individual factor score matrix.

4.4.1. Blind Spot Detection System

The driver's perceived usefulness of the BSD system, the expected ease of use of it as well as the opinion of the drivers on the introduction of the system in the training and testing have been expressed in the form of 3 main questions with a few items in each question. The final result, meaning the extraction of a single value that expresses the participants' view on these three topics, has been conducted with factor analysis as described in the following sections.

Reliability Analysis

A separate reliability analysis was run for each of the questions. In all cases, Cronbach's alpha value was relatively high (Table 20), meaning that there is high internal consistency in the answers of the respondents. With regard to the deletion of items, none of the items would lead to a higher reliability coefficient. So, all items took part in the next steps.

Table 20. Reliability analysis for the BSD factors.

	Cronbach's alpha
Factor 1 "Perceived Usefulness"	0.873
Factor 2 "Expected Ease of Use"	0.855
Factor 3 "Training and Testing"	0.669

Factor Analysis

The factor analysis for this part of the questionnaire displays small differences from the analysis described in the previous paragraphs, since the aim was not the identification of number of factors but the creation of the final individual score matrix. Firstly, no rotation has been used in the interpretation of the factor loadings, since only one factor was extracted in each case. Secondly, there was no need in the application of the threshold of keeping the items with above 0.4 loadings, since all items loaded significantly higher than this threshold on the factors. The importance and contribution of each sub-question to the respective topic is illustrated quantitatively through loadings in Table 21.

It has to be noted that before conducting factor analysis, the items have been assessed for their sampling adequacy by using the KMO test, which yielded a sufficient value both in case of the whole factor and the items themselves.

Table 21. Interpretation of factors for the BSD system.

Factor 1 "Perceived Usefulness"	
Item	**Loading**
Perceived usefulness for traffic safety	0.825
Perceived usefulness for lane changing	0.855
Perceived usefulness for improvement of driving performance	0.673
Perceived usefulness for collision avoidance	0.806
Perceived usefulness for entering and leaving the highway	0.683
Factor 2 "Expected Ease of Use"	
Item	**Loading**
Interaction with the system is expected to be clear	0.754
System is expected easy to use	0.895
Driver is expected to become skilful in understanding and using the system	0.810
Factor 3 "Training and Testing"	
Item	**Loading**
Importance of knowing the system before using it	0.471
Importance of introducing the system in the theoretical part of training	0.578
Importance of introducing the system in the drivers' test	0.822
Importance of using a video as a teaching tool	0.455

Factor 1 "Perceived Usefulness" explained 60% of the variance, while factor 2 "Expected Ease of Use" and factor 3 "Training and Testing" explained 68% and 36% of the variance respectively. As far as "Training and

Testing" is concerned, it is seen the item that loads highest on the factor is related to the introduction of the BSD system into testing. This is supposed to be of significant importance, since the second and third item of this factor are the actual focus of the present work. The loadings prove that these items highly contribute in the relevant factor. Hence, it can be stated that conclusions drawn regarding training and testing will be highly reliable. In contrast, the first and fourth item of this factor have lower loadings, which are, however, still higher than the 0.4 threshold.

4.4.2. Adaptive Cruise Control system

As in the BSD system, 3 questions with almost similar content have been used to reflect on the driver's perceived usefulness of the ACC system, the expected ease of use as well as the opinion of the drivers on the introduction of the system in the training and testing. The differences are found in the first set of questions and they are a result of the different functions and applications of the two systems. The next paragraphs depict the main results of the Reliability and Factor Analysis. More details can be found in Appendix IV.

Reliability Analysis

The results of the reliability analysis showed that the Cronbach's alpha value was relatively high (Table 22), so internal consistency in the respondents' answers is ensured. As a consequence, the deletion of items has not been considered and a second evaluation of the items would follow using the KMO test.

Table 22. Reliability analysis for the ACC factors.

	Cronbach's alpha
Factor 1 "Perceived Usefulness"	0.814
Factor 2 "Expected Ease of Use"	0.805
Factor 3 "Training and Testing"	0.708

It is seen that the Cronbach's alpha values are similar among the two systems. In both cases, "Perceived Usefulness" is found to have the highest consistency, followed by the "Expected Ease of Use" and the "Training and Testing". Internal consistency measures whether several items supposed to measure the same general construct produce similar scores. Hence, the fact that the factors, which consist of similar items, present the same values of reliability is considered to be normal.

Factor Analysis

Looking at the factor loadings for the ACC system, one could reckon that the answers on the two systems follow the same pattern. Factor 1 explained 53% of the variance, whereas factor 2 and factor 3 explained 59% and 41% of the variance respectively. Moreover, the loadings for factor 2 are the highest, followed by the loadings on factor 1 and factor 3.

As far as "Training and Testing" is concerned, a difference is found when comparing the answers of the BSD system. Specifically, in case of the ACC system, the introduction of it in the theoretical part of the training is considered more important than the introduction of it in the drivers' test (Table 23). The rest of the training and testing related items also present differences between the two systems. Although the use of a video as a teaching tool contributed the least to the 3rd factor in case of the BSD, for ACC the corresponding item ranks second in the factor loadings. The reasons for that could possibly be related with the type and range of applications of the systems as well as the type of video that was shown as part of the questionnaire. Since this raises some interest, it is further investigated through the responses to the relevant open-ended questions in a next section.

Table 23. Interpretation of factors for the ACC system.

Factor 1 "Perceived Usefulness"

Item	Loading
Perceived usefulness for traffic safety	0.724
Perceived usefulness for efficiently adjusting to the traffic situations	0.716
Perceived usefulness for improvement of driving performance	0.608
Perceived usefulness for collision avoidance	0.622
Factor 2 "Expected Ease of Use"	
Item	**Loading**
Interaction with the system is expected to be clear	0.785
System is expected easy to use	0.781
Driver is expected to become skilful in understanding and using the system	0.737
Factor 3 "Training and Testing"	
Item	**Loading**
Importance of knowing the system before using it	0.400
Importance of introducing the system in the theoretical part of training	0.854
Importance of introducing the system in the drivers' test	0.608
Importance of using a video as a teaching tool	0.622

4.4.3. Knowledge and Understanding of the systems

The knowledge of an object or a situation is assumed to play an important role in the attitude one adopts towards it. Taking this assumption into account, participants were asked 3 questions before being given the rest of the ADAS related questions. First, drivers were asked to rate their familiarity with the systems, by indicating their answers to 1 question on a Likert scale item (1=not at all, 5=extremely). Afterwards, they were asked to answer two open-ended questions about the systems' functions and the situations the systems are applied to. The repetition of the same open-ended questions after the introduction of the video in the questionnaire aimed to gather information for assessing their level of understanding of the system as well as the quality of the video in terms of transferring information.

The results of this analysis, which includes answering two sub-questions: (1) To which extent do learner drivers know about the systems and their operation? and (2) To which extent do learner drivers understand how the systems operate?, will assist in answering the research question "What is the need of the introduction of a BSD and ACC systems in driving training and testing from learner drivers' perspective?".

Familiarity – Likert Scale Item

With regard to the knowledge of the system, according to the responses, more than 50% of the learner and around 45% of the experienced drivers were totally unaware of the BSD (Figure 14 and Figure 15, left), while only about 20% of all participants reckoned that they were moderately familiar with it. In contrast, the proportion of respondents being unfamiliar, somewhat familiar and moderately familiar was more or less equally distributed among the ACC responses in both groups of respondents (Figure 14 and Figure 15, right).

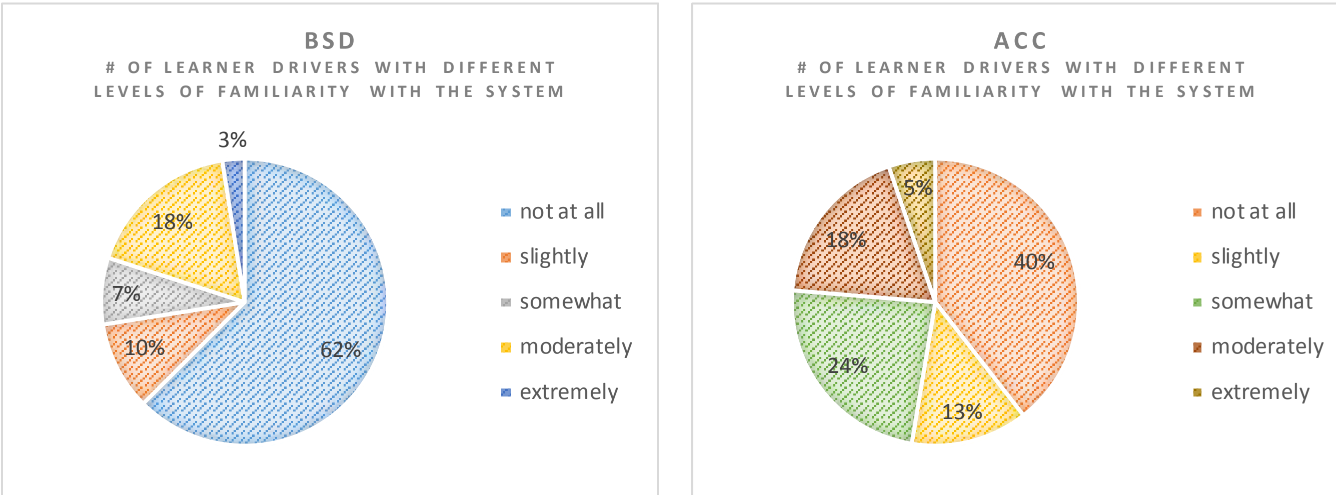


Figure 14. Familiarity of the learner drivers with the system. Left: BSD. Right: ACC.

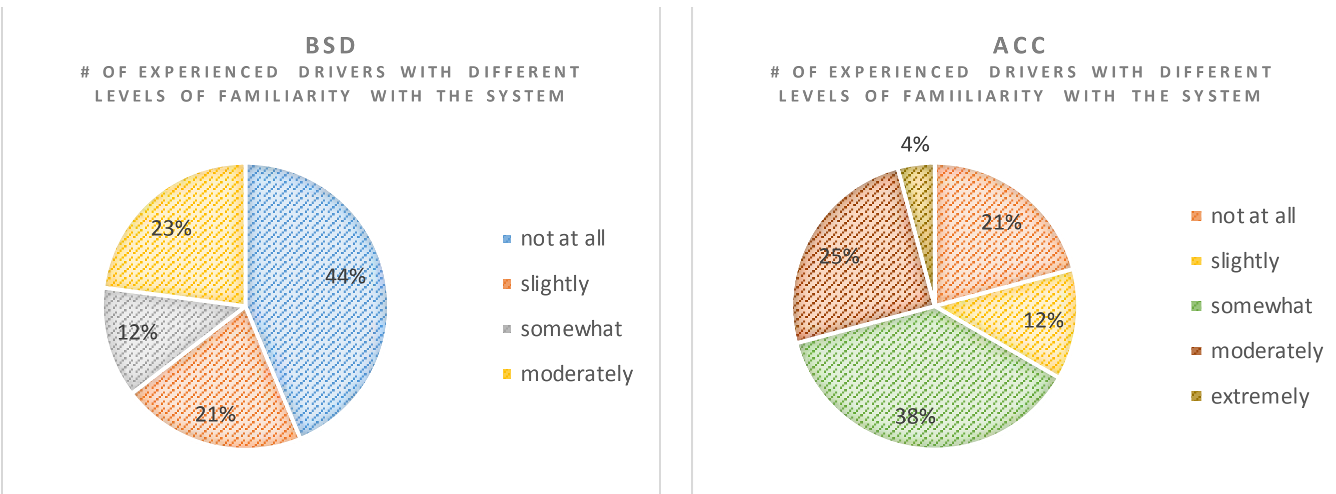


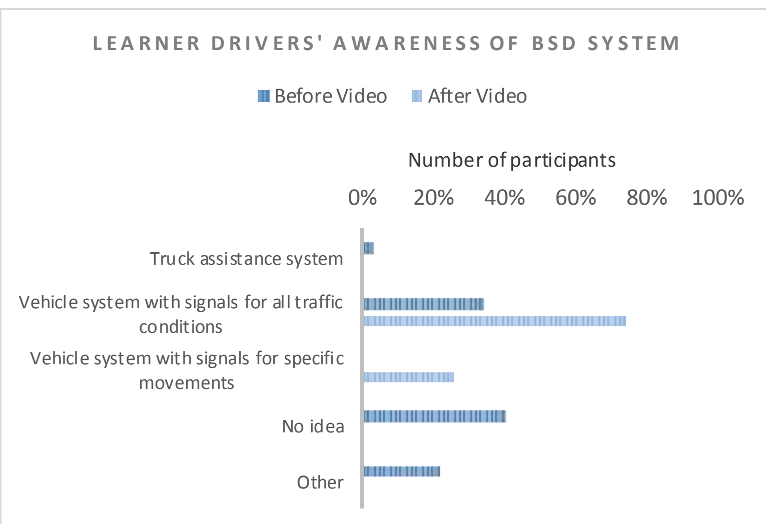
Figure 15. Familiarity of the experienced drivers with the system. Left: BSD. Right: ACC.

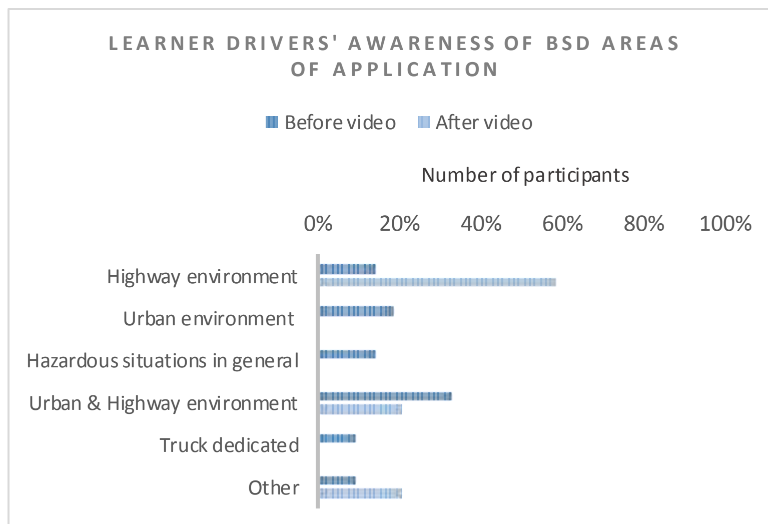
Familiarity – Open-Ended Questions

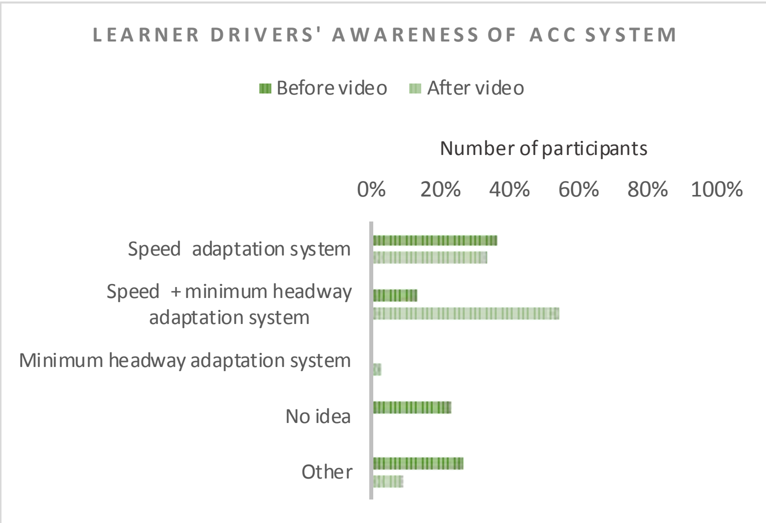
However, the analysis of the open-ended questions led to different results. When being asked about the BSD system's function, 45% of the learner drivers gave a well-aimed answer, while only 23% of them gave a wrong response. The rest of them (32%) claimed that they had no idea on the topic. Approximately 70% of the experienced drivers were sufficiently familiar with the BSD system. The percentage of them, having a wrong perception of the system or no idea at all reached around 15%. In both groups (learner and experienced), participants explained correctly the system's function, but they seemed to be hesitant in declaring to be familiar with it. This is seen from the comparison of the answers between the Likert scale and the open-ended questions, which showed that people knew more about the system than they stated to know. Talking about the system's application, only 33% of the learner drivers really knew in which manoeuvres the BSD is needed, whereas the respective percentage exceeded 70% for the experienced drivers.

On the other hand, as far as the ACC system is concerned, the number of correct answers were by far less than the number of people who stated to be familiar with it. Specifically, the number of wrong answers on the function of ACC reached more than 50% for the learner drivers, which shows how wrong their perception of the system is, since the same percentage of people stated that they were acquainted with it. Having a thorough look at the answers, most of the learner drivers described the main functions of the standard cruise control system instead of the adaptive cruise control. The same applied for the situations the system is applied to. Nevertheless, opposite results were found in the experienced drivers', where 75% of them knew how the ACC operates. The percentage of experienced drivers, however, who actually knew the situations of the ACC applications hardly reached 33%, since most of them assumed that the system only works in highway traffic conditions.

Concerning the understanding of the systems, the video display improved the learner drivers' awareness of the BSD system (Figure 16), since the percentage of learner drivers who declared to be totally unaware was eliminated to 0%. Although the respondents' answers were not very specific, even after the demonstration of the video, around 30% of the learner drivers answered correctly on the way the system functions in certain driving manoeuvres. With regard to the situations the system is applied to, a shift has been noticed from the capability of the system to assist in both urban and highway roads to the use of it in highway environments only. Given the fact that the system is designed to provide signals for different situations in both types of roads, the cause of this shift can be detected in the situations the video emphasized on (high speed driving). The percentage of learner respondents whose knowledge about the ACC function was enhanced increased by more than 30%. Despite the fact that the video showed that the ACC can be used for a speed range of 0-200km/h in all road environments, the proportion of learner drivers who answered correctly raised by only 20% (8 out of 40 people). A relatively high percentage of the participants (40%) maintained their view that the ACC is only used in highways.







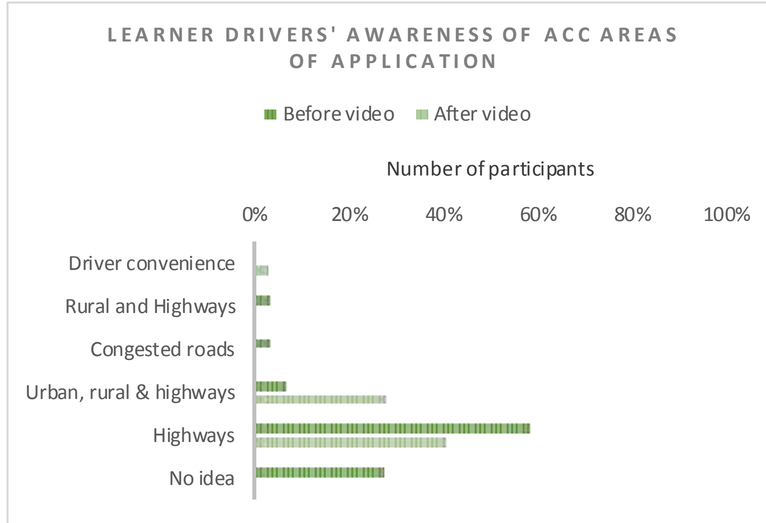
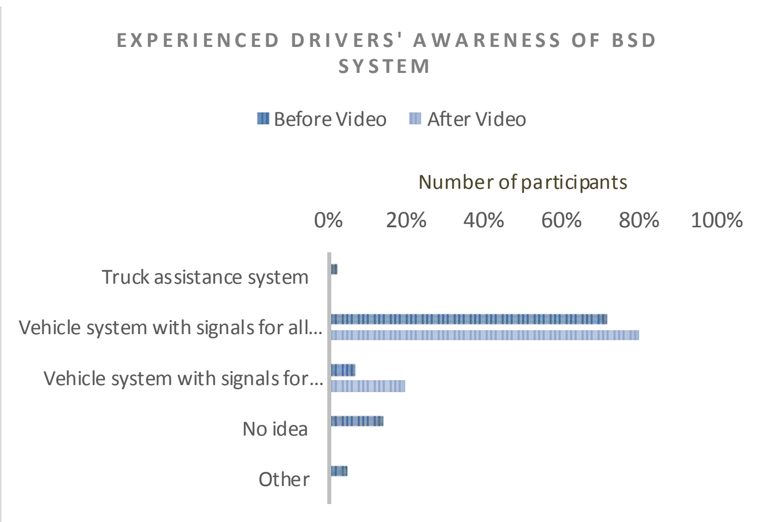
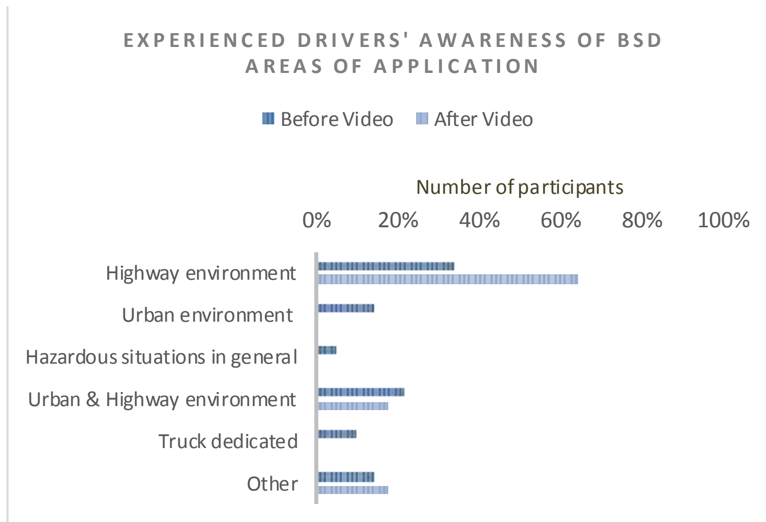
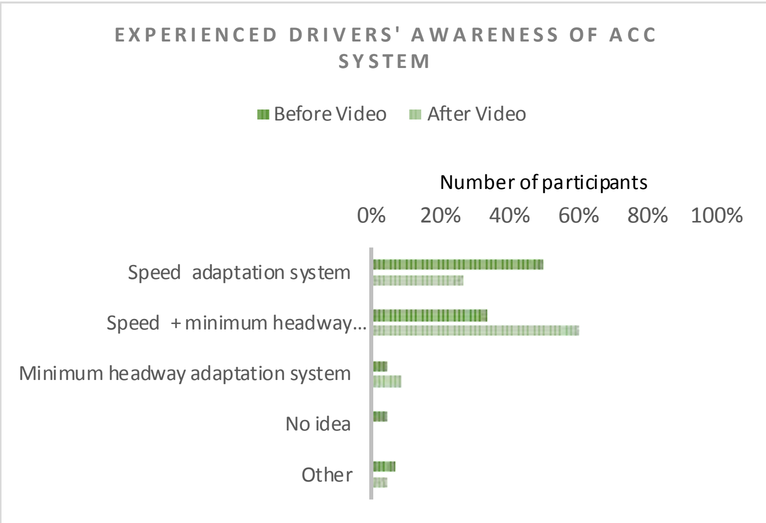


Figure 16. Learner drivers' understanding of the systems. A comparison of their awareness before and after the video.







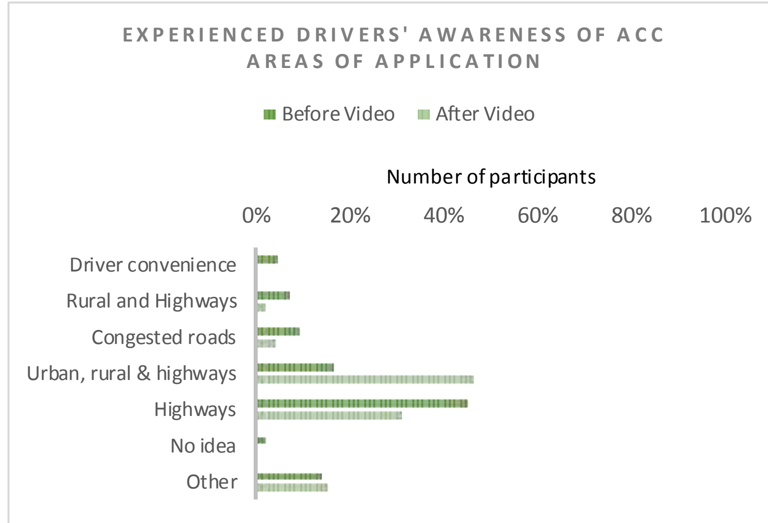


Figure 17. Experienced drivers' understanding of the systems. A comparison of their awareness before and after the video.

Experienced drivers awareness of the BSD system did not increase at the same level as the learner drivers, since the knowledge about its function and areas of application was already relatively higher compared to the learner drivers. Specifically, drivers' familiarity with the BSD system increased by approximately 10% and 20% in terms of function and areas of application. As far as the ACC system is concerned, the same pattern of answers is noticed among the learner and the experienced drivers. A rise of around 30% was noted in the familiarity of the experienced drivers with the ACC, together with a proportionate improvement of this group's knowledge on the situations where the system can be used. Although urban and rural use of the system is explained in the video, the experienced drivers' belief that highway traffic conditions are the only cases where the system can be used, remained rather high (40%). This can be partly explained by the fact that part of the respondents have been using Cruise Control or its adaptive version under these conditions, thus the impact of the video was smaller compared to their own experience.

Comparisons between the two groups of drivers regarding the systems' knowledge and understanding are made later in this chapter, in order to draw conclusions on the effect of driving experience on these two elements.

4.4.4. Usefulness and Willingness to use

Another vital aspect regarding the BSD and ACC systems is the drivers' perceived usefulness and their willingness to use them. Firstly, participants were asked to rate how useful they believe the systems would be in a number of different driving tasks and traffic safety related aspects. Secondly, they were asked to reflect on their willingness to use the systems in different traffic situations and driving environments.

The results of this analysis will assist in answering two different research questions: (1) "What is the need of the introduction of a BSD and ACC systems in driving training and testing from learner drivers' perspective?" and (2) "To which extent are learner drivers willing to use the systems?" by responding to the question "In which traffic and road conditions are the drivers most willing to use the system?".

What is the perception of usefulness of the systems in different driving situations (hazards, overtaking, etc.)?

Concerning usefulness, for the BSD system drivers were asked to state in their opinion how useful the system would be in improving their driving performance and their safety. Moreover, they were requested to think about the usefulness of it in assisting them when changing lanes, in collision avoidance and in entering/exiting a highway. In the ACC related questions, lane changing and entering/exiting a highway items were changed into items related with the system's assistance in adjusting to different traffic situations by maintaining a safe distance headway.

A Friedman test (Conover, 1998) has been employed in order to assess the fluctuations of the drivers' considerations about usefulness of both systems depending on the driving tasks and safety issues. The test has been conducted separately for each group of drivers, aiming to identify any significant differences in the perceived usefulness subject to the factors mentioned above. Before the test, the null hypothesis and the alternative hypothesis were formulated.

H_0: The perceived usefulness of the drivers about the system is the same for all driving tasks and safety aspects.

H_α: The perceived usefulness of the drivers about the system is different for at least one driving task or traffic safety aspect.

For the learner drivers, the results of the Friedman test showed a statistically significant difference in perceived usefulness of the BSD system depending on which type of driving tasks and safety aspects were given to the participants, $\chi^2=46.563$, $p<0.0001$. The same applies for the ACC system ($\chi^2=39.081$, $p<0.0001$). However, Friedman test is an omnibus test, giving the overall difference in case it exists. It does not indicate which measures differ significantly from each other. Hence, post-hoc tests had to be utilised in order to recognise in which cases significant differences exist.

Table 24. Statistically significant results in learner drivers perceived usefulness of the BSD system.

Improving driving performance	Collision avoidance	Overtaking	Merging in highway	Driving Safety
Z	-0.4196	-0.421	-2.882	-4.311
Asymp. Sign. (2-tailed)	<0.0001	<0.0001	0.004	<0.0001

Post hoc analysis with Wilcoxon signed-rank tests has been conducted with a Bonferroni correction. An adjustment was necessary because multiple (10) comparisons have taken place, increasing the chance of declaring a result significant although it is not (Type I error). To avoid such an error, the level of significance (p-value) has been divided with the number of comparisons. After the application of the Bonferroni correction, the new significance level was set at $p<0.005$. Table 24 shows the comparisons where the statistical significance is found. It is seen that the "perceived usefulness of the BSD system in improving the driving performance of the drivers" is apparent in all statistically significant pairs, meaning that this element is probably the common denominator for the existence of significant differences in the usefulness of the BSD system. Given the respondents' answers in the Likert scale questions, the system is expected to contribute in driving performance in a considerably lower extent compared to other driving situations or safety aspects. For the rest 6 compared pairs (e.g. Driving Safety-Collision avoidance, Driving Safety-Overtaking, Collision avoidance-Merging in highway), there were no significant differences in the perceived usefulness of the system.

Furthermore, the significant differences in perceived usefulness of the systems were investigated for the experienced group of drivers (Table 25).

Table 25. Statistically significant results in experienced drivers perceived usefulness of the BSD system.

Improving driving performance	Collision avoidance	Overtaking	Merging in highway	Driving Safety
Z	-4.442	-3.646	-3.010	-4.347
Asymp. Sign. (2-tailed)	<0.0001	<0.0001	0.003	<0.0001

A similar procedure was followed for the ACC system (significance level after the Bonferroni correction $p<0.008$) (Table 26).

Table 26. Statistically significant results in usefulness of the ACC system.

		D. Performance-Adjustment in traffic situations	D. Safety-Adjustment in traffic situations	D. Performance-Collision Avoidance
Learner drivers	**Z**	-3.269	-2.985	-
	Asymp. Sign. (2-tailed)	0.001	0.003	-
Experienced drivers	**Z**	-4.150	-	-2.909
	Asymp. Sign. (2-tailed)	<0.0001	-	0.004

The perceived usefulness of the BSD is found to differ in the same way for both learner and experienced drivers (Table 24 and Table 25). This is not the case for the ACC system (Table 26), where the learner drivers have a significantly different opinion about how useful the system is when the improvement of their traffic safety (less useful) was compared to their improvement in adjusting to the traffic situations (more useful). Important differences are also found when the enhancement of traffic safety (less useful) and the adjustment to the road conditions (more useful) are compared. The situation is quite altered for the experienced drivers, who believe that the ACC system's usefulness is lower in the improvement of driving performance than in the adjustment in traffic situations and in the assistance for collision avoidance.

To which extent are learner drivers willing to use the systems?

As far as the willingness to use the systems is concerned (Table 27 and Table 28), learner drivers have different levels of eagerness to use the BSD system in different road environments: more specifically, they are more eager to use the BSD system in highway and rural environments compared to urban environments. For the experienced drivers, the willingness to use the BSD system is higher in highway environments compared to congested traffic conditions and rural roads. No significant difference in the willingness of experienced drivers group to use the BSD was identified between urban and rural roads.

Table 27. Statistically significant differences in the willingness to use the BSD system.

		Urban-Highway	Urban-Rural	Highway-Rural	Highway-Congestion
Learner drivers	Z	-3.549	-3.394	-	
	Asymp. Sign. (2-tailed)	0.001	0.003	-	
Experienced drivers	Z	-3.167[d]	-	-4.092	-3.546
	Asymp. Sign. (2-tailed)	0.002	-	<0.0001	<0.0001

Concerning the ACC system, both groups of drivers proved to be significantly more willing to use the system while driving in highways than in urban, rural roads and congested environments. They were also more willing to use the ACC system in rural roads than urban roads. However, experienced drivers also claimed that they are not willing to use the system to the same extent in urban roads and congested situations. They are highly willing to use the ACC system in congested situations, while they are considerably less eager to do that in free flow urban conditions. Since congested situations most likely occur in urban roads, it can be assumed that a distinction is made by the experienced group between the two cases.

Table 28. Statistically significant differences in willingness to use the ACC system.

		Urban-Highway	Urban-Rural	Highway-Rural	Highway-Congestion	Urban-Congestion
Learner drivers	Z	-3.987	-3.385	-2.769	-3.003	-
	Asymp. Sign. (2-tailed)	<0.0001	0.001	0.006	0.003	-
Experienced drivers	Z	5.401	-4.550	-3.649	-4.104	-3.072
	Asymp. Sign. (2-tailed)	<0.0001	<0.0001	<0.0001	<0.0001	0.002

4.4.5. Training and testing in more depth

Besides aspects like the systems' awareness, understanding, perceived usefulness and willingness to use, one of the fundamental research questions is related to the introduction of the two systems in young drivers' driving education, meaning their driving training and testing. The same Likert scale question has been asked for both systems and comprised of 4 sub-questions (Likert scale items). The first sub-question asked the participants to rate how important they think the learning about the system before using it is. The question was not directly associated with the drivers' educational methods. Instead, it attempted to grasp the general attitude of people towards being acquainted with the system before starting using it. Afterwards, participants were directly asked to rate how important they consider the introduction of the systems in drivers' training (lessons) and testing (exam). In the end, the potential of utilizing a video, like the ones used for the questionnaire in this study, was examined. For all Likert scale items, respondents had to reflect by choosing an answer from 1 (strongly disagree) to 5 (strongly agree). After each sub-question an open-ended question asked the participants to provide an explanation for their answer.

The present sub-section illustrates the analysis of the questions regarding training and testing, being both Likert scale and open-ended questions. These results will be used to answer the research question *"What is the need of the introduction of a BSD and ACC systems in driving training and testing from learner drivers' perspective?"*.

A pattern of particular interest is seen in Figure 18, where the fluctuations of the answers of the two groups regarding the introduction of the BSD and ACC systems in educational procedures are shown. For both systems the same trend is followed by both groups of participants. Focusing on the big picture, a relatively large number of drivers consider having a general acquaintance with the systems necessary before the use of them. However, the percentage of drivers agreeing in the introduction of the systems in training is slightly and significantly reduced in the case of BSD and ACC respectively, followed by a more radical fall for the case of introduction of the systems in drivers' testing.

The use of a video as a learning tool seems to be moderately acceptable for the BSD system and more welcomed for the ACC system.

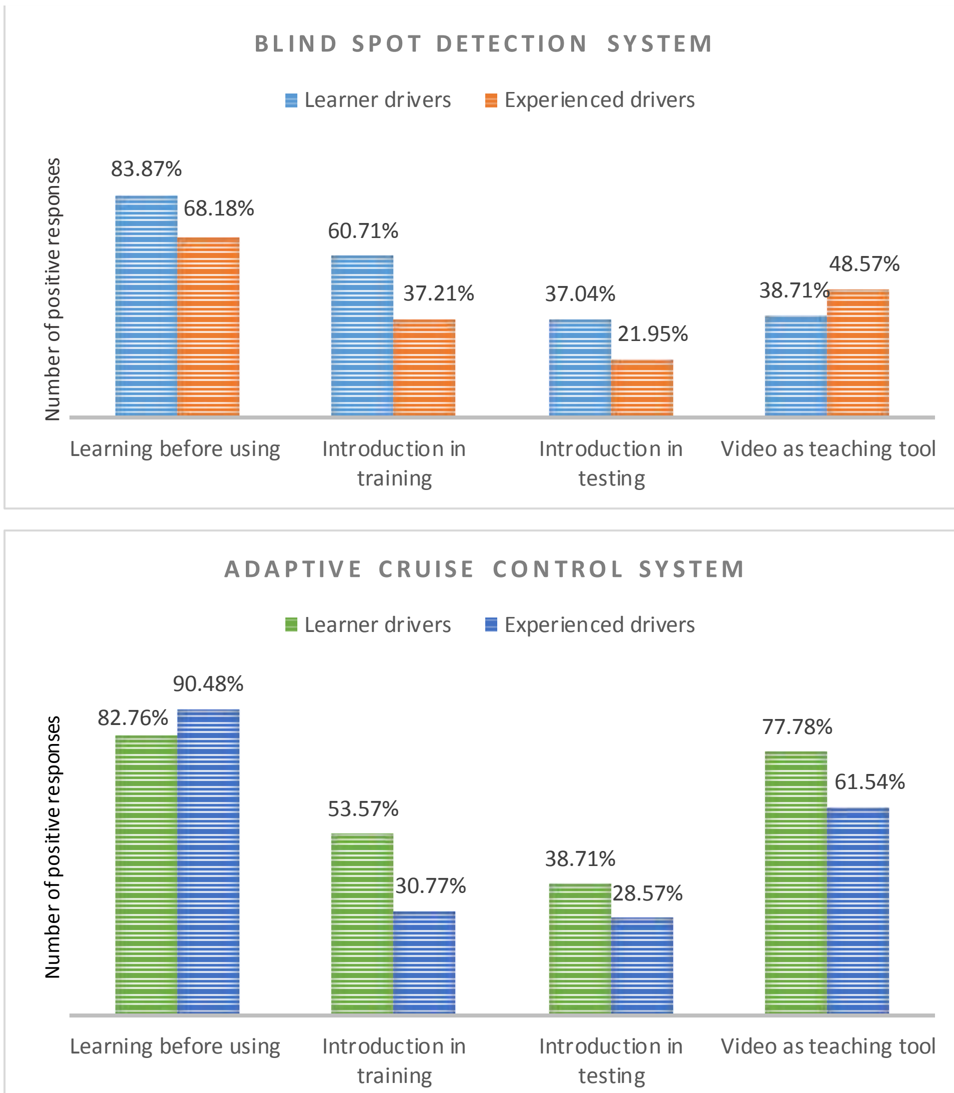


Figure 18. Trends in positive responses to the introduction of the systems in training and testing.

Elaborating more on each system, a general agreement (among the learner and experienced drivers) exists in becoming familiar with the BSD system before using it in real driving conditions. Nonetheless, the proportion of participants who agree in implementing real innovations in driving education is profoundly less (60% for the learner and 37% for the experienced drivers). When the questions about training and testing of the BSD system were introduced, most of the participants reckoned that the system is nothing more than a number of signals to the driver, thus no special training and testing is needed on that. Based on this explanation, more than 50% of the participants considered that the use of a video would be redundant as a training method, since the manual would be more than sufficient for a system like that. Another reason of the system's introduction disapproval was the increased chances of overreliance on it and the loss of self-awareness (20% for the learner and 35% for the experienced drivers). Approximately 10% of the answers were explained through the pretty low current availability and use of the system as well as doubt about the extent of its use in the coming future.

ACC related answers displayed the same trends in the examined set of questions. However, the complexity of the system raised the percentages of acceptance of the system in all the examined areas except for the introduction in training. This can be partly explained by the fact that this system is more popular than the BSD system. Although the positiveness of the experienced drivers remained lower than that of the learner drivers, a slight increase was noticed in the proportion of experienced respondents who positively perceived the introduction of the ACC system in training and testing compared to the respective introduction of BSD system. In the same questions, the responses of learner drivers remained at the same level with the BSD related ones. Finally, a considerable rise was recorded in the acceptance of the use of a video in drivers' education. According to all respondents' answers to the open-ended questions, the ACC system requires the drivers' involvement at a higher level compared to the BSD. Therefore, the more detailed the teaching tools are the better the understanding of the system and its complications.

To conclude, experienced drivers adopt a rather hesitant attitude towards the systems in terms of general knowledge, training and testing. It can be assumed that experience plays an important role in such point of view, since in most of the open-ended questions, experienced drivers emphasized on the importance of raising and practicing self-skills and the negative impacts of potential overreliance on the systems during driving. Responses like "*It is important to teach students to look for themselves, so they will be able to drive safely in every car. Using the BSD system during the lessons will only make the student lazy to look the old fashioned way*" or "*The driver's skills should be checked. The ACC system makes driving easier and safer, but the driver should be safe even without it*" have been used to reflect the opinion of these drivers towards the ADAS concept in drivers' education procedures. Despite the fact that learner drivers' answers followed the same pattern, their more positive attitude has been based on the fact that safety is reassured if inexperienced drivers are already familiar with the technological assistance available in cars. While agreeing with the experienced drivers on the importance of developing self-driving skills first, learner drivers claim that "…*I believe that the BSD system should be tested in an exam in order to make the drivers become more familiar with it and not make them get confused later on, in case no test was performed in advance*" and "*The ACC system will hopefully make for a safer drive and it could also improve the driving performance of the new or inexperienced driver*". To summarise, learner drivers prove to be more optimistic and willing to be trained and tested on the systems, compared to the experienced ones who generally believe that such changes in drivers' education will have more negative than positive effects on young drivers. To examine whether statistically significant differences occur between the two groups, MANOVA tests are conducted later in this chapter.

4.5. Correlation analysis

In the previous paragraph, the attitude of the participants towards the introduction of the two ADAS systems in training and testing has been analysed, without any reference to the differences in answers from different types of drivers (i.e. drivers' profiles).

Initial parts of the analysis included Factor analysis for the behavioural inventories. From these inventories, drivers' scores on the different factors in the self-image and driver stress scales were obtained. Using this information, an investigation of the impact of drivers' profile on their attitude towards the driver assistance systems is important.

The results of factor analysis (driver profiles) have been examined along with the answers of the participants regarding the ADAS introduction to drivers' education. Correlation analysis has been used in order to examine the relationship between drivers' profiles and drivers' attitude to ADAS, answering the sub-question *"What are the driving related characteristics of drivers from which each system is asked more?"*. Before that, correlation analysis has been carried out between the results of the two behavioural questionnaires, aiming not only to identify any potential relationships in the results but also to check if any indicated associations in the results make sense for a driver's profile. The following paragraphs describe the results of Pearson correlation conducted in SPSS software.

4.5.1. Associations between Driver Self-Images and Driver Stress

The analysis first examined the relationships between the various behavioural profiles of drivers: driver stress and driver self-image (Table 29 and Table 30). Concerning learner drivers (Table 29), Pearson correlations between the variables of the same inventory showed that there is a sensible meaning of the extracted factors, since self-images of confident and courteous drivers highly correlate with each other but not with the impulsive driver self-image. Among the two Driver Self-Image and the Driver Stress Inventory, Pearson correlations indicated that Dislike of Driving as a source of stress during driving is significantly and negatively correlated with the self-image of the confident driver. Hence, the more confident a driver is the less they are stressed due to their sense of disliking driving. Hazard Monitoring as a stressor was positively related to courteous drivers, while impulsive driver self-image was positively related with both Dislike of Driving and Thrill seeking as causes of stress. Thus, the more responsible and careful drivers perceived themselves, the more stressed they would feel from being hazard attentive. On the other hand, the more impulsive a driver, the more the impact of disliking driving and thrill seeking on their stress levels.

Table 29. Pearson correlation between different driver stressors and driver self-images. Learner drivers.

	Driver Self Image			Driver stress Inventory		
	Confident	Courteous	Impulsive	Dislike of Driving	Hazard Monitoring	Thrill seeking
Confident	1					
Courteous	**0.558****	1				
Impulsive	0.049	0.150	1			
Dislike of Driving	**-0.477****	0.020	**0.337***	1		
Hazard Monitoring	0.254	**0.384***	0.256	0.271	1	
Thrill seeking	0.240	-0.186	**0.454****	-0.074	-0.019	1

* Correlation is significant at the 0.01 level (2-tailed)
** Correlation is significant at the 0.05 level (2-tailed)

For experienced drivers, similarly with the learner drivers (see Table 30), Dislike of Driving is negatively correlated with the self-image of the confident driver. However, none of the stressors is significantly related to the self-image of courteous driver. Finally, experienced drivers who perceive themselves as impulsive are significantly stressed by Hazard Monitoring and Thrill seeking related actions. In contrast to the learner drivers, Dislike of Driving does not increase drivers' stress, regardless the drivers' self-image (confident, courteous, and impulsive). So, the level of experience seems to influence the causes of driver stress in relation to different drivers' types. For drivers with a certain level of experience, the more confident drivers are the less affected they are from dislike of driving. In the meantime, impulsive drivers are stressed from thrill seeking reasons as well as hazard detection efforts. The last correlation means that, although being impetuous, experience makes drivers more concerned about latent hazards, making them an important source of stress while driving.

Table 30. Pearson correlation between driver stressors and driver self-images. Experienced drivers.

	Driver Self Image			**Driver stress Inventory**		
	Confident	Courteous	Impulsive	Dislike of Driving	Hazard Monitoring	Thrill seeking
Confident	1					
Courteous	0.260	1				
Impulsive	0.060	-0.207	1			
Dislike of Driving	**-0.414****	-0.201	0.042	1		
Hazard Monitoring	0.182	0.185	**0.327***	-0.152	1	
Thrill seeking	0.113	-0.110	**0.491***	0.097	0.110	1

* Correlation is significant at the 0.01 level (2-tailed)
** Correlation is significant at the 0.05 level (2-tailed)

4.5.2. Associations between Driver Self-Images and ADAS related attitude

As already mentioned, the acquisition of information on the beliefs of learner and experienced drivers towards the ADAS introduction to training and testing is not sufficient to draw meaningful and reliable conclusions. The type of drivers having different opinions should be detected and matched to the respective points of view. This is examined through the use of Pearson correlation analysis.

Table 31. Pearson correlation between learner driver self-images and attitude towards ADAS in training and testing.

	Confident	**Courteous**	**Impulsive**
Positive attitude towards the introduction of BSD in training and testing.	-0.116	-0.242	-0.056
Positive attitude towards the introduction of ACC in training and testing.	**-0.318****	-0.252	0.035

* Correlation is significant at the 0.01 level (2-tailed)
** Correlation is significant at the 0.05 level (2-tailed)

Table 31 shows that learner drivers' opinion about the introduction of the BSD system is unaffected by the driver characteristics, since there is no significant correlation between the driver self-images and the view of the drivers on the inclusion of the BSD system in drivers' education. In comparison to the BSD, learner drivers ACC related attitude is affected by the self-image of the confident driver. Specifically, the self-image of a confident driver is negatively related to the attitude of the young drivers towards introducing the ACC system in their driving training and testing. Thus, the more confident the driver feels, the less they need such an innovation in the driver's education.

Table 32. Pearson correlation between experienced driver self-images and attitude towards ADAS in training and testing.

	Confident	Courteous	Impulsive
Positive attitude towards the introduction of BSD in training and testing.	-0.185	0.165	**-0.410****
Positive attitude towards the introduction of ACC in training and testing.	-0.059	**0.371****	**-0.316***

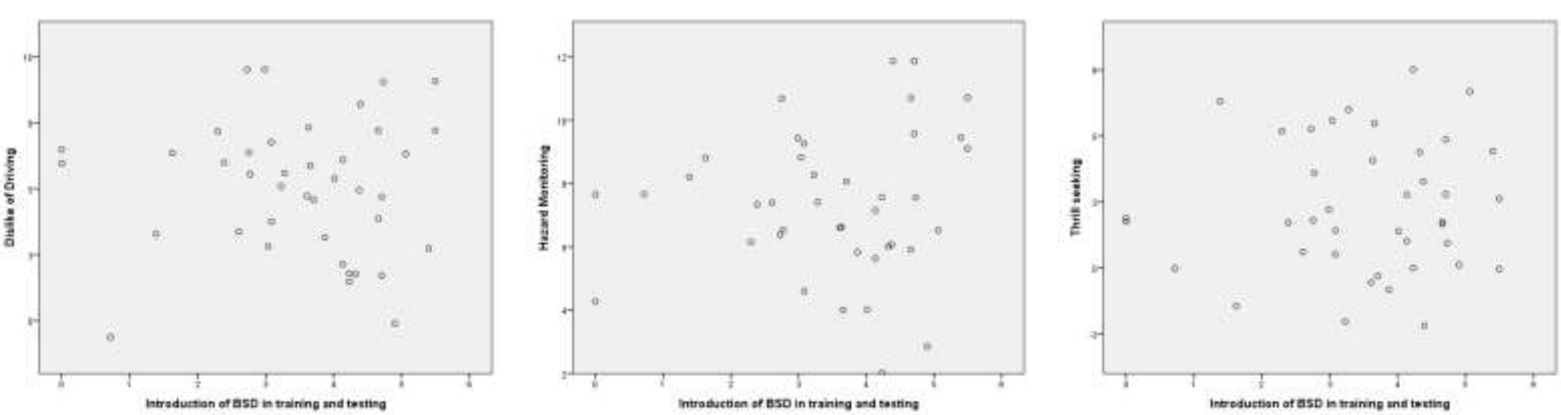
* Correlation is significant at the 0.01 level (2-tailed)
** Correlation is significant at the 0.05 level (2-tailed)

With regard to the experienced drivers (Table 32), the self-image of the impulsive driver is negatively correlated with the introduction of the BSD system to training and testing. Significant positive correlation is found between the self-image of courteous driver and the involvement of ACC in training and testing, which is significantly negatively correlated with the impulsive driver self-image. It can be stated that experienced drivers who perceive themselves as courteous, consider that being trained with the ACC system is important, while those with opposite driving behaviour (aberrant) maintain the same negative view for the establishment of both systems in young drivers' education.

4.5.3. Associations between Driver Stress and ADAS related attitude.

Figure 19 and Figure 20 illustrate the strength and the direction of the relationship between the three sources of drivers' stress and the view of the respondents on the introduction of the BSD and ACC system in drivers' training and testing. A strong relationship, either positive or negative, usually means that there is statistical significance between the two variables of the relationship.

As far as the perception of the learner drivers about the importance of including the two ADAS in training and testing is concerned, the scatterplots display rather weak relationships between the tested variables. Since there is large variability in the data, no line of best fit can be drawn and no pattern in the data points can be found, therefore, little or no correlation is found between the causes of driver stress and the opinion of the drivers about the understudy educational innovation.



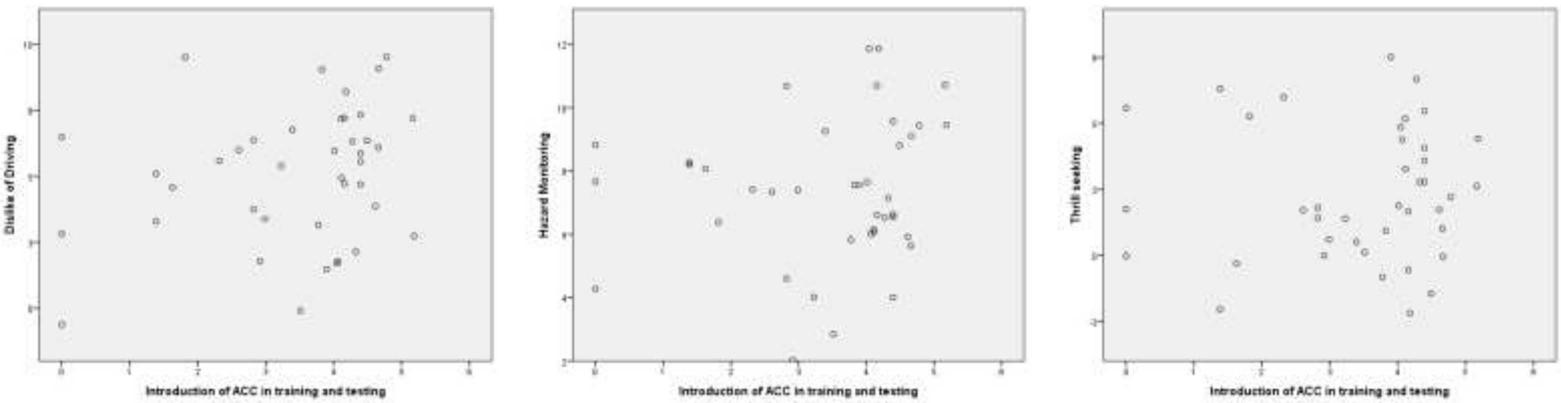


Figure 19. Scatterplots of the relationship between driver stressors and introduction of systems in training and testing. Top: BSD, Bottom: ACC. Learner drivers.

The same situation is found when the point of view of the experienced drivers is discussed. In other words, the data points are rather dispersed in all scatterplots, indicating the absence of a significant relationship between the stress sources and the drivers' reflection on the importance of establishing the two systems in training and testing. Nonetheless, a significantly negative relationship is found between Thrill seeking and the considerations of the experienced drivers regarding the systems' involvement in drivers' education. Therefore, the higher the tendency of the experienced drivers to search for thrill and adventure while driving, the lower the importance of being trained and tested for the BSD ($r=-0.420^{**}$, $p=0.003$) and the ACC ($r=-0.358^{*}$, $p=0.013$) system is.

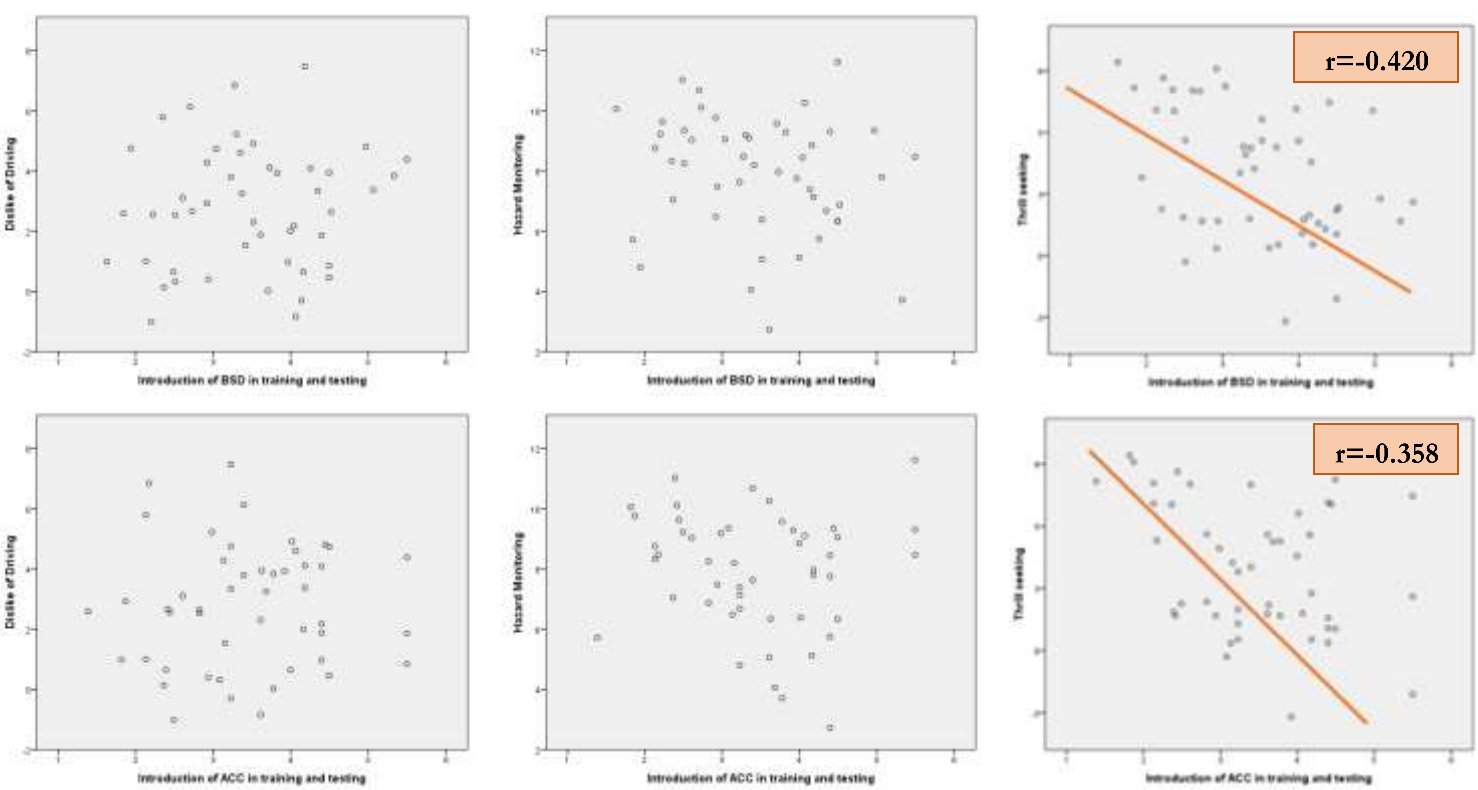


Figure 20. Scatterplots of the relationship between driver stressors and introduction of systems in training and testing. Top: BSD, Bottom: ACC. Experienced drivers.

Taking into account that the previous Pearson correlations yielded a significant positive relation between the self-image of the impulsive driver and the Thrill seeking cause of driver stress as well as the fact that the self-image of the impulsive driver negatively related with the introduction of the systems in case of the experienced drivers, it was quite anticipated that the Thrill seeking stressor would significantly relate with their view on this issue.

4.5.4. Differences between experienced and learner drivers

The answers given by the learner and experienced drivers in the questions analysed in the previous paragraphs have displayed differences between the groups in different areas regarding the two examined ADAS. The present section investigates if the existing differences are significant or not. The results aim to assist in making inferences on whether the level of experience plays a considerable role in forming a certain opinion on the use of ADAS or not.

What are the differences between learner and experienced drivers in terms of usefulness, ease of use as well as training and testing of the systems?

The sub-question "*Do drivers find the system easy to use?*" also finds an answer in this section.

As already discussed in the methodology of the data analysis in Chapter 3, the comparison of the attitude of the two examined groups of participants ($\mathrm{H}_0^f - \mathrm{H}_0^h$) has been achieved by conducting Multivariate Analysis of Variance (MANOVA). In all comparisons, the independent groups consisted of the group of the learner and the experienced drivers. Concerning the dependent variables, the perceived usefulness of the BSD and the ACC systems comprised the dependent variables of the first comparison, while in the second and third comparison the perceived ease of use and the perceived importance of the establishment of the two systems in the drivers' lessons and exams have been the dependent variables respectively.

To begin with the first comparison, no significant difference has been found between the different types of participants in terms of their perception of the usefulness of the BSD and ACC system. Therefore, the levels of experience did not determine how useful the participants perceive the systems. In addition, no significance was found in the perceived ease of use based on the level of experience of the drivers ($p=0.158>0.05$, Wilk's $\Lambda=0.958$, partial $\eta^2=0.042$). Finally, MANOVA yielded the same results for the third comparison, where the p value almost reached the value of 1.

The exact results of MANOVA are reported in Table 33. Descriptive statistics of the mean and standard deviation can be used to understand the reason why no significance is noticed, since the values of the means are very close to each other in all compared cases. Figure 21 is an example showing how close the means of the two groups of participants regarding the perceived usefulness of the BSD and ACC system are.

The answers of the participants ranged between 1 and 5, meaning *strongly disagree*, *disagree*, *neither agree or disagree*, *agree* and *strongly agree* respectively. Rounding the mean values of the learner and experienced drivers, it is seen that a general agreement in the perception of the BSD and ACC systems is reached between the two groups. Since the mean values' rounding results to the value of 4, it can be concluded that both types of drivers, regardless their experience, reckon that they agree that the systems would assist in improving traffic safety and driving performance as well as be useful in helping drivers in several driving tasks. Furthermore, both groups agree that the systems are expected to be easy in use, while the same applies for their view on the acceptance of the systems in drivers' educational stages. The level of agreement in the answers regarding training and testing is obvious even without rounding of the values, since the means are almost equal for both groups and both systems.

Table 33. MANOVA results for comparing the answers of learner and experienced drivers.

		Mean		Standard Deviation		Wilk's Λ	Significance
		Learner	Experienced	Learner	Experienced		
Perceived Usefulness	BSD	4.03	4.22	1.466	0.821	0.977	0.378
	ACC	3.62	3.98	1.446	0.937		
Perceived Ease of Use	BSD	3.98	4.39	1.233	0.923	0.958	0.158
	ACC	3.74	3.94	1.457	0.972		
Acceptance in Training & Testing	BSD	3.50	3.46	1.378	0.961	0.999	0.969
	ACC	3.42	3.44	1.392	0.976		

Finally, it is noticed that the standard deviation has been always bigger than 1 for the learner drivers and less than this value for the experienced ones, meaning that the proportion of learner drivers who have had different opinions on these topics was larger than the respective number of experienced participants.

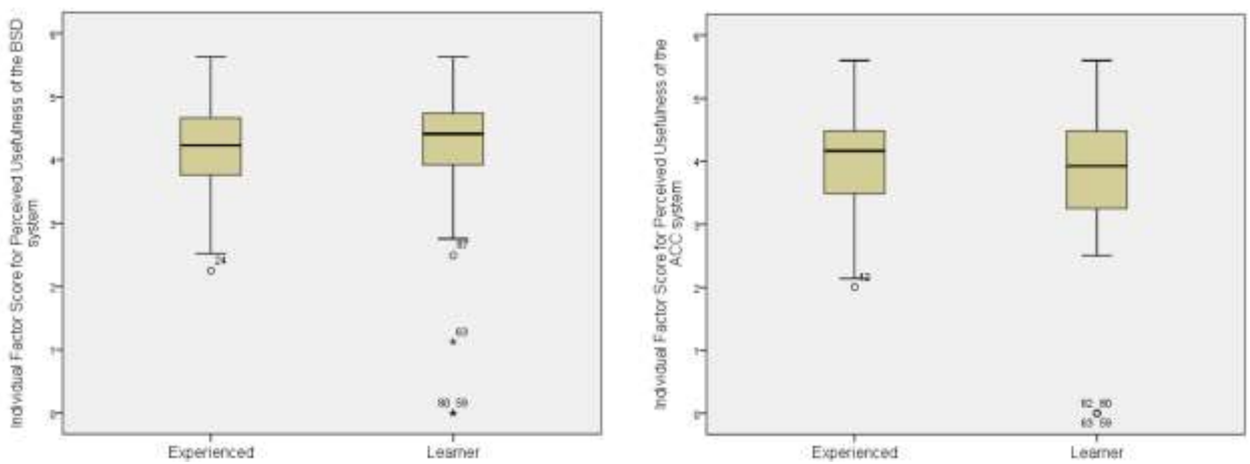


Figure 21. Box Plots of Mean and S.D. of Perceived Usefulness of the systems. Left: BSD, Right: ACC

4.6. Interviews

As already mentioned, the in-depth interviews as a data collection tool intended to get more insight on specific parts of the questionnaire that resulted in diverse answers of the participants.

According to statistics, at least 30 people are needed in order to achieve better accuracy of the standard deviation estimate. Therefore, at least 30 people with certain characteristics (driving experience, frequency of driving, etc.) were needed for each of the groups in order to fill in the questionnaires. After this recruitment, a smaller group of learner drivers would be collected for the in-depth interviews based on the diversity in their answers.

Aiming for higher reliability, the minimum number of participants per group was set to 60 people and several ways were employed for the recruitment of the participants, as described in Chapter 3. More than 80 experienced drivers were collected, whereas the number of learner drivers did not climb higher than 40, despite the intense recruitment attempts. Wanting to have a balance between the two groups, the number of experienced drivers was reduced to 48 after a filtering procedure. This procedure discarded from the analysis all experienced drivers who drive a car less than once per month and drivers who drive less than 1000 km per year. The rest of the responses were left unused.

After filtering the learner group of participants, 4 learner drivers (2 males and 2 females) between 24 and 27 years with different views on the two systems expressed their willingness to participate in this next stage of data collection. The interviews took place in 4 separate sessions, having an average duration of 40 minutes each. As described in Appendix III, the interview consisted of 4 parts. The first part included introductory questions, followed by the core section which was related with the ADAS systems and was split into the BSD and ACC part. Next, a few questions on both systems were asked. Finally, in the fourth section, the interviewees had the chance to add anything they thought was missing from the discussion.

4.6.1. 1st section: Introduction

In this section, the interviewed participants were asked to describe the driving tasks and traffic situations they consider difficult to achieve and they would like to have help in.

According to the interviewees' responses, their most common problem, in which they would like to have some assistance, is efficiently dealing with multitasking. Both in urban and highway environments, learner drivers are asked to carry out a variety of tasks at the same time. On the one hand, in urban environments multitasking difficulties are mostly raised in roundabouts and intersections, where the driver needs to be alert of the movements and direction of all types of traffic (cars, public transport, cyclists, and pedestrians). At the same time, the driver needs to steer the vehicle, be aware of the surrounding hazards as well as control the speed of the vehicle depending on the traffic conditions. Nevertheless, most of the driver's attention is usually given on one of the tasks, meaning that the rest of the tasks, major or minor, are overlooked. As a result, the probability of causing an accident are increased. On the other hand, multitasking in highway environments involves keeping a certain headway from the vehicle in front, driving according to the speed limits as well as monitoring of hazards.

4.6.2. 2nd section: BSD system

Using the aforementioned sayings as a basis, most of the interviewees mentioned that the BSD system would effectively help them in improving their safety in such complex situations. Given the fact that most of the driving tasks require looking the road ahead, the need of hazard monitoring in addition to these driving tasks increases the levels of mental workload. The fear of not being capable to fulfil these demands increases their stress levels and leads to loss of concentration, which itself results in underperforming during driving. Therefore, a system the drivers could rely on in terms of being alert about vehicles in the rear of the car and specifically in their blind spot, is expected to assist them in maintaining their safety both as learners and beginners. In the meantime, from another perspective, the BSD system would not really help learner drivers. As a master student at TU Delft stated "*An aid like that would have the adverse effect for people who tend to rely on these systems and do not learn how to manually drive in real road conditions*". Similar statements have been used as reasoning for opposing to the system by most of the learner and experienced drivers who negatively commented on the system in the questions that have been already presented in the questionnaire.

Asking about the advantages and the disadvantages of adding the BSD system in drivers' training and testing, the main benefit for the learner drivers is considered to be the variety of ways the system provides to keep the drivers alert (visual, audible and haptic). Being overloaded with several tasks at the same time, the learner driver needs more than one sign to stay alert regarding their blind spot, since the visual warning may be missed in case they forget to check their blind spot. Being "persistent" in the way of alerting drivers is the characteristic of the BSD system that is appreciated more for its introduction in the driving classes. Although the interviewees reached a general agreement on the system's strengths, there were various points of view concerning the system's introduction disadvantages. Firstly, the creation of overreliance on the system was the biggest disadvantage of adding the system in the drivers' education, since people should learn and practice how to improve their own driving skills. The existence of such a system would possibly make students dependent on it, reducing their need to practice their own skills. Secondly, limitations of the system as well as the chances of system failure during driving comprise the source of serious doubts about the extent to which a driver can trust the system, especially for beginners who do not easily realise how crucial it is to know how to react in such a situation. Finally, it was also mentioned that if the system provided only a visual signal on the side mirrors, it would not be an important addition to the driving classes.

Moreover, the interviewees were asked about the way they would like to be trained and tested on the system. With regard to the training, 3 out of 4 learner drivers (75%) reckoned that they would prefer to learn how to interact with the system during the practical part of their training, meaning their driving classes. According to these respondents, the system is rather straightforward and based on a visual concept, thus there is no need to have a whole section in theory devoted on that. Instead, a few information about the system and its limitations could be added to the already blind spot related part of theory. In addition, the use of a video like the one used for the questionnaire purposes seemed to increase the interest of the students, considering that all interviewees recommended the introduction of similar videos in the theoretical part of the training. Regarding the testing of the system, all interviewees stated that the BSD system is straightforward enough, so there is no necessity in practically testing it (on the road). Instead, it would be important that a few questions on the system would be added in the theoretical part of the test.

Finally, the interviewees were asked to claim what the most important aspect of the introduction of the system in training and testing in their opinion was. All interviewees agreed that the most significant aspect of the system's introduction to drivers' education and exams is its contribution to their safety both as learner drivers and after getting the driving licence. Last but not least, all of them emphasized on the importance of clarifying to learner drivers that the BSD system is only an auxiliary device, thus they need to train their own strengths and skills and avoid relying on the system.

4.6.3. 3rd section: ACC system

The same set of questions was used for the ACC system part of the interview. Regarding the usefulness of the ACC system in the driving tasks the participants needed maximum assistance in, the interviewees stated that the ACC system seems to be very effective when driving on both the highway and urban areas. Having to deal with several driving tasks, the presence of the system provides the inexperienced drivers with confidence and reduces the anxiety caused from their fear of not reacting in time to the demands of the traffic conditions. Specifically, two of the interview participants mentioned that they think the system is very useful in maintaining the distance from the vehicle in front when they have their mind lane changing and their blind spot. In addition, another respondent mentioned that the ACC would help her in slowing down in stop and go traffic. In this case, she would have more time is evaluating the surrounding traffic conditions and make decisions faster than without having the system.

Concerning the advantages and disadvantages of adding the ACC system in training and testing, most of the interviewees focused on the fact that the system would mostly benefit the traffic flow and the rest of the drivers than the beginner driver. Despite the fact that the ACC system does not improve the driving performance of the driver by keeping a certain distance and headway from the traffic ahead, it can contribute to achieve harmonious traffic flow, which would be disturbed by the existence of hesitant and slow learner or beginner drivers. As far as the disadvantages of the system are concerned, the system was described more as a luxurious device than a necessity. Doubts regarding the overreliance on the system were raised, strengthened by the fact that during training the trainer/teacher plays the role of an extra aid, so the need for the ACC system is not obvious.

Taking into account the differences between the BSD and ACC systems in terms of aim and function, different answers were expected on the training and testing questions of the ACC related part. All interviewees agreed on the fact that they would like to be trained on the ACC system during their driving classes, since they would actually need to learn how to activate, set up and deactivate the system. Compared to the BSD system, they recommended being taught about the system in more than one driving class, aiming to get acquainted enough with it. Although theoretical training has not been considered necessary, learner drivers stated that theoretical questions on the use of the ACC system could be a valuable addition to the driving exam. Ideas of such questions were also provided during the interviews. To be more specific, learner drivers said that it would be useful for them to be given descriptions of different traffic situations, while being asked if they should enable the system or take control of the car themselves. In this way they would have to think critically for which traffic conditions the ACC system is appropriate so that they would have to enable its function. Additionally to the theoretical questions, 3 out of 4 drivers said that they would like to be tested on the system while driving in real traffic conditions, because they should know how to interact with the system in different occasions.

It is seen that learner drivers would like to be practically trained on both systems. However, in case of the BSD system they would prefer taking theoretical tests only, whereas they considered both theoretical and practical exams on the ACC system very important. As expected, drivers have different preferences for their training and testing depending on the system and this is mainly caused by the fact that they perceive the ACC much more complex than the BSD system.

When asked about the most important aspect of the ACC system's introduction to their driving education, learner drivers focused on the importance of clarifying that the system is introduced as supplementary help to the driver. They also mentioned that the advantages of the system would be more obviously seen when used by more experienced drivers.

Table 34 summarises the results of the interview for both systems.

Table 34. ADAS related interview findings.

	BSD	**ACC**
Assisted driving tasks	1. Multitasking (alertness for blind spot) 2. Reduction of mental workload	Multitasking (maintaining headway, slowing down in time)
Advantages	Multiple ways of warnings provision	Harmonious traffic flow
Disadvantages	1. Overreliance 2. Limitations of the system	1. Overreliance 2. More a luxury than a necessity
Preferred training method	Practice (driving lessons)	Practice (driving lessons)
Preferred testing method	Theory (Questions)	1. Theory (Questions) 2. Practice (Driving exam)
System's introduction most important aspect	Introduced as auxiliary system	Introduced as auxiliary system
Preferred sequence of introduction	1st	2nd

4.6.4. 4th section: Combination of the systems

In this section of the interview, learner drivers were asked to say how effective the combination of the two systems would be both during the driving classes and after them. The answers included statements like "*the combination of the systems would be effective in increasing the overall traffic safety, especially for beginner drivers who do not feel confident about their driving skills and they need assistance for situation awareness*" and "*the combination would be effective, although we have to take into account that it takes more time to incorporate the ACC system*". Thus, it seems that learner drivers positively perceive the simultaneous introduction of these two systems in training and testing. Another point of view was that the combination of systems would be more effective if systems of similar level in automation were combined. Specifically, one of the people interviewed stated that he would prefer combining ACC with a system more automated than BSD, like automatic lane changing system, since in this case the driver would be really relieved from demanding driving tasks.

Next, learner drivers were asked to talk about the sequence with which they would prefer the systems to be introduced. Despite the fact that all interviewees were attracted by the convenience the ACC system offers to the driver, most of them emphasized on the contribution of the BSD system in drivers' traffic safety. According to their sayings, missing vehicles in your blind spot is one of the most common causes of traffic accidents. In addition, controlling your speed and distance headway is easier to do manually, because it comprises the basic driving task. Assisting the driver in a more advanced task than that, the BSD system is considered more important to introduce in the whole procedure than the ACC system.

4.7. Conclusions

This chapter was focused on the analysis of the data collected from the questionnaire and the interviews. 88 participants, 48 experienced and 40 learner drivers, took part in the study. Before the statistical tests, **factor analysis** for the two behavioural inventories and the ADAS related part was conducted. It resulted in 3 driver self-images: "confident", "courteous" and "impulsive", and 3 driver stressors: "Dislike of Driving", "Hazard Monitoring" and "Thrill seeking". The same analysis was conducted for the BSD and ACC related part, where 3 factors were extracted: "Perceived Usefulness", "Expected Ease of Use" and "Training and Testing".

As for the <u>correlations between the two behavioural inventories</u>, the more responsible and careful learner drivers perceived themselves, the more stressed they feel from being hazard attentive. Meanwhile, the more impulsive a driver, the more the impact of disliking driving and thrill seeking on their stress levels. For experienced drivers, Dislike of Driving is significantly negatively correlated with confident drivers. Also, impulsive experienced drivers are significantly stressed by Hazard Monitoring and Thrill seeking. In contrast to the learner drivers, Dislike of Driving does not increase drivers' stress, regardless the drivers' self-image (confident, courteous, and impulsive).

Regarding the **ADAS related part**, the <u>knowledge</u> about the BSD system was sufficient for 45% of the learners and 70% of the experienced, whereas the percentage was lower for the ACC system in case of the learner drivers and around 75% in case of the experienced ones. The <u>perceived usefulness</u> of the BSD system was statistically significantly higher for traffic safety and tasks like overtaking rather than for improving the driving performance of learner and experienced drivers. The ACC system's usefulness was found statistically significant for its assistance in adjustment to the traffic conditions compared to other tasks and safety for both groups of drivers. Moreover, both groups of drivers are more <u>willing to use</u> both systems in highway environments, followed by rural roads, compared to urban and congested roads. Finally, the acceptance of <u>BSD and ACC in training and testing</u> in superior for learner drivers compared to the experienced ones who generally believe that such changes in drivers' education will have more negative than positive effects on young drivers.

Pearson correlation showed that learner drivers' opinion about the introduction of the BSD system is unaffected by the driver characteristics. As for ACC, the more confident the driver feels, the less they need such an innovation in the driver's education. Courteous experienced drivers consider that being trained with the ACC system is important, while those with aberrant driving behaviour maintain the same negative view for the establishment of both systems in young drivers' education. In addition, the higher the tendency of the experienced drivers to search for thrill and adventure while driving, the lower the importance of being trained and tested for the BSD and the ACC system is.

MANOVA results yielded no significant differences were found in the perception of the two systems and their introduction to drivers' training and testing between learner and experienced drivers.

Finally, the main findings of the **in-depth personal interviews** for the small number of interviewees were:

- High usefulness of the systems for multitasking during driving
- Drivers' overreliance being the main disadvantage
- Practical training and testing preferred (for BSD theoretical training is preferred)
- Introduction of the systems as auxiliary only
- The BSD system is given priority for the introduction in drivers' training and testing

Conclusions & Discussion

"A whole is that which has beginning, middle, and end"

- Aristotle

The present chapter covers the conclusions of this research, which are derived from the results of the data analysis when linked to the problem definition and the developed methodology. It begins with an overview of the traffic safety problem of novice drivers, followed by the existing approaches to it. It continues with the outcomes of the data analysis and a comparison with the existing literature. Finally, a reflection on the total work is made.

5.1. Main findings

The following paragraphs provide a brief revision of the problem statement, followed by the present study's approach and the conclusions of it.

5.1.1. Problem and Research Gap

Inexperienced drivers attract a lot of attention because of their relatively high frequency of involvement in traffic accidents compared to experienced drivers. Meanwhile, ADAS have been designed to help drivers in difficult and risky driving tasks. They could especially contribute in mitigating novice drivers' crash involvement by assisting them in hazard detection and speed adaptation, which are two of the main causes of high accident risk for novice drivers.

Drivers' education has gone through a lot of changes throughout the last decades, trying to adjust to the new traffic conditions and the technological developments worldwide and in The Netherlands specifically. These changes involved: basic alterations to the *pre-test practice structure,* improvement of the *quality in drivers' training*, changes in the *driving test*, introduction of *probationary periods*. Nonetheless, driving training and testing have not sufficiently incorporated the higher order levels of GDE matrix, such as personal motives, lifestyle (4th level) and goals for driving (3rd level), that affect drivers' performance not only in strategic level but also in tactical and operational driving. *ADAS systems can be integrated* with the driver training practices so as to improve drivers' performance and traffic safety. A prerequisite for that is the identification of the impact of these systems on young drivers.

Given that limited literature is found on the effects that ADAS could have on novice drivers, the present study aimed to investigate the perception of learner drivers towards the Blind Spot Detection (BSD) system and Adaptive Cruise Control (ACC) system. Since it is very crucial that the training environment provides trainees appropriate opportunities for gaining knowledge and skills that are relevant to the actual driving environment, the potential of introducing these systems in drivers' training and testing was also examined.

5.1.2. Approach of the present research

In this thesis, the perception of learner drivers towards the BSD and ACC systems have been investigated, in order to examine the potential of the systems' integration to drivers' training and testing. This was achieved with the assistance of two multi-content online questionnaires that have been developed for the thesis' needs. The Driver Self-Image Inventory, Driver Stress Inventory (DSI) and an ADAS related video-based questionnaire were the fundamental parts of the survey. Next, interviews were conducted, aiming to verify the questionnaire results and collect more elaborate answers. The data has been analysed with several statistical analyses and tests, which have been carefully selected after research, in order to answer the main research question.

5.1.3. Learner drivers towards the BSD and ACC systems

The acquisition of a coherent impression of the perception of learner drivers towards the examined systems has been achieved through the results of the data analysis which answered a series of research questions and sub-questions. At this point, the answers to the questions are translated into conclusions both when examined individually and when examined collectively.

The 1st research question was:

What is the need of the introduction of the BSD and ACC systems in driving training and testing from learner drivers' perspective?

Several parameters were assumed to play an important role to the learner drivers' need, being the knowledge about the systems, their understanding of them, as well as, their perceived usefulness in different driving situations and driving tasks. Beyond these parameters, the driving profile of the learner drivers to whom the systems are more needed was used to reach more comprehensive conclusions.

- Sub-question 1a: To which extent do learner drivers know about the systems and their operation?

Knowledge about the system: The existence and use of the **BSD system** was **relatively known** to 45% of the learner drivers, whereas the areas of application of the system appeared to be quite unclear to them. On the other hand, the **ACC system** was often **confused with the Cruise Control system**, thus creating a wrong impression of its capabilities and areas of application to more than 50% of the learner drivers. Taking into account that most of the learner drivers consider themselves sufficiently familiar with the system, it could be assumed that only a small proportion of them would assess their introduction to the driving training and testing as important.

- Sub-question 1b: To which extent do learner drivers understand how the systems operate?

Understanding of the systems: After the **use of video** as teaching tool, the familiarity with the systems was radically increased for both systems (30% improvement), proving that only the use of a simple video highly contributes to the **increase of learner drivers' acquaintance** with the systems. Thus, further training could probably lead to very good understanding and interaction with the systems, before using them in real traffic environments.

- Sub-question 1c: What is the learner drivers' perception of usefulness of the systems in different driving situations (hazards, overtaking, etc.)?

Perceived usefulness: Considering the perceived usefulness of the systems as another main determinant of the need for them, learner drivers' perception of usefulness of the BSD and ACC systems is highly dependent on the type of driving tasks and safety aspects the system is used for. The **BSD system** is considered to be **useful in improving the traffic safety** of the drivers as well as **assist** them in several driving tasks such as **collision avoidance, lane changing and merging/exiting highways**. In contrast, it is not believed to be able to help in improving the drivers' driving performance. Concerning the **ACC system**, learner drivers recognize its **usefulness in properly adjusting to the traffic conditions** by maintaining their speed and distance headway from the vehicle in front.

It is seen that the difference between the two systems in terms of aim and operation has been obvious to learner drivers. Although both systems mainly aim for increasing the safety levels of the drivers (in a different way each), the **ACC** system has been considered of **providing convenience** to the driver **rather than safety**. One could reckon that this rises from the type of driving tasks the drivers have maximum difficulty accomplishing. Identifying objects and especially small vehicles in high speeds has been reported as one of the most difficult driving tasks, especially when multi-tasking driving is required. Therefore, the **ACC** system is **appealing** to the drivers **but not necessary** in terms of traffic safety enhancement.

- Sub-question 1d: What are the driving related characteristics of drivers from which each system is asked more?

Type of drivers in relation to necessity of the systems: The type of drivers to whom the systems are more necessary has been taken into account. Nevertheless, the **necessity of the BSD** system is **independent of the learner drivers' self-images** as drivers, meaning that 60% and 40% of the learner drivers who said they needed the system in training and testing respectively, were not related to their driver profile. The same applies for those who stated that there is no need for such an innovation. Compared to the BSD system, **the more confident** a learner driver feels, **the less they need the ACC** system and the more they oppose to its introduction into the drivers' training and the testing procedure. This is in line with the study of Hoedemaeker (1999), which stated that the expected acceptance of the system is lower in case it contradicts the drivers' needs.

Concluding on the need of the introduction of the BSD and ACC systems in driving training and testing from the learner drivers' perspective, the general impression is that the **BSD system** is considered to be **more needed**. The main reason for this is the fact that the BSD system covers a wider range of driving tasks and traffic situations where its usefulness is recognised compared to the ACC system. This is highly relevant to the type of driving tasks in which the BSD system is expected to assist. Blind spots mostly exist in the rear side of the car, while most of the driving tasks are performed on the front side of the car looking at the road ahead. Compared to the "front" tasks that can be easier combined and executed simultaneously, the identification of hazards in the rear side of the car requires bigger effort. The necessity of the system is increased more if one considers that the Blind spot is actually an area the drivers will never be able to look at without having to turn their head. As one interviewee stated during the interview, "*Having an eye on your blind spot makes you feel much safer than having a system controlling your headway, since you can do this on your own*". Multi-tasking is considered to be highly demanding for learner drivers, since it requires control of the vehicle, situational awareness, hazard monitoring as well as the ability to intervene in any situation needed. Learner drivers claimed that they waste a lot of energy and time thinking when concentrating on one task, increasing the chance of underperforming in one or more other tasks.

Table 35 summarises the scoring of the systems in the different parameters measured to determine the need of the learner drivers for the introduction of the systems to their training and testing. On the one hand, the BSD system and its operation is less known to learner drivers compared to the ACC system. Based on that, the need for their familiarization with it is higher. On the other hand, the BSD is simpler and understood more easily, e.g. with a manual only, than the ACC. In other words, if only the understanding of the systems is considered, ACC's need for introduction to training and testing is higher due to its complexity. Similar way of reasoning applies for the other components. Taking into account that the need for the BSD system is higher in 75% of the components, one is led to the conclusion drawn in the previous paragraph, that the BSD system is considered to be more needed.

Table 35. Scoring of the BSD and ACC systems as determinants for the need of the systems' parameters.

	Knowledge of the system	Understanding of the system	Usefulness of the system	Independence from driver's profile
BSD	**Low** familiarity **-Higher** need	**Good** understanding - **Lower** need	**Very** useful **–** **Higher** need	**Independent** from drivers' profile **–** **Higher** need
ACC	**High** familiarity **-Lower** need	**Poor** understanding **-** **Higher** need	**More convenient** than useful **-** **Lower** need	**Dependent** from drivers' profile **–** **Lower** need

The 2nd research question was:

To which extent are learner drivers willing to use the systems?

The willingness to use the systems has been examined together with the ease of use of them and relevant conclusions were drawn.

- Sub-question 2a: Do learner drivers find the system easy to use?

Expected ease of use: The expected ease of use, which was found to be almost equal for both systems (M_{BSD}=3.98, M_{ACC}=3.74), has been **relatively high**, with learner drivers stating that "*the BSD system is very straightforward*" and "*the ACC system is easy to use but more complex compared to the BSD system*". On the one hand, being easy to use can raise the drivers' willingness to use the systems. On the other hand, drivers finding the system easy to use find no necessity in being taught about it and oppose to the introduction of the systems to training and testing procedures. To conclude, although the ease of use and the simplicity of the systems increases the willingness to use them, it reduces the total need of introducing them in the learner drivers' education.

- Sub-question 2b: In which traffic and road conditions are learner drivers most willing to use the system?

Willingness to use: The acceptance of in-car assistance systems has been found to differ between different driving environments (Mitsopoulos, Regan, & Haworth, 2002). Learner drivers are most willing to use both systems in **highway environments and rural roads**. However, given the results of the previous analysis, it is believed that the content of the presented videos highly contributed to the formation of the levels of willingness to use for the different road environments. As already mentioned, important elements of the systems might be absent from the videos. This is much more important in the case of the willingness to use the systems, since the ACC system's video presented more different driving environments than the video of the BSD system. Therefore, the possibility of bias in the respective answers increases.

Table 36. Determinants of the willingness to use the systems.

	Ease of Use of the system	Driving environments
BSD	**High** ease - **Lower** need	Highway
ACC	**High** complexity - **Higher** need	Highway Rural

Table 36 presents the determining for the willingness to use elements. It is seen that the BSD system and the interaction with it is considered straightforward compared to the ACC. In the meantime, the ACC system seems applicable in a wider range of driving environments. Combining the abovementioned findings with the statements of the learner drivers, the latter are less willing to accept the introduction of the BSD system in the training and testing because of its easiness and simplicity compared to the ACC system. However, no similar reasoning can be given for the environments the systems can be applied to, since none of the participants provided relevant reasoning for rejecting one of the systems. It appears that a direct comparison between the systems is not really feasible like in the case of the need for the system, which was presented earlier.

The 3rd research question was:

What are the differences between learner and experienced drivers in terms of usefulness, ease of use as well as training and testing of the systems?

This question aimed to figure out if the attitude of the drivers towards the different assistance systems is related to the drivers' experience. Although few differences have been found between the two groups, mainly based on their answers to the open-ended questions, the Multivariate Analysis of Variance showed **no significant differences** in the answers of the two types of respondents on the usefulness, ease of use and acceptance of the systems in training and testing.

A **general agreement in the perception of BSD and ACC** systems is reached between the two groups. Regardless of driving experience, participants agree that the two systems would assist in improving traffic safety and driving performance as well as be useful in helping drivers in several driving tasks. Additionally, both groups believe that the systems are expected to be easy to use, while the same applies for their view on the acceptance of the systems in drivers' education. However, experienced drivers' have more unanimous views on the topics (same answers to the questions) than learner drivers whose answers presented higher standard deviation.

5.2. Reflection

The present reflection section reveals my considerations on the outcomes of this study. First, some concerns on the findings are expressed, followed by my opinion on the contribution of this study to a practical and a scientific level.

Beginning with the results of this research, a few comments on the following topics need to be made:

- ease of use of the systems as a determinant for the systems introduction to training and testing
- driver profiles in relation to the need of BSD and ACC
- absence of differences in perception of ADAS between learner and experienced drivers

According to the respondents, the ACC and BSD systems are so straightforward and easy to use that their introduction to drivers' training and testing is not necessary. Without underestimating or judging the respondents' beliefs, the **ease of use of the systems** has not been used as one of the main determining factors for the integration of the systems in drivers' training and testing. This is based on literature research that has been done on the benefits of the systems in traffic safety, traffic flow and the environment (Benmimoun, Aust, Faber, Saint Pierre, & Zlocki, 2011; Jermakian, 2011; Malta, et al., 2012). Such aspects are thought to be more important in making decisions for this innovation than the expected ease of use of them.

Concerning **driver profiles**, the need of the BSD system has been found to be independent of the driving profile of participants. This is not the case for ACC, where a statistically significant negative relation was found between confident drivers and the need for the system. On the one hand, the reliability and accuracy of the results could be doubted, since similar relations were expected to be found for the BSD system. Concerns about reliability can be related with the small sample size available. On the other hand, there is confidence that given the needs of the study and the scientific level, the most appropriate methods were used to generate results. The results are also in line with the findings of Turetschek (2006), who concluded that systems with a warning character (like BSD) are more widely accepted and respected than intervening systems (like ACC).

Concerning **the absence of differences in perception of ADAS between learner and experienced** drivers, a comparison has been made between the observed and expected results. The Multivariate Analysis of Variance led to results that were different from the anticipated ones. Previous studies have shown significant differences between experienced and inexperienced drivers in terms of driving performance in different tasks (Summala, 1996; Deery, 2000; Vlakveld,, 2014). However, in most of these studies, the driving performance of different types of drivers was examined using driving simulators to calculate several indicators, like acceleration, braking frequency and overtaking manoeuvres (Brown & Groeger, 1988; Pollatsek, Fisher, & Pradhan, 2006; Kass, Cole, & Stanny, 2007).

Compared to these studies, the present study used an exploratory approach instead of an experimental approach to study the impact of the systems on different types of drivers. Since experienced and learner drivers have different needs in assistance while driving, it was expected that the present study would yield deviations in their perception towards ADAS. Nevertheless, this exploratory study could not reject the null hypothesis of no differences. This is different from past studies, which showed that age and experience influence drivers' behaviour and related aspects. Nonetheless, it does not contradict them. This can be attributed to the fact that the present work relates to certain ADAS related aspects which have not been investigated before. Finally, no literature focusing on the impacts of the BSD system on different types of drivers has been found, so there were no BSD related expectations for the results.

Other considerations are related to the **generalization of the main findings** of this research. The results of the study as well as the suggestions made for the integration of the two systems in training and testing have taken only the perspective of learner and experienced drivers into account, thus they should not be easily generalized. From my standpoint, such an innovation should be seen as an issue which involves a number of stakeholders:

1. CBR
2. Driving schools – Instructors
3. Government
4. **Learner Drivers**
5. Parents (for learner drivers below 18 years) etc.

A Cost Benefit Analysis (CBA), including all stakeholders, is thought to be the appropriate tool to assess the integration of the systems in training and testing. Nonetheless, a CBA cannot be performed since studies for the different stakeholders in relation to this topic are not available at the moment.

Considering the existing **doubts about the practical integration of the systems** in the near future, the present study supports the introduction of the systems to training and testing. Based on the present research and previous studies, the advantages of BSD and ACC outweigh the disadvantages. The introduction of the systems is really important, if not necessary, due to the relatively high number of crash rates of novices. Moreover, the views of drivers about the sequence of the systems' introduction (1st BSD, 2nd ACC) is found to be sensible, given the drivers' difficulties in blind spot monitoring. Therefore, the BSD system's introduction is recommended before the ACC.

With regard to the **value of the present research at practical level and scientific level**, its results can be used as first step in the area of ADAS and drivers' education. The knowledge of the advantages and limitations of ACC and BSD as well as the perception of the drivers towards them is the starting point to build on.

5.3. Conclusions

Having discussed about all the research questions and their sub-questions, the main research question is revisited.

The main research question was:

"What is the learner drivers' perspective on the Blind Spot Detection (BSD) and Adaptive Cruise Control (ACC) systems and their introduction to drivers' training and testing?"

Figure 22 presents the **main findings** for the reasons why the introduction of each one of the two systems in the training and testing of drivers is important, answering the main research question of this thesis. All measures have been taken into account in order to conclude on which system is valued as more important and thus is more needed in learner drivers' education. The high complexity of the ACC system together with the variety of road environments the users are willing to use increase the eagerness of learner drivers to be trained and tested on the system. Meanwhile, the low familiarity of learner drivers with the BSD system, its high perceived usefulness for traffic safety and the fact that it is accepted by all drivers, regardless the driver's profile, ranks the BSD system as a higher priority in drivers' education. The only element not presented in Figure 21 is the perception of the drivers about the ease of use of the systems, based on which the BSD is easy to use, thus not very needed in testing. When the importance and usefulness of a system are high, being easy to use does not comprise a crucial reason for not including the system in drivers' education. Hence, the perception of the ease of use of the systems, has been left out of the largely determining factors of the attitude of the learner drivers towards the introduction of the systems in training and testing.

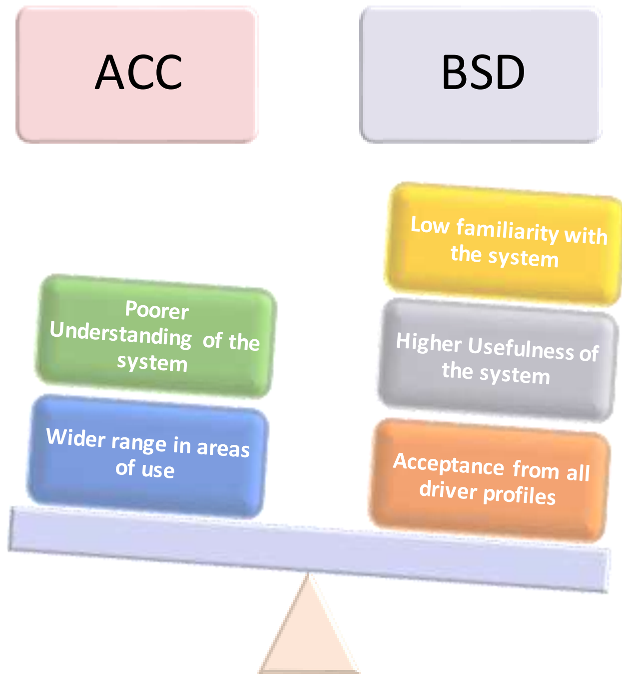


Figure 22. Overall picture of the reasons for the introduction of each of the systems.

All in all, both systems are considered important for different reasons, based on the learner drivers' point of view. Having a short experience in driving, learner drivers reckon that relieving the young driver from the stress caused by multitasking as well as the contribution in the increase of traffic safety levels (both for the beginner driver and the surrounding traffic) rank the BSD system first in their preferences for driving assistance. The BSD system is considered as an ADAS increasing traffic safety, whereas the ACC system is believed to be luxurious system assisting in harmonious traffic flow. For these reasons, learner drivers ranked the BSD system as a higher priority over ACC when the sequence of the systems in the drivers' education issue was on the table. These results confirm outcomes of previous studies, where systems with a warning character, like BSD, were found to be more widely accepted than intervening systems, like ACC.

Recommendations and Future Research

The present thesis comprised a first step to investigate the perception of learner drivers towards the BSD and ACC systems and their introduction in driving training and testing. Based on the results of the present study and the existing knowledge, a set of suggestions for the systems' integration to drivers' training and testing are given. Moreover, problematic issues and assumptions that have been made during the research are used as input for a list of recommendations. Finally, suggestions for further research in the same field of study are provided.

6.1. The potential of BSD and ACC systems' introduction to drivers' education

There is a variety of currently applied methods that have proved to be successful in enhancing road safety, such as the introduction of the upper levels of drivers' training and testing through the GDE matrix and the Graduated licence. Driver assistance in-car systems have the potential to contribute to improving traffic safety of drivers and novice drivers especially by helping them in performing difficult tasks, like speed adaptation and hazard monitoring. Introducing BSD and ACC system in drivers' training and testing is considered to be an effective way of directing technology to the needs of young drivers. A few suggestions can be made for such an innovation.

The introduction of the two systems into driving classes should aim at:

1. **Comprehensive teaching of basic and advanced driving tasks**, taking into account all psychological factors affecting the driver while performing. Concerning this, the driving profile of learner drivers as well as the main causes of drivers' stress should be taken into account, so that each learner driver is dealt with in a suitable way during their education. With regard to the GDE (Goals for Driver Education) matrix such components would be part of the uppermost level of the matrix (3rd and 4th level), influencing the drivers' performance at lower levels. Tackling drivers as individuals with different driving needs would lead to a safer and easier interaction of these drivers with these ADAS. A prerequisite for that is assuring that learner drivers understand the background and the fundamental features of the systems. The attainment of this, obtains first that the content of the training enables drivers to react safely to all input interfaces and properly perceive all the systems' interferences.
2. **Training should educate drivers on how to handle system failures**, from recognising them to tackling them. Finally, learner drivers should be taught about the basic principles of the systems'

operation together with not only the ideal scenarios for each type of ADAS, but also the critical situations where reduced ADAS functionality is anticipated, like incorrect or delayed alarms.

3. **Testing should assess the interaction of the driver with the systems**. This can be a part of the 1st and 2nd level in the GDE matrix, where basic skills for controlling the vehicle and the surrounding traffic are tested.
4. **Testing with ADAS should assess drivers' decisions in critical situations.** Depending on the demands of the traffic situation, the driver can be judged on his decision (appropriate or not) to activate or deactivate the systems. With regard to the testing methods in The Netherlands, this can be a part of the "independent driving" during the test.

Based on the ADAS related components that need to be included in drivers' education and the input obtained from the open-ended part of the questionnaire and the interviews, Figure 23 displays a general suggestion for the establishment of the systems in drivers' training and testing. Considering overreliance of drivers on the systems, it is considered that the systems are introduced after a certain number of lessons. The point of introduction lies on the decision of the instructor, who realizes when the learner driver can drive the car manually sufficiently enough to be introduced to more advanced concepts; in this case driving with ADAS.

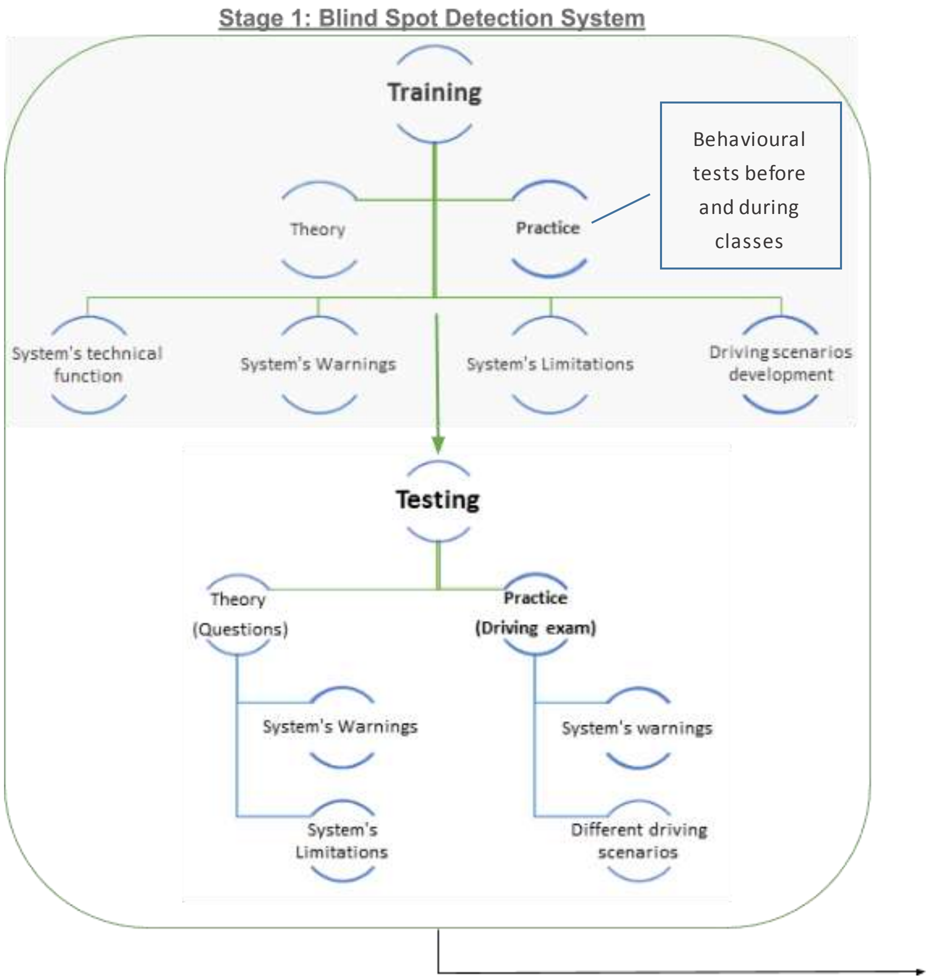
Moreover, before the practical part of drivers' training, it is important for the learner drivers to go through some behavioural tests, like driver stress related tests. These will gather information about drivers' behaviours, which are often not obvious during the driving learning and testing process. After a certain number of classes, questionnaires like the Driver Self-Image Inventory can be given to the drivers. Such a questionnaire will provide the instructor with information about the way learners perceive themselves as drivers based on their small experience. This also reflects the drivers' view of their driving progress. Knowledge of the profile of learner drivers assists in special treatment of the driver during the part of practical driving lessons, when the ADAS system is introduced. As a consequence, the way of introduction, the time and the duration of the introduction of the system varies for different learners drivers.

It has to be noted that this is only a first step towards the introduction of the systems in driving training and testing, since it is only based on the results of this research thesis. A pilot-introduction of the systems is considered necessary before a permanent change in the drivers' curriculum in training and testing.

In addition, the guidelines given in this report are still broad due to the fact that this is the first study focusing on this topic from the learner drivers' perspective. Before the permanent implementation of the systems, a protocol has to be developed for both training (teaching methods) and testing (assessment criteria). The development of a comprehensive protocol requires answers to questions like:

- What is the proper way to introduce the systems into drivers' training (stage of training, theoretical or practical lessons, etc.)?
- Which ADAS related criteria should be added for the assessment of learner drivers' performance during testing according to the GDE matrix?
- Which changes should be made to *instructors'* training in order for them to be able to transfer the relevant knowledge?
- What is the way of short and long term evaluation of the systems' introduction to training and testing in terms of drivers' safety and performance?

The answers to such questions require further investigation of this research topic. A number of recommendations are given in the following paragraphs.



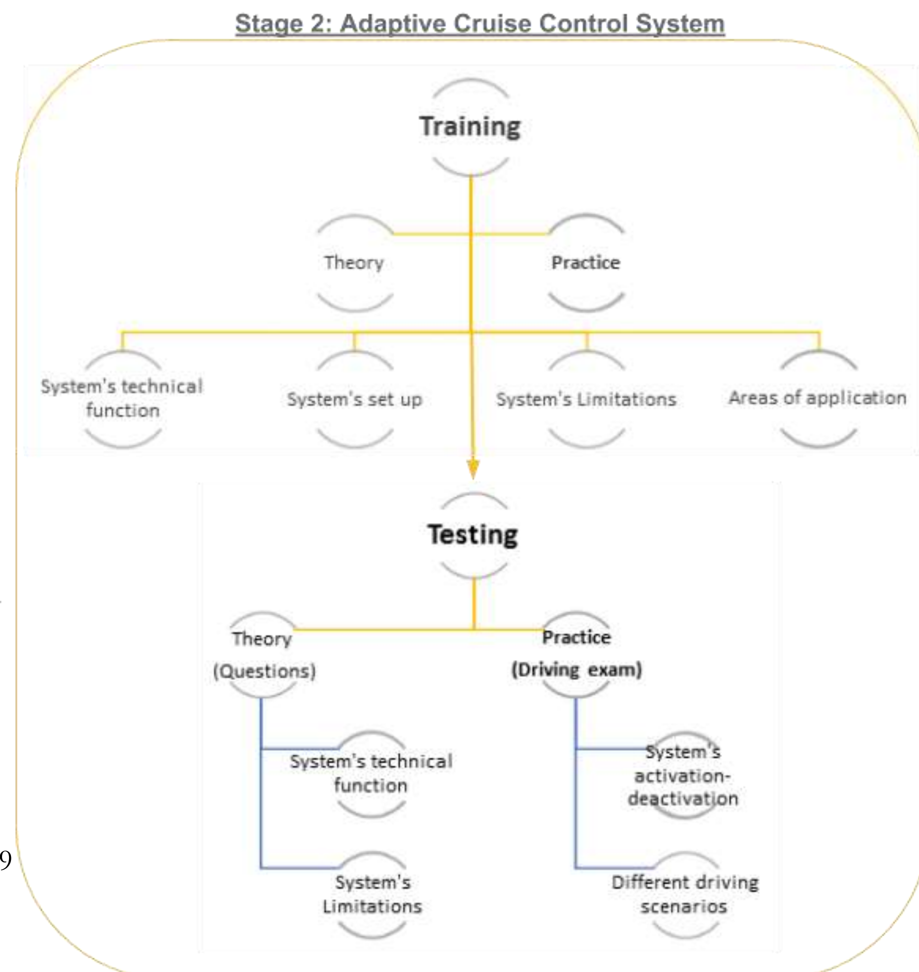


Figure 23. Proposed introduction of the BSD and ACC systems into drivers' training and testing.

6.2. Practical recommendations

The practical issues mentioned in this paragraph consist of problems that came up during the development of the methodology of the thesis. The following limitations can be listed:

- Sample Size

One of the most problematic parts of the present thesis was the recruitment of the participants. According to statistics, at least 30 people are needed in order to achieve good accuracy of the standard deviation estimate. Therefore, at least 30 people with certain characteristics (driving experience, frequency of driving, etc.) were needed for each of the defined groups. Aiming for higher reliability and avoidance of issues like wrongly filled-in questionnaires, the minimum number of participants per group was set to 60 people. Several ways were employed for the recruitment of the participants, which was supposed to be carried out in less than a month time. Given that the recruitment of the participants mostly took place at TU Delft campus, it was expected that the needed sample would be easily collected for both groups. However, more than 80 experienced drivers were collected, while the number of learner drivers did not reach more than 40, even after two months of recruitment and the intense recruitment attempts of CBR. In order to have a balance between the two groups, the number of experienced drivers was reduced to 48 after a filtering procedure, as described in Chapter 4. The rest of the responses were left unused.

Taking these challenges into account, it is proposed that future studies on this topic should use a bigger sample than the one included in this study. It is thought that conducting exactly the same study with 60 participants per group might yield different results, especially regarding the significance of the differences in perception of ADAS among the two groups.

A bigger sample might probably also result in different results for the factor analysis, which was quite problematic, particularly for the Driver Self-Image inventory. The decision of the appropriate number of factors recovery has been widely studied (Guilford, 1954; Gorsuch, 1974; Lingard & Rowlinson, 2006; de Winter, Dodou, & P.A, 2009; Comrey & Lee, 2013), concluding that a number of components affect the consistency of factor recovery, being sample size (N), number of variables (p), number of factors (f) as well as the level of loadings to the factors (λ). Communalities are also considered to play a considerable role in that. Given that most of the factor loadings in both inventories are lower than 0.8, which is common for behavioural and social data (Lingard & Rowlinson, 2006), and that there is a relatively small number of factors and variables, the sample size has to be as high as possible in order to ensure reliability in the results. Sample sizes below 50 have been considered small (Gorsuch, 1974), whereas other studies mentioned that a sample size of 200 comprises the minimum (Guilford, 1954) or that 1000 participants would be the ideal sample (Comrey & Lee, 2013).

According to the study of de Winter et al. (2009), results showed that when data fulfil certain requirements, meaning high loadings, low number of factors and high number of variables, factor analysis can yield reliable results for sample sizes smaller than 50. Meanwhile, a sample size between 50 and 100 seems to be sufficient to assess psychometric properties (Sapnas & Zeller, 2002). However, the present study used a sample size of 88, while the factor loadings were medium and the communalities and the number of variables were not very high. Based on de Winter et al. (2009), the sample size for the recovery of 3 factors in the Driver Self-Image Inventory would require a number between 17 (for loadings around 0.8) and 353 (for loadings around 0.4). As for the DSI, the required sample size ranges from 17 (for loadings around 0.8) and 234 (for loadings around 0.4). Although the sample size of this study lies within these limits (88 participants), it is recommended that future studies are conducted with sample sizes closer to the highest minimum number, so that consistency and reliability of the results is ensured and limitations that might stem from small sample sizes are overcome.

- Used Videos

Besides the sample size, another practical issue that might have affected the results of the analysis as well as the drawn conclusions is related to the used videos in the questionnaire part of data collection. Specifically, the illustrated traffic situations might have affected the responses of the participants because of the considered driving environments. The use of videos aimed to familiarise the participants with the systems so that they would be able to fill in the rest of the questionnaire and examine the potential of using such videos as teaching tools during drivers' training. Nevertheless, these videos comprised a combination of videos found in YouTube video sharing website, after going through a certain amount of alterations in terms of content and size. Comprising a combination of commercial videos only, the final videos are considered to sufficiently illustrate the function and areas of operation of each system. Nonetheless, it cannot be denied that the BSD related video consisted of parts recorded by non-professional video makers but by regular people. As a result, the video's resolution and sound was not of high quality. Meanwhile, for each system a big number of videos, which had to go through a selection procedure, was gathered. Although there has been an extensive search for videos, the final product-video does not cover all the situations the systems apply to. Taking into consideration that there was a positive reaction to the videos from most of the respondents, it is recommended that more elaborate and coherent videos are used. This can be done by another selection of videos as well as by recording new videos from the field, including all driving scenarios that are considered important. The latter applies both for next studies and the possibility of using such videos as an addition to the already existing drivers' teaching methods.

6.3. Future research recommendations

During the current research, a variety of ideas for the present study's expansion and development were generated but could not be implemented because of the restricted time and scope of this thesis. As already mentioned, this report is a first step to investigate the potential of the introduction of two ADAS systems into drivers' education. The following ideas are given as recommendations for future research, having as a basis the conclusions of this study.

- Use of different behavioural inventories

The Driver Self-Image and the Driver Stress inventories have been selected among the currently available questionnaires examining driving behaviour. This has been done considering the groups of people under study as well as the chosen methodology, being video-based questionnaires and interviews. In this concept, the relationship between the perceived self-image as drivers as well as the main causes of stress during driving was examined. A broader study could possibly employ more than two behavioural dimensions to investigate the relevant associations. Thus, it is suggested that other behavioural inventories are used in order to figure out which other driving characteristics may significantly affect the attitude of drivers towards these two technologies. For instance, the Driving Style Questionnaire (DSQ) might be used together with the Dundee Stress State Questionnaire (DSSQ) instead of the Driver Self-Image Inventory which has been used together with the Driver Stress Inventory (DSI). The results of such a study might be used to confirm this study's results or question them. However, the aforementioned examples should be altered so that they would be addressed to learner drivers.

- Inclusion of more factors affecting perception towards ADAS

As for the ADAS related part of the questionnaire, certain measures were assumed to play a role when the attitude of the drivers towards ADAS systems is determined. These included the level of knowledge and understanding of the systems, the perceived usefulness to use, ease of use, and willingness to use as well as the perceived importance of the systems' introduction in training and testing. As proved, the ease of use of the systems does not play a significant role in determining drivers' beliefs towards the systems. Since other elements might considerably affect the attitude of learner and experienced drivers regarding ADAS, it is recommended that future studies attempt to embrace more factors affecting this attitude of drivers, , such as sociodemographic characteristics or their familiarity and occupation with technological advances, so as to result in a more comprehensive study.

- Assign weights on factors affecting perception towards ADAS

After the selection of the measures determining drivers' perception towards the two systems, no weighting methods were used to assign different levels of importance to the measures. As a result, the used measures were considered to equally affect drivers in forming an attitude to the introduction of the two ADAS in training and testing. Nonetheless, this does not sufficiently reflect reality, where factors usually affect decisions, behaviours and attitudes in a different way. Therefore, an idea for a future study would be to define the extent to which each of the contributing factors influences the attitude's formation. Weights/indicators need to be calculated in order to be taken into account next time the perception of the drivers towards the introduction of these or other ADAS is investigated. A follow up study could examine the differences in the results of the studies with and without weights.

- Simulator and field experiments

Considering that this study has examined the perception of drivers towards the BSD and ACC system in a conceptual and exploratory way, the next step in this area should be conducted in an experimental way. Having used questionnaires and conducted interviews, the way that drivers' attitudes are determined based on their driving profile and other factors is only known to a certain level. Questionnaires suffer from social desirability and drivers might not reflect on their characteristics and profiles correctly. Thus, questionnaires are still a subjective way of gathering information. Next, driving simulator experiments could be used, using the same sample of people, in order to examine the driving performance of the participants in a variety of driving scenarios (hazardous and tricky traffic situations) with and without the use of the systems. Specifically, the participants would drive in a "control" scenario, with no assistance. After that, they would be asked to drive the same route with the assistance of a BSD system and an ACC assistance system respectively. At the end, they would drive the selected route being assisted by the combination of the two systems. In this way, the improvement in the learner drivers' performance would be assessed and a comparison with their stated preferences (as presented in this thesis) could be made. An even further experiment is suggested, including field experiments with learner drivers driving in real traffic conditions with and without the assistance of the systems. During such experimental studies, mental workload and situation awareness levels of the drivers should also be calculated, since according to the literature they comprise important reasons of accident causation by novice drivers.

- Other aspects for the systems' introduction to drivers' education

As mentioned in the previous chapter, a lot of research remains to be conducted to decide about the way of the systems' integration to training and testing of drivers. Thus, it is recommended that future studies embrace the perception of different stakeholders (CBR, government, instructors, etc.) towards this innovation. In addition, research related to the training of the drivers' instructors, the way of evaluation of the drivers after the innovation is implemented as well as the way the benefits of such a change for traffic safety of novice drivers and not only needs to be done.

- Systems' limitations

Finally, the systems' limitations are considerably important and brought to the forefront when they are introduced to drivers' education and during their use in real driving conditions. This thesis has only approached the systems' limitations through the open-ended questions of the questionnaire. It has been seen that the systems' chances of breaking down (failing) or other deficiencies comprise important factors of low trust to the systems. Therefore, it is proposed that future research tries to cover this aspect by examining what would be the impact of the systems' limitations on learner and experienced drivers' perceptions and behaviours.

References

AAA. (2014). *Evaluating Technologies Relevant to the Enhancement of Driver Safety*. Washington, DC: AAA Foundation for Traffic Safety.

Aberg, L., & Rimmo, P. A. (1998). Dimensions of aberrant driver behaviour. *Ergonomics, 41*(1), 39-56.

af Wåhlberg, A. E. (n.d.). *The road to Driver Risk Index; A review.* Uppsala, Sweden.

Albert, G. (2011). *Analysis and Modeling of Driving Behavior Using In-Vehicle Data Recorders.* Haifa.

Allen, T. M., Lumenfeld, H., & Alexander, G. J. (1971). *Driver information needs (No. HS-011 999).*

Anderson, R., Hutchinson, T. P., Linke, B., & Ponte, G. (2011). *Analysis of crash data to estimate the benefits of emerging vehicle technology*. Queensland, Australia: Centre for Automotive Safety Research.

Auberlet, J. M., Pacaux, M. P., Anceaux, F., Plainchault, P., & Rosey, F. (2010). The impact of perceptual treatments on lateral control: a study using fixed-base and motion-base driving simulators. *Accident Analysis & Prevention, 42*(1), 166-173.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory.* Englewood Cliffs: Prentice-Hall, Inc.

Basch, C. E. (1987). Focus group interview: An underutilized research technique for improving theory and practice in health education. *Health Education & Behavior, 14*(4), 411-448.

Becker, S., Brockmann, M., Jung, C., Mihm, J., Schollinski, H., Schwarz, J., & Winkle, T. (2004). *RESPONSE 2 – Final Report:ADAS – from Market Introduction Scenarios towards a Code of Practice for Development and Evaluation.* Transport Research & Innovation Portal.

Begg, D. J., & Langley, J. D. (2004). Identifying predictors of persistent non-alcohol or drug-related risky driving behaviours among a cohort of young adults. *Accident Analysis & Prevention, 36*(6), 1067-1071.

Beirness, D. (1993). Do we really drive as we live? The role of personality factors in road. *Alcohol, Drugs & Driving, 9*, 129-143.

Bekiaris, E., & Stevens, A. (2005). Common risk assessment methodology for advanced driver assistance systems. *Transport Reviews, 25*(3), 283-292.

Bekiaris, E., Amditis, A., & Panou, M. (2003). DRIVABILITY: a new concept for modelling driving performance. *Cognition, Technology & Work, 5*(2), 152-161.

Benda, H. V., & Hoyos, C. G. (1983). Estimating hazards in traffic situations. *Accident Analysis & Prevention, 15*(1), 1-9.

Benmimoun, M., Aust, M. L., Faber, F., Saint Pierre, G., & Zlocki, A. (2011). SAFETY ANALYSIS METHOD FOR ASSESSING THE IMPACTS OF ADVANCED DRIVER ASSISTANCE SYSTEMS WITHIN THE EUROPEAN LARGE SCALE FIELD TEST "EUROFOT". *8th ITS European Congress.*

Benmimoun, M., Pütz, A., Zlocki, A., & Eckstein, L. (2013). euroFOT: Field Operational Test and Impact Assessment of Advanced Driver Assistance Systems: Final Results. *Proceedings of the FISITA 2012 World Automotive Congress* (pp. 537-547). Springer Berlin Heidelberg.

Benmimoun, M., Zlocki, A., & Eckstein, I. L. (2013). BEHAVIORAL CHANGES AND USER ACCEPTANCE OF ADAPTIVE CRUISE CONTROL (ACC) AND FORWARD COLLISION WARNING (FCW): KEY FINDINGS WITHIN AN EUROPEAN NAT-URALISTIC FIELD OPERATIONAL TEST. *23rd Enhanced Safety of Vehicles Conference.* Seoul, Korea.

Boyce, C., & Neale, P. (2006). *Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input*. Watertown: MA: Pathfinder International.

Boyce, T. E., & Geller, E. S. (2002). An instrumented vehicle assessment of problem behavior and driving style:: Do younger males really take more risks? *Accident Analysis & Prevention, 34*(1), 51-64.

Breed, S., E.W, D., & C.W, J. (2006). *Patent No. US7049945 B2.* Retrieved from https://www.google.com/patents/US7049945

Brezillon, J., & Tijus, C. (2007). New representation of GADGET's matrix for a driver typology. *Driving Simulation Conference.* North America .

Brookhuis, K. A., De Waard, D., & Janssen, W. H. (2001). Behavioural impacts of advanced driver assistance systems–an overview. *European Journal of Transport and Infrastructure Research, 1*(3), 245-253.

Brown, C. M. (2001). The concept of behavioural adaptation: Does it occur in response to lane departure warnings? *Proceedings of the International Conference on Traffic and Transport Psychology* (pp. 4-7). Berne, Switzerland: CH.

Brown, I. D., & Copeman, A. K. (1975). Drivers' attitudes to the seriousness of road traffic offences considered in relation to the design of sanctions. *Accident Analysis & Prevention, 7*(1), 15-26.

Brown, I. D., & Groeger, J. A. (1998). Risk perception and decision taking during the transition between novice and experienced driver status. *Ergonomics, 31*(4), 585-597.

Butler, S. (1996). Child protection or professional self-preservation by the baby nurses? Public health nurses and child protection in Ireland. *Social science & medicine, 43*(3), 303-314.

Caetano, R., & Clark, C. L. (2000). Hispanics, Blacks and Whites driving under the influence of alcohol: Results from the 1995 National Alcohol Survey. *Accident Analysis & Prevention, 32*(1), 57-64.

Caffray, C. M., & Schneider, S. L. (2000). Why do they do it? Affective motivators in adolescents' decisions to participate in risk behaviours. *Cognition & Emotion, 14*(4), 543-576.

Chaloupka, C., Risser, R., Antoniades, A., Lehner, U., & Praschl, M. (1998). *Auswirkungen neuer Technologien im Fahrzeug auf das Fahrverhalten.* Bergisch-Gladbach: Mensch und Sicherheit.

Chan, E., Pradhan, A. K., Pollatsek, A., Knodler, M. A., & Fisher, D. L. (2010). Are driving simulators effective tools for evaluating novice drivers' hazard anticipation, speed management, and attention maintenance skills? *Transportation research part F: traffic psychology and behaviour, 13*(5), 343-353.

Changing minds. (2015). Retrieved from http://changingminds.org/explanations/research/analysis/parametric_non-parametric.htm

Chen, C. T., & Chen, Y. S. (2009). Real-time approaching vehicle detection in blind-spot area. *Intelligent Transportation Systems*, 1-6.

Chien, Y. T., & Chang, C. Y. (2012). Exploring the impact of animation‐based questionnaire on conducting a web‐based educational survey and its association with vividness of respondents' visual images. *British Journal of Educational Technology, 43*(3), E81-E85.

Chira-Chavala, T., & Yoo, S. M. (1994). Potential safety benefits of intelligent cruise control systems. *Accident Analysis & Prevention, 26*(2), 135-146.

Chliaoutakis, J. E., Darviri, C., & Demakakos, P. T. (1999). The impact of young drivers' lifestyle on their road traffic accident risk in greater Athens area. *Accident Analysis & Prevention, 31*(6), 771-780.

Cho, J. H., Nam, H. K., & Lee, W. S. (2006). Driver behavior with adaptive cruise control. *International journal of automotive technology, 7*(5), 603-608.

CIECA. (2007). *CIECA project 2007: Integrating the GDE matrix into category B driver training and the practical driving test.*

Clarke, D. D., Ward, P., & Truman, W. (2005). Voluntary risk taking and skill deficits in young driver accidents in the UK. *Accident Analysis & Prevention, 37*(3), 523-529.

Colbourn, C. J. (1978). Perceived risk as a determinant of driver behavior. *Accident Analysis & Prevention, 10*(2), 131-141.

Comrey, A. L., & Lee, H. B. (2013). *A first course in factor analysis.* Psychology Press.
Conover, W. J. (1998). *Practical Nonparametric Statistics.* New York: John Wiley & Sons.
Conrad, F. G., Couper, M. P., Tourangeau, R., & Peytchev, A. (2006). Use and non-use of clarification features in web surveys. *Journal of Official Statistics-Stockholm, 22*(2), 245.
Cooper, M. L., Shapiro, C. M., & Powers, A. M. (1998). Motivations for sex and risky sexual behavior among adolescents and young adults: a functional perspective. *Journal of personality and social psychology, 75*(6), 1528-1558.
Cowles, K. V. (1996). Cultural perspectives of grief: an expanded concept analysis. *Journal of Advanced Nursing, 23*(2), 284-294.
Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334.
Crundall, D. E., & Underwood, G. (1998). Effects of experience and processing demands on visual information acquisition in drivers. *Ergonomics, 41*(4), 448-458.
Currie, G., Richardson, T., Smyth, P., Vella-Brodrick, D., Hine, J., Lucas, K., . . . Stanley, J. (2009). Investigating links between transport disadvantage, social exclusion and well-being in Melbourne—Preliminary results. *Transport Policy, 16*(3), 97-105.
Davidse, R. J., Hagenzieker, M. P., van Wolffelaar, P. C., & Brouwer, W. H. (2009). Effects of in-car support on mental workload and driving performance of older drivers. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 51*(4), 463-476.
de Winter, J. C., Dodou, D., & P.A, W. (2009). Exploratory factor analysis with small sample sizes. *Multivariate Behavioral Research, 44*(2), 147-181.
Deary, I. J., & Der, G. (2005). Reaction time, age, and cognitive ability: Longitudinal findings from age 16 to 63 years in representative population samples. *Aging, Neuropsychology, and Cognition, 12*(2), 187-215.
Deci, E. L., & Ryan, R. M. (1985). *ntrinsic motivation and self-determination in human behavior*. New York: Springer Science & Business Media.
Deery, H. A. (2000). Hazard and risk perception among young novice drivers. *Journal of safety research, 30*(4), 225-236.
Deery, H. A., & Love, A. W. (1996). The effect of a moderate dose of alcohol on the traffic hazard perception profile of young drink‐drivers. *Addiction, 91*(6), 815-827.
DiStefano, C., Zhu, M., & Mindrila, D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research & Evaluation, 14*(20), 1-11.
Donovan, D. M., Umlauf, R. L., & Salzberg, P. M. (1988). Derivation of personality subtypes among high-risk drivers. *Alcohol, Drugs & Driving*.
Dragutinovic, N., Brookhuis, K. A., Hagenzieker, M. P., & Marchau, V. A. (2005). Behavioural effects of advanced cruise control use: A meta-analytic approach. *European journal of transport and infrastructure research EJTIR, 5*(4).
Dym, C. L., Little, P., Orwin, E. J., & Spjut, R. E. (2009). The Design Process. In *Engineering design: a project-based introduction* (pp. 17-32). New York: Wiley.
Dziuban, C. D., & Shirkey, E. C. (1974). When is a correlation matrix appropriate for factor analysis? Some decision rules. *Psychological Bulletin, 81*(6), 358.
Eggemeier, F. T., Wilson, G. F., Kramer, A. F., & Damos, D. L. (1991). Workload assessment in multi-task environments. *Multiple-task performance*, 207-216.
Ehlgen, T., Pajdla, T., & Ammon, D. (2008). Eliminating blind spots for assisted driving. *Intelligent Transportation Systems, 9*(4), 657-665.
Emmerson, K. (2008). *Road Safety Research Report No. 87, Learning to Drive: The evidence.* London: Department for Transport.

Engstrom, I., Gregersen, N. P., Hernetkoski, K., Keskinen, E., & Nyberg, A. (2003). *Young novice drivers, driver education and training. Literature review.* Linköping: Swedish Naional Road and Transport Research Institute.

Ferguson, S. A. (2003). Other high-risk factors for young drivers—how graduated licensing does, doesn't, or could address them. *Journal of Safety Research, 34*(1), 71-77.

Fisher, D. L., Pollatsek, A. P., & Pradhan, A. (2006). Can novice drivers be trained to scan for information that will reduce their likelihood of a crash? *Injury Prevention, 12*(1), i25-129.

Fowler Jr, F. J. (2013). *Survey research methods.* Sage publications.

Freeman, J. E., Wishart, D. E., Davey, J. D., Rowland, B. D., & Williams, R. (2009). Utilising the driver behaviour questionnaire in an Australian organisational fleet setting: can it identify risky drivers? *Journal of the Australasian College of Road Safety, 20*(2), 38-45.

French, D. J., West, R. J., Elander, J., & Wilding, J. M. (1993). Decision-making style, driving style, and self-reported involvement in road traffic accidents. *Ergonomics, 36*(6), 627-644.

Fuller, R. (2005). Towards a general theory of driver behaviour. *Accident Analysis & Prevention, 37*(3), 461-472.

Furnham, A., & Saipe, J. (1993). Personality correlates of convicted drivers. *Personality and individual differences, 14*(2), 329-336.

Genschow, J., Sturzbecher, D., & Willmes-Lenz, G. (2014). *Novice Driver Preparation – An International Comparison (Annex: Country profiles).* Bremen: Bergisch Gladbach.

George, D., & Mallery, P. (2001). *SPSS for Windows.* Boston: Allyn and Bacon.

Glendon, A. I., Dorn, L., Matthews, G., Gulian, E., Davies, D. R., & Debney, L. M. (1993). Reliability of the driving behaviour inventory. *Ergonomics, 36*(6), 719-726.

Golias, I., & Karlaftis, M. G. (2001). An international comparative study of self-reported driver behavior. *Transportation Research Part F: Traffic Psychology and Behaviour, 4*(4), 243-256.

Gorsuch, R. L. (1974). *Factor analysis.* Philadelphia: Saunders.

Graesser, A. C., Cai, Z., Louwerse, M. M., & Daniel, F. (2006). Question Understanding Aid (QUAID) a web facility that tests question comprehensibility. *Public Opinion Quarterly, 70*(1), 3-22.

Gras, M. E., Sullman, M. J., Cunill, M., Planes, M., Aymerich, M., & Font-Mayolas, S. (2006). Spanish drivers and their aberrant driving behaviours. *Transportation Research Part F: Traffic Psychology and Behaviour, 9*(2), 129-137.

Gregersen, N. P. (1994). Systematic cooperation between driving schools and parents in driver education, an experiment. *Accident Analysis & Prevention, 26*(4), 453-461.

Gregersen, N. P. (1996). Young drivers' overestimation of their own skill—an experiment on the relation between training strategy and skill. *Accident Analysis & Prevention, 28*(2), 243-250.

Gregersen, N. P., & Berg, H. Y. (1994). Lifestyle and accidents among young drivers. *Accident Analysis & Prevention, 26*(3), 297-303.

Gregersen, N. P., & Bjurulf, P. (1996). Young novice drivers: Towards a model of their accident involvement. *Accident Analysis & Prevention, 28*(2), 229-241.

Groeger, J. A., & Brown, I. D. (1989). Assessing one's own and others' driving ability: Influences of sex, age, and experience. *Accident Analysis & Prevention, 21*(2), 155-168.

Groeger, J. A., & Rothengatter, J. A. (1998). Traffic psychology and behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour, 1*(1), 1-9.

Guilford, J. P. (1954). *Psychometric methods.* New York: McGraw-Hill.

Gulian, E., Matthews, G., Glendon, A. I., Davies, D. R., & Debney, L. M. (1989). Dimensions of driver stress. *Ergonomics, 32*(6), 585-602.

Gusfield, J. (1991). Risky roads. *Society, 28*(3), 10-16.

Hardy, B., & Fenner, R. A. (2015). Towards the sustainability of road transport through the introduction of AV technology. *Proceedings of the Institution of Civil Engineers-Engineering Sustainability. 168*, pp. 192-203. Thomas Telford Ltd.

Hennessy, D. A., & Wiesenthal, D. L. (1997). The relationship between traffic congestion, driver stress and direct versus indirect coping behaviours. *Ergonomics, 40*(3), 348-361.

Hine, J., & Scott, J. (2000). Seamless, accessible travel: users' views of the public transport journey and interchange. *Transport Policy, 7*(3), 217-226.

Hoedemaeker, D. (1999). *Driving with intelligent vehicles - Driving behaviour with Adaptive Cruise Control and the acceptance by individual drivers.* Delft: Delft University Press.

Hoedemaeker, M., & Brookhuis, K. A. (1998). Behavioural adaptation to driving with an adaptive cruise control (ACC). *Transportation Research Part F: Traffic Psychology and Behaviour, 1*(2), 95-106.

Hoffmann, E. R., & Mortimer, R. G. (1996). Scaling of relative velocity between vehicles. *Accident Analysis and Prevention, 28*(4), 415-421.

Hoogendoorn, R. G. (2012). *Empirical research and modeling of longitudinal driving behavior under adverse conditions.* Delft: Delft University of Technology.

Horberry, T., Anderson, J., Regan, M. A., Triggs, T. J., & Brown, J. (2006). Driver distraction: the effects of concurrent in-vehicle tasks, road environment complexity and age on driving performance. *Accident Analysis & Prevention, 38*(1), 185-191.

Howard, D., & Dai, D. (2014). Public Perceptions of Self-driving Cars: The Case of Berkeley. *Transportation Research Board 93rd Annual Meeting*, (pp. No. 14-4502). California.

Hyland, M. E., Bott, J., Singh, S., & Kenyon, C. A. (1994). Domains, constructs and the development of the breathing problems questionnaire. *Quality of Life Research, 3*(4), 245-256.

Institute, H. L. (2012a). *Mercedes-Benz collision avoidance features: initial results.* Highway loss data institute.

Institute, H. L. (2012b). *Volvo collision avoidance features: initial results.* Highway Loss Data Institute.

Ivers, R., Senserrick, T., Boufous, S., Stevenson, M., Chen, H. Y., Woodward, M., & Norton, R. (2009). Novice drivers' risky driving behavior, risk perception, and crash risk: findings from the DRIVE study. *American journal of public health, 99*(9), 1638.

Iversen, H. (2004). Risk-taking attitudes and risky driving behaviour. *Transportation Research Part F: Traffic Psychology and Behaviour, 7*(3), 135-150.

Jain, J., & Lyons, G. (2008). The gift of travel time. *Journal of Transport Geography, 16*(2), 81-89.

Jamieson, S. (2004). Likert scales: How to (ab)use them. *Medical education, 38*(12), 1217-1218.

Jermakian, J. S. (2011). Crash avoidance potential of four passenger vehicle technologies. *Accident Analysis & Prevention, 43*(3), 732-740.

Kahneman, D. (1973). *Attention and effort.* Englewood Cliffs: NJ: Prentice-Hall.

Kaiser, H. (1974). An index of factorial simplicity. *Psychometrika 39*, 31-36.

Kaiser, H. F. (1958). The varimax criterion for analytic rotation in factor analysis. *Psychometrika, 23*(3), 187-200.

Kaiser, H. F., & Caffrey, J. (1965). Alpha factor analysis. *Psychometrika, 30*(1), 1-14.

Kass, S. J., Cole, K. S., & Stanny, C. J. (2007). Effects of distraction and experience on situation awareness and simulated driving. *ransportation Research Part F: Traffic Psychology and Behaviour, 10*(4), 321-329.

Kavale, S. (1983). understanding: The qualitative research interview: a phenomenological and a hermeneutic model of. *Journal of Phenomenological Psychology, 14*(1983), 171-196.

Kelly, M., & Nielson, N. (2005). *Does Age Matter? Age Distinctions in Insurance Law Commission of Canada.* Research Project LCC04-019A.

Kidd, P. S., & Parshall, M. B. (2000). Getting the focus and the group: enhancing analytical rigor in focus group research. *Qualitative health research, 10*(3), 293-308.

Kingsley, K. J. (2009). Evaluating crash avoidance countermeasures using data from FMCSA/NHTSA'S large truck crash causation study. *Proceedings of the 21s International Technical Conference on the Enhanced Safety of Vehicles Conference (ESV)-International Congress Center*. Stuttgart, Germany.

Kitzinger, J. (1995). Introducing focus groups. *British Medical Journal, 311*(7000), 299.

Klunder, G. A., Mak, J., Wilmink, I. R., Schirokoff, A., Sihvola, N., & Kosmatopoulos, E. (2009). *Impact of information and communication technologies on energy efficiency in road transport*. TNO.

Klunder, G., Li, M., & Minderhoud, M. (2009). Traffic flow impacts of adaptive cruise control deactivation and (Re) activation with cooperative driver behavior. *Transportation Research Record: Journal of the Transportation Research Board, 2129*, 145-151.

Kontogiannis, T., Kossiavelou, Z., & Marmaras, N. (2002). Self-reports of aberrant behaviour on the roads: errors and violations in a sample of Greek drivers. *Accident Analysis & Prevention, 34*(3), 381-399.

Kyriakidis, M., Happee, R., & De Winter, J. (2014). Public opinion on automated driving: Results of an international questionnaire among 5,000 respondents. *Available at SSRN 2506579*.

Lajunen, T., Parker, D., & Stradling, S. G. (1998). Dimensions of driver anger, aggressive and highway code violations and their mediation by safety orientation in UK drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 1*(2), 107-121.

Lajunen, T., Parker, D., & Summala, H. (1999). Does traffic congestion increase driver aggression? *Transportation Research Part F: Traffic Psychology and Behaviour, 2*(4), 225-236.

Lang, B., Parkes, A., Cotter, S., Robbins, R., Diels, C., Vanhulle, P., . . . Kapplusch, J. P. (2007). Train-all integrated system for driver training and assessment using interactive education tools and new training curricula for all modes of road transport. *TRAIN ALL Consortium.*

Lankshear, A. J. (1993). The use of focus groups in a study of attitudes to student nurse assessment. *Journal of Advanced Nursing, 18*(12), 1986-1989.

Larsson, A. F. (2012). Driver usage and understanding of adaptive cruise control. *Applied ergonomics, 43*(3), 501-506.

Lee, J. D. (2007). Technology and teen drivers. *Journal of safety research, 38*(2), 203-213.

Lind, L. H., Schober, M. F., & Conrad, F. G. (2001). Clarifying question meaning in a web-based survey. *Proceedings of the American Statistical Association, section on survey research methods.*

Lindgren, A., & Chen, F. (2006). State of the art analysis: An overview of advanced driver assistance systems (adas) and possible human factors issues. *Human factors and economics aspects on safety*, (pp. 38-50). Sweden.

Lingard, H., & Rowlinson, S. (2006). Letter to the editor. *ConstructionManagement and Economics, 24*, 1107-1109.

Lonero, L. P. (2008). Trends in Driver Education and Training. *American journal of preventive medicine, 35*(3), S316-S323.

Lotan, T., & Toledo, T. (2007). Driving patterns of young drivers within a graduated driver licensing system. *Transportation Research Board 86th Annual Meeting* (pp. No 08-1080). Transportation Research Board.

Louviere, J. (1988). *Analyzing decision making: Metric conjoint analysis.* Beverly Hills: Sage.

Lu, M., Wevers, K., & Van Der Heijden, R. (2005). Technical feasibility of advanced driver assistance systems (ADAS) for road traffic safety. *Transportation Planning and Technology, 28*(3), 167-187.

Ma, R., Sheik-Nainar, M. A., & Kaber, D. B. (2005). Situation Awareness in Driving While Using Adaptive Cruise Control and a Cell Phone. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting. 49*, pp. 381-385. SAGE Publications.

Magori, V. (1989). Signal processing for smart ultrasonic sensors. *VLSI and Computer Peripherals. VLSI and Microelectronic Applications in Intelligent Peripherals and their Interconnection Networks* (pp. 3-21). IEEE.

Magori, V. (1994). Ultrasonic sensors in air. *Ultrasonics Symposium, 1994. Proceedings. 1*, pp. 471-481. IEEE.

Mahapatra, R. P., Kumar, K. V., Khurana, G., & Mahajan, R. (2008). Ultra sonic sensor based blind spot accident prevention system. *Advanced Computer Theory and Engineering* (pp. 992-995). IEEE.

Malik, H., & Rakotonirainy, A. (2008). The need of intelligent driver training systems for road safety. *Systems Engineering, ICSENG'08. 19th International Conference* (pp. 183-188). IEEE.

Malta, L., Aust, M. L., Faber, F., Metz, B., Saint Pierre, G., & Benmimoun, M. (2012). D6. 4 Final results: Impacts on traffic safety. *Public Deliverable, euroFOT consortium.*

Marchau, V. A., Van der Heijden, R. E., & Molin, E. J. (2005). Desirability of advanced driver assistance from road safety perspective: the case of ISA. *Safety Science, 43*(1), 11-27.

Marchau, V., Wiethoff, M., Penttinen, M., & Molin, E. (2001). Stated preferences of European drivers regarding advanced driver assistance systems. *European journal of transport and infrastructure research EJTIR, 1*(3).

Markus, H., & Wurf, E. (1987). The dynamic self-concept: A social psychological perspective. *Annual review of psychology, 38*(1), 299-337.

Matthews, G. (2002). Towards a transactional ergonomics for driver stress and fatigue. *Theoretical Issues in Ergonomics Science, 3*(2), 195-211.

Matthews, G., Desmond, P. A., Joyner, L., Carcary, B., & Gilliland, K. (1996). Validation of the driver stress inventory and driver coping questionnaire. *International Conference on Traffic and Transport Psychology*, (pp. 1-27). Valencia, Spain.

Matthews, G., Emo, A. K., & Funke, G. J. (2005). A short version of the Dundee Stress State Questionnaire. *Twelfth Meeting of the International Society for the Study of Individual Differences.* Adelaide, Australia.

Matthews, G., Tsuda, A., Xin, G., & Ozeki, Y. (1999). Individual differences in driver stress vulnerability in a Japanese sample. *Ergonomics, 42*(3), 401-415.

Matthews, M. L., & Moran, A. R. (1986). Age differences in male drivers' perception of accident risk: The role of perceived driving ability. *Accident Analysis & Prevention, 18*(4), 299-313.

Matuszyk, L., Zelinsky, A., Nilsson, L., & Rilbe, M. (2004). Stereo panoramic vision for monitoring vehicle blind-spots. *Intelligent Vehicles Symposium* (pp. 31-36). IEEE.

Maxwell, J. P., Grant, S., & Lipkin, S. (n.d.). Further validation of the propensity for angry driving scale in British drivers. *Personality and Individual Differences, 38*(1), 213-224.

Maycock, G. (2001). *Novice driver accidents and the driving test.* TRL REPORT 527.

Mayhew, D. R., Simpson, H. M., & Pak, A. (2003). Changes in collision rates among novice drivers during the first months of driving. *Accident Analysis & Prevention, 35*(5), 683-691.

Mayhew, D., & Simpson, H. (1995). *The role of driving experience: implications for the training and licensing of new drivers.* Canada: Insurance Bureau of Canada.

McGwin Jr, G., & Brown, D. B. (1999). Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis & Prevention, 31*(3), 181-198.

McKenna, F., & Crick, J. (26-27 September 1990). 1991. *Behavioural Research in Road Safety*. Nottingham University.

McKnight, A. J., & McKnight, A. S. (2003). Young novice drivers: careless or clueless? *Accident Analysis & Prevention, 35*(6), 921-925.

Michon, J. A. (1993). *Generic intelligent driver support.* CRC Press.

Michon, J. A., Smiley, A., & Aasman, J. (1990). Errors and driver support systems. *Ergonomics, 33*(10-11), 1215-1229.

Milech, D., Glencross, D., & Hartley, L. (1989). *Skills acquisition by young drivers: perceiving, interpreting and responding to the driving environment.* Federal Office of Road Safety.

Minitab. (2015). Retrieved from A comparison of the Pearson and Spearman correlation method: http://support.minitab.com/en-us/minitab-express/1/help-and-how-to/modeling-statistics/regression/supporting-topics/basics/a-comparison-of-the-pearson-and-spearman-correlation-methods/

Mirus, F., Pfadt, J., Connette, C., Ewert, B., Grüdl, D., & Verl, A. (2012). *Detection of Moving and Stationary Objects at High Velocities using Cost-Efficient Sensors, Curve-Fitting and Neural Networks.* Retrieved from http://www.elektromobilitaet.fraunhofer.de/content/dam/elektromobilitaet/de/documents/fsem_ii/fmirus_iros12_detection_of_moving_and_stationary_objects_at_high_velocities_using_cost-efficient_sensors_curve_fitting_and_neural_networks.pdf

Mitsopoulos, E., Regan, M. A., & Haworth, N. (2002). Acceptability of in-vehicle intelligent transport systems to Victorian car drivers. *Road Safety Research, Policing and Education Conference.* Adelaide: South Australia.

Mohn, T. (2014, December 12). *Blind Spot and Lane Departure Systems Get Mixed Reviews In New Evaluation.* Retrieved from Forbes: http://www.forbes.com/sites/tanyamohn/2014/12/12/blind-spot-and-lane-departure-systems-get-mixed-reviews-in-new-evaluation/

Moore, M., & Zuby, D. (2013). Collision avoidance features: initial results. *23rd International Conference on the Enhanced Safety of Vehicles.*

Morgan, D. L. (1997). *Focus groups as qualitative research* . Sage Publications.

Morgan, D. L. (1997). *The focus group guidebook.* Sage publications.

Mourant, R. R., & Rockwell, T. H. (1972). Strategies of visual search by novice and experienced drivers. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 14*(4), 325-335.

Mourant, R. R., & Rockwell, T. H. (1972). Strategies of visual search by novice and experienced drivers. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 14*(4), 325-335.

Nilsson, L. (1995). Safety effects of adaptive cruise controls in critical traffic situations. *Steps Forward. Intelligent Transport Systems World Congress*, *3*.

Norman, D. (2007). *The design of future things.* New York: Basic Books.

Norman, D. A., & Shallice, T. (1986). *Attention to action.* US: Springer.

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances in health sciences education, 15*(5), 625-632.

Ohno, H. (2001). Analysis and modeling of human driving behaviors using adaptive cruise control. *Applied Soft Computing, 1*(3), 237-243.

Oppewal, H., & Timmermans, H. (1992). Conjuncte Keuze Experimenten: Achtergronden, Theorie, Toepassingen en Ontwikkelingen. In A. Bronner, *Jaarboek van de Nederlandse Vereniging van Marktonderzoekers* (pp. 33-58 (In Dutch)).

Özkan, T., & Lajunen, T. (2005). A new addition to DBQ: Positive driver behaviours scale. *Transportation Research Part F: Traffic Psychology and Behaviour, 8*(4), 355-368.

Parker, D., Lajunen, T., & Stradling, S. (1998). Attitudinal predictors of interpersonally aggressive violations on the road. *Transportation Research Part F: Traffic Psychology and Behaviour, 1*(1), 11-24.

Parker, D., Reason, J. T., Manstead, A. S., & Stradling, S. G. (1995). Driving errors, driving violations and accident involvement. *Ergonomics, 38*(5), 1036-1048.

Parsons, J. T., Halkitis, P. N., Bimbi, D., & Borkowski, T. (2000). Perceptions of the benefits and costs associated with condom use and unprotected sex among late adolescent college students. *Journal of adolescence, 23*(4), 377-391.

Patten, C. J., Kircher, A., Östlund, J., Nilsson, L., & Svenson, O. (2006). Driver experience and cognitive workload in different traffic environments. *Accident Analysis & Prevention, 38*(5), 887-894.

Pedan, M., McGee, K., & Krug, E. (2002). *Injury: A leading cause of the global burden of disease.* Geneva, Switzerland: World Health Organization.

Peräaho, M., Keskinen, E., & Hatakka, M. (2003). *Driver competence in a hierarchical perspective; Implications for driver education.* Report to Swedish Road Administration.

Peters, D. A. (1993). Improving quality requires consumer input: Using focus groups. *Journal of Nursing Care Quality, 7*(2), 34-41.

Piao, J., & McDonald, M. (2008). Advanced driver assistance systems from autonomous to cooperative approach. *Transport Reviews, 28*(5), 659-684.

Pollatsek, A., Fisher, D. L., & Pradhan, A. (2006). Identifying and remedying failures of selective attention in younger drivers. *Current Directions in Psychological Science, 15*(5), 255-259.

Pöysti, L., Rajalin, S., & Summala, H. (2005). Factors influencing the use of cellular (mobile) phone during driving and hazards while using it. *Analysis & Prevention, 37*(1), 47-51.

Quimby, A. R., & Watts, G. R. (1981). *Human factors and driving performance (No. LR 1004 Monograph).* Berkshire, England: Transport and Road Research Laboratory.

R.H, M., & A.L, T. (2005). *Patent No. US6859148 B2.* Retrieved from https://www.google.com/patents/US6859148

Rakotonirainy, A., & Steinhardt, D. (2009). In-vehicle technology functional requirements for older drivers. *Proceedings of the 1st international conference on automotive user interfaces and interactive vehicular applications* (pp. 27-33). ACM.

Ranney, T. A. (1994). Models of driving behavior: a review of their evolution. *Accident Analysis & Prevention, 26*(6), 733-750.

Raubenheimer, J. (2004). An item selection procedure to maximize scale reliability and validity. *SA Journal of Industrial Psychology, 30*(4), 59.

Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: a real distinction? *Ergonomics, 33*(10-11), 1315-1332.

Reinhardt, W., & Kompfner, P. (2007). *ICT for Clean & Efficient Mobility Final Report Draft.*

Ricolfi, L. (2002). *Manuale di Analisi dei Dati.* Roma: GLF editori Laterza.

Rudin-Brown, C. M., & Parker, H. A. (2004). Behavioural adaptation to adaptive cruise control (ACC): implications for preventive strategies. *Transportation Research Part F: Traffic Psychology and Behaviour, 7*(2), 59-76.

Rundmo, T., & Iversen, H. (2004). Risk perception and driving behaviour among adolescents in two Norwegian counties before and after a traffic safety campaign. *Safety Science, 42*(1), 1-21.

Saad, F. (2004). Behavioural adaptations to new driver support systems. Some critical issues. *IEEE International Conference on Systems, Man and Cybernetics* , (pp. 288-293).

Sagberg, F. (2000). *Evaluation of 16 years age limit for practising with private car: accident risk after driver's test.* Oslo: Institute of Transport Economics.TOI rapport, 498.

Sagberg, F., & Bjørnskau, T. (2006). Hazard perception and driving experience among novice drivers. *Accident Analysis & Prevention, 38*(2), 407-414.

Säljö, R. (2000). *Lärandet i praktiken. Ett sociokulturellt perspektiv [Learning in Practice: A sociocultural perspective].* Stockholm: Prisma.

Sapnas, K. G., & Zeller, R. A. (2002). Minimizing sample size when using exploratory factor analysis for measurement. *Journal of nursing measurement, 10*(2), 135-154.

Sarter, N. (2008). Investigating mode errors on automated flight decks: Illustrating the problem-driven, cumulative, and interdisciplinary nature of human factors research. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 50*(3), 506-510.

Sayer, J. R., Fancher, P. S., Bareket, Z., & Johnson, G. E. (1995). *Automatic target acquisition autonomous intelligent cruise control (AICC): Driver comfort, acceptance, and performance in highway traffic No. 950970.* SAE.

Schleicher, S., & Gelau, C. (2011). The influence of Cruise Control and Adaptive Cruise Control on driving behaviour–A driving simulator study. *Accident Analysis & Prevention, 43*(3), 1134-1139.

Scott-Parker, B., Watson, B., & King, M. J. (2009). Understanding the psychosocial factors influencing the risky behaviour of young drivers. *Transportation research part F: traffic psychology and behaviour, 12*(6), 470-482.

Selzer, M., & Vinokur, A. (1974). Life events, subjective stress and traffic accidents. *American Journal of Psychiatry, 131*, 903-906.

Sheldon, M. R., Fillyaw, M. J., & Thompson, W. D. (1996). The use and interpretation of the Friedman test in the analysis of ordinal‐scale data in repeated measures designs. *Physiotherapy Research International, 1*(4), 221-228.

Sheskin, D. J. (2003). *Handbook of parametric and nonparametric statistical procedures.* crc Press.

Shope, J. T., & Molnar, L. J. (2003). Graduated driver licensing in the United States: evaluation results from the early programs. *Journal of Safety Research, 34*(1), 63-69.

Siegel, S. (1956). *Nonparametric statistics for the behavioral sciences.* New York, NY: US: McGraw-Hill .

Sim, J., & Snell, J. (1996). Focus groups in physiotherapy evaluation and research. *Physiotherapy, 82*(3), 189-198.

Smiley, A. (2000). Behavioral adaptation, safety, and intelligent transportation systems. *Transportation Research Record: Journal of the Transportation Research Board, 1724*(1), 47-51.

Snyder, M., & Cantor, N. (1997). Understanding personal and social behavior: a functionalist strategy. In G. Lindzey, D. Gilbert, & F. S.T, *Handbook of Social Psychology.* New York: McGraw-Hill.

Sotelo, M. Á., & Barriga, J. (2008). Blind spot detection using vision for automotive applications. *Journal of Zhejiang University SCIENCE A, 9*(10), 1369-1372.

Stanton, N. A., & Marsden, P. (1996). From fly-by-wire to drive-by-wire: safety implications of automation in vehicles. *Safety Science, 24*(1), 35-49.

Stanton, N. A., & Young, M. S. (2005). Driver behaviour with adaptive cruise control. *Ergonomics, 48*(10), 1294-1313.

Stanton, N. A., Young, M., & McCaulder, B. (1997). Drive-by-wire: the case of driver workload and reclaiming control with adaptive cruise control. *Safety Science, 27*(2), 149-159.

Strohm, K. M., Bloecher, H. L., Schneider, R., & Wenger, J. (2005). Development of future short range radar technology. *Radar Conference, EURAD* (pp. 165-168). IEEE.

Sucha, M., Sramkova, L., & Risser, R. (2014). he Manchester driver behaviour questionnaire: self-reports of aberrant behaviour among Czech drivers. *European Transport Research Review, 6*(4), 493-502.

Sümer, N., Ayvaşik, B., Er, N., & Özkan, T. (2001). Role of monotonous attention in traffic violations, errors, and accidents. *In Proceedings of the First International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design*, (pp. 167-173).

Summala, H. (1987). Young driver accidents: Risk taking or failure of skills? *Alcohol, Drugs & Driving*.

Summala, H. (1996). Accident risk and driver behaviour. *Safety Science, 22*(1), 103-117.

SWOV. (2012). *Young novice drivers.* The Hague, the Netherlands.

Tabachnick, B., & Fidell, L. S. (2007). *Using multivariate statistics.* NJ: Pearson Allyn & Bacon.

Taubman - Ben-Ari, O. (2004). Risk taking in adolescence: "to be or not to be". In J. Greenberg, S. Koole, & T. Pyszczynski, *Experimental Existential Psychology.* Guilford, New York.

Taubman-Ben-Ari, O. (2008). Motivational sources of driving and their associations with reckless driving cognitions and behavior. *Revue Européenne de Psychologie Appliquée/European Review of Applied Psychology, 58*(1), 51-64.

Taubman-Ben-Ari, O. (2010). Young drivers' attitudes toward accompanied driving: A new multidimensional measure. *Accident Analysis and Prevention, 42*, 1009-1017.

Taubman-Ben-Ari, O., Mikulincer, M., & Gillath, O. (2004). The multidimensional driving style inventory—scale construct and validation. *Accident Analysis & Prevention, 36*(3), 323-332.

Taylor, D. H. (1964). Drivers' galvanic skin response and the risk of accident. *Ergonomics, 7*(4), 439-451.

Techmer, A. (2004). Real-time motion analysis for monitoring the rear and lateral road. *IEEE Intelligent Vehicle Symp*, (pp. 704-709).

Thurstone, L. L. (1944). *A factorial study of perception.*

Timmermans, H. (1982). Consumer choice of shopping centre: an information integration approach. *Regional Studies, 16*(3), 171-182.

Tobias, S., & Carlson, J. E. (1969). Brief report: Bartlett's test of sphericity and chance findings in factor analysis. *Multivariate Behavioral Research, 4*(3), 375-377.

Tourangeau, R., Rips, L. J., & Rasinski, K. (2000). *The psychology of survey response.* Cambridge: Cambridge University Press.

Tronsmoen, T. (2008). Associations between self-assessment of driving ability, driver training and crash involvement among young drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 11*(5), 334-346.

Tsai, L. W., Hsieh, J. W., & Fan, K. C. (2005). Vehicle detection using normalized. *IEEE Transactions on Image Processing, 16*(3), 850-864.

Tsugawa, S. (2006). Trends and issues in safe driver assistance systems: Driver acceptance and assistance for elderly drivers. *IATSS research, 30*(2), 6-18.

Turetschek, C. (2006). Potentials and Risks of New Technologies in the Training of young drivers. *Proceedings of the Conference on European guidelines for the application of new technologies for driver training and education.* Madrid: Humanist NoE.

Turoff, M. (2002). Past and future emergency response information systems. *Communications of the ACM, 45*(4), 29-32.

Twisk, D. A., & Stacey, C. (2007). Trends in young driver risk and countermeasures in European countries. *Journal of safety research, 38*(2), 245-257.

Ulleberg, P., & Rundmo, T. (2002). Risk–taking attitudes among young drivers: The psychometric qualities and dimensionality of an instrument to measure young drivers' risk–taking attitudes. *Scandinavian Journal of Psychology, 43*(3), 227-237.

Ulleberg, P., & Rundmo, T. (2003). Personality, attitudes and risk perception as predictors of risky driving behaviour among young drivers. *Safety science, 41*(5), 427-443.

Underwood, G., Chapman, P., Brocklehurst, N., Underwood, J., & Crundall, D. (2003). Visual attention while driving: sequences of eye fixations made by experienced and novice drivers. *Ergonomics, 46*(6), 629-646.

Vagias, W. M. (2006). *Likert-type scale response anchors.* Clemson University: Clemson International Institute for Tourism & Research Development, Department of Parks, Recreation and Tourism Management.

Valldorf, J. (2005). *Advanced microsystems for automotive applications* . Springer.

Van der Molen, H. H., & Botticher, A. M. (1988). A hierarchical risk model for traffic participants. *Ergonomics, 31*(4), 537-555.

van Schagen, I., & Wijlhuizen, G. d. (2015). *Accompanied driving in the Netherlands: Why do participate and why?* SWOV, The Hague.

van Wolffelaar, P. C., & van Winsum, W. (1992). A new driving simulator including an interactive intelligent traffic environment. *The 3rd International Conference on Vehicle Navigation and Information Systems* (pp. 499-506). IEEE.

Vaughn, S., Schumm, J. S., & Sinagub, J. M. (1996). *Focus group interviews in education and psychology*. Sage publications.

Vissers, J., Mesken, J., Roelofsz, E., & Claesen, R. (2008). Driving Test: A Pilot Study. In *Driver behaviour and training*. The Netherlands.

Viti, F., Hoogendoorn, S. P., Alkim, T. P., & Bootsma, G. (2008). Driving behavior interaction with ACC: results from a Field Operational Test in the Netherlands. *Intelligent Vehicles Symposium* (pp. 745-750). IEEE.

Vlakveld, W. P. (2014). A comparative study of two desktop hazard perception tasks suitable for mass testing in which scores are not based on response latencies. *Transportation research part F: traffic psychology and behaviour, 22*, 218-231.

Vlakveld, W., Romoser, M. R., Mehranian, H., Diete, F., Pollatsek, A., & Fisher, D. L. (2011). Do crashes and near crashes in simulator-based training enhance novice drivers' visual search for latent hazards? *Transportation Research Record: Journal of the Transportation Research Board, 2265*(1), 153-160.

Vollrath, M., Meilinger, T., & Krüger, H. P. (2002). How the presence of passengers influences the risk of a collision with another vehicle. *Accident Analysis & Prevention, 34*(5), 649-654.

Walker, W. E. (2000). Policy analysis: a systematic approach to supporting policymaking in the public sector. *Journal of multi-criteria decision analysis, 9*(1-3), 11-27.

Wallis, T. S., & Horswill, M. S. (n.d.). Using fuzzy signal detection theory to determine why experienced and trained drivers respond faster than novices in a hazard perception test. *Accident Analysis & Prevention, 39*(6), 1177-1185.

Wang, J., Bebis, G., & Miller, R. (2005). Overtaking vehicle detection using dynamic and quasi-static background modeling. *IEEE Computer Society Conference on Computer Vision and Pattern Recognition-Workshops* (p. 64). IEEE.

Wang, Y. K., & Chen, S. H. (2005). A robust vehicle detection approach. *IEEE Conference on Advanced Video and Signal Based Surveillance* (pp. 117-122). IEEE.

Wenger, J. (2005). Automotive radar-status and perspectives. *Compound Semiconductor Integrated Circuit Symposium* (pp. 1-4). IEEE.

Whelan, M., Senserrick, T., Groeger, J., Triggs, T., & Hosking, S. (2004). *Learner driver experience project*. Monash University: Accident Research Centre, Report No.221.

WHO. (2013). *Global Status Report on Road Safety 2013. Supporting a decade of action.* Geneva, Switzerland: World Health Organization.

Williams, A. F. (2003). Teenage drivers: patterns of risk. *Journal of safety research, 34*(1), 5-15.

Williams, A. F. (2006). Young driver risk factors: successful and unsuccessful approaches for dealing with them and an agenda for the future. *Injury Prevention, 12*(suppl 1), i4-i8.

Woods, D. D. (1994). Apparent simplicity, real complexity. *Human performance in automated systems: Current research and trends*, 1-7.

Xie, C. Q., & Parker, D. (2002). A social psychological approach to driving violations in two Chinese cities. *Transportation Research Part F: Traffic Psychology and Behaviour, 5*(4), 293-308.

Xiong, H., & Boyle, L. N. (2012). Drivers' Adaptation to Adaptive Cruise Control: Examination of Automatic and Manual Braking. *IEEE Transactions on Intelligent Transportation Systems, 13*(3), 1468-1473.

Yagil, D. (1998). Gender and age-related differences in attitudes toward traffic laws and traffic violations. *Transportation Research Part F: Traffic Psychology and Behaviour, 1*(2), 123-135.

Young, K. L., Regan, M. A., Triggs, T. J., Jontof-Hutter, K., & Newstead, S. (2010). Intelligent speed adaptation—Effects and acceptance by young inexperienced drivers. *Accident Analysis & Prevention, 42*(3), 935-943.

Young, K., Regan, M., Mitsopoulos, E., & Haworth, N. (2003). *Acceptability of in-vehilce intelligent transport systems to young novice drivers in New South Wales.* Monash University, Australia: Accident Research Centre.

Young, M. S., & Stanton, N. A. (2007). Back to the future: Brake reaction times for manual and automated vehicles. *Ergonomics, 50*(1), 46-58.

Zheng, P., & McDonald, M. (2005). Manual vs. adaptive cruise control–Can driver's expectation be matched? *Transportation Research Part C: Emerging Technologies, 13*(5), 421-431.

Zhu, M., & Ghodsi, A. (2006). Automatic dimensionality selection from the scree plot via the use of profile likelihood. *Computational Statistics & Data Analysis, 51*(2), 918-930.

Zhu, Y., Comaniciu, D., Pellkofer, M., & Koehler, T. (2006). Reliable detection of overtaking vehicles using robust information fusion. *IEEE Transactions on Intelligent Transportation Systems. 7*, pp. 401-414. IEEE.

Zwahlen, H. T., Adams, C. C., & DeBals, D. P. (1988). Safety aspects of CRT touch panel controls in automobiles. *Second International Conference on Vision in Vehicles.* Amsterdam.

Appendix I

Questionnaire for learner and experienced drivers

Learner Drivers Questionnaire Version

Questionnaire

Thank you for agreeing to complete this questionnaire. This study is being conducted by Anastasia Tsapi, a MSc student at the Department of Transport and Planning, Technical University of Delft (A.Tsapi@student.tudelft.nl).

It takes approximately 25 minutes to fill out the questionnaire.

Your participation is on a voluntary basis and all of the information will be completely confidential and used only for the purposes of this research. You can skip any question you do not want to answer. Also you can quit at any time.

This research is related to driving assistance systems and safety.By participating in this study and by a reliable filling of this questionnaire you are assisting the researcher to improve and promote the research in road safety.

1. Gender

- Male
- Female

2. What is your age?

____

3. What is your primary mode of transportation?

- Private vehicle
- Public transportation
- Motorcycle
- Walking/cycling
- Other: __________

4. How many hours of professional driving training have you had?

5. Below is a list of traits. For each of them, please indicate the extent to which it reflects your current perception of yourself as a driver.

	1 - Not at all	2	3	4	5	6 - Very much
cautious	○	○	○	○	○	○
experienced	○	○	○	○	○	○
nervous	○	○	○	○	○	○
responsible	○	○	○	○	○	○
fast	○	○	○	○	○	○
considerate	○	○	○	○	○	○
rash (reckless)	○	○	○	○	○	○
clear-thinking	○	○	○	○	○	○
self-confident	○	○	○	○	○	○
polite	○	○	○	○	○	○
law-abiding	○	○	○	○	○	○
calm	○	○	○	○	○	○
patient	○	○	○	○	○	○
decisive	○	○	○	○	○	○
risk taker	○	○	○	○	○	○

6. Please answer the following questions on the basis of your usual or typical feelings about driving. Indicate how strongly you agree or disagree with each of the following statements.

Does it worry you to drive in bad weather?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I am disturbed by thoughts of having an accident or the car breaking down

0 - very rarely	1	2	3	4	5	6	7	8	9	10 - very often
○	○	○	○	○	○	○	○	○	○	○

Do you think you have enough experience and training to deal with risky situations on the road safely?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I find myself worrying about my mistakes and the things I do badly when driving

0 - very rarely	1	2	3	4	5	6	7	8	9	10 - very often
○	○	○	○	○	○	○	○	○	○	○

I would like to risk my life as a racing driver

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

My driving would be worse than usual in an unfamiliar rental car

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I sometimes like to frighten myself a little while driving

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I get a real thrill out of driving fast

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I make a point of carefully checking every side road I pass for emerging vehicles

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Do you think it is worthwhile taking risks on the road?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Advice on driving from a passenger is generally:

0 - unnecessary	1	2	3	4	5	6	7	8	9	10 - useful
○	○	○	○	○	○	○	○	○	○	○

I like to raise my adrenaline levels while driving

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Do you feel confident in your ability to avoid an accident?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Do you usually make an effort to look for potential hazards when driving?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I would enjoy driving a sports car on a road with no speed-limit

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

When driving on an unfamiliar road do you become more tense than usual?

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I make a special effort to be alert even on roads I know well

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I enjoy the sensation of accelerating rapidly

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

If I make a minor mistake when driving, I feel it's something I should be concerned about

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I always keep an eye on parked cars in case somebody gets out of them, or there are pedestrians behind them

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I feel more anxious than usual when I have a passenger in the car

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I make an effort to see what's happening on the road a long way ahead of me

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I try very hard to look out for hazards even when it's not strictly necessary

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

When you pass another vehicle do you feel in command of the situation?

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

When you pass another vehicle do you feel tense or nervous?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

When you're in a hurry, other drivers usually get in your way

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

When I come to negotiate a difficult stretch of road, I am on the alert

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Do you feel more anxious than usual when driving in heavy traffic?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I enjoy cornering at high speed

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Blind Spot Detection System

The following part of the questionnaire relates to the Blind Spot Detection system.

7. How familiar are you with the Blind Spot Detection system?

	not at all	slightly	somewhat	moderately	extremely
	○	○	○	○	○

8. What is a Blind Spot Detection system and how does it function?

9. To which situations does the Blind Spot Detection system apply to?

Continue »

33% completed

Blind Spot Detection (BSD) system VIDEO

At this point you are kindly asked to watch the following video which describes the Blind Spot Detection system.

Please answer the following questions based on the video's content.

10. I find the video useful in explaining what a Blind Spot Detection system is.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
	○	○	○	○	○

11. What is a Blind Spot Detection system and how does it function?

12. To which situations does the Blind Spot Detection system apply to?

13. How does the system warn the driver?

14. Answer the following questions on the expected usefulness of the system.

I expect that using the system would...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...increase my driving safety	○	○	○	○	○
...enable me to change lanes and overtake other vehicles more efficiently and safely	○	○	○	○	○
...improve my driving performance	○	○	○	○	○
...help me to avoid collisions	○	○	○	○	○
...help me to enter and exit the highway more safely and easily	○	○	○	○	○

15. Answer the following questions on the expected ease of use of the system.

I expect that...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...my interaction with the system will be clear and understandable	○	○	○	○	○
...the Blind Spot Detection system will be easy to use	○	○	○	○	○
...it will be easy for me to become skilful at understanding and using the system	○	○	○	○	○

16. Indicate how willing you are to use the Blind Spot Detection system in the following situations:

I am willing to use the system...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...in urban environments (30-50km/h)	○	○	○	○	○
...in rural environments (80km/h)	○	○	○	○	○
...in highway environments (100-130km/h)	○	○	○	○	○
...in highly congested situations	○	○	○	○	○

17. Answer the following questions on the training and testing of the system.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to learn about the system before using it	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce the system in the theoretical part of driving training	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to include driving with the system in the driving test	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce a video such as the one shown above to explain the system to learner drivers	○	○	○	○	○

Please explain why you agree or disagree.

Adaptive Cruise Control (ACC) System

The following part of the questionnaire relates to the Adaptive Cruise Control system.

18. How familiar are you with the Adaptive Cruise Control system?

	not at all	slightly	somewhat	moderately	extremely
	○	○	○	○	○

19. What is an Adaptive Cruise Control system and how does it function?

20. To which situations does the Adaptive Cruise Control system apply to?

« Back Continue »

66% completed

Adaptive Cruise Control (ACC) system VIDEO

At this point you are kindly asked to watch the following video which describes the Adaptive Cruise Control system.

Please answer the following questions based on the video's content.

21. I find the video useful in explaining what an Adaptive Cruise Control system is.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
	○	○	○	○	○

22. What is an Adaptive Cruise Control system and how does it function?

23. To which situations does the Adaptive Cruise Control system apply to?

24. Answer the following questions on the expected usefulness of the system.

I expect that using the system would...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...increase my driving safety	○	○	○	○	○
...enable me to adjust to the traffic conditions more efficiently and keep a safer distance from the leading vehicle	○	○	○	○	○
...improve my driving performance	○	○	○	○	○
...help me to avoid collisions	○	○	○	○	○

25. Answer the following questions on the expected ease of use of the system.

I expect that...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...my interaction with the system will be clear and understandable	○	○	○	○	○
...the Adaptive Cruise Control system will be easy to use.	○	○	○	○	○
...it will be easy for me to become skilful at understanding and using the system	○	○	○	○	○

26. Indicate how willing you are to use the Adaptive Cruise Control system in the following situations:

I am willing to use the system...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...in urban environments (30-50km/h)	○	○	○	○	○
...in rural environments (80km/h)	○	○	○	○	○
...in highway environments (100-130km/h)	○	○	○	○	○
...in highly congested situations	○	○	○	○	○

27. Answer the following questions on the training and testing of the system.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to learn about the system before using it	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce the system in the theoretical part of driving training	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to include driving with the system in the driving test.	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce a video such as the one shown above to explain the system to learner drivers	○	○	○	○	○

Please explain why you agree or disagree.

28. My english skills in terms of reading comprehension are:

	poor	fair	good	very good	excellent
	○	○	○	○	○

29. My english skills in terms of listening comprehension are:

	poor	fair	good	very good	excellent
	○	○	○	○	○

The second stage of the research includes exchanging opinions organised in focus groups.

If you are willing to participate, please write your e-mail below.

E-mail address

A lottery will take place for the people who participate in this study by filling in the questionnaire.

If you are willing to participate, please write your e-mail below.

E-mail address

Thank you for participating!

« Back Submit

100%: You made it.

Never submit passwords through Google Forms.

Experienced Drivers Questionnaire Version

Questionnaire

Thank you for agreeing to complete this questionnaire. This study is being conducted by Anastasia Tsapi, a MSc student at the Department of Transport and Planning, Technical University of Delft (A.Tsapi@student.tudelft.nl).

It takes approximately 25 minutes to fill out the questionnaire.

Your participation is on a voluntary basis and all of the information will be completely confidential and used only for the purposes of this research. You can skip any question you do not want to answer. Also you can quit at any time.

This research is related to driving assistance systems and safety.By participating in this study and by a reliable filling of this questionnaire you are assisting the researcher to improve and promote the research in road safety.

1. Gender

- Male
- Female

2. What is your age?

3. What is your primary mode of transportation?

- Private vehicle
- Public transportation
- Motorcycle
- Walking/cycling
- Other:

4. How long do you own a driver license?

5. On average, how often did you drive a car in the last 12 months?

- Everyday
- 4 to 6 days a week
- 1 to 3 days a week
- Less than once a month
- Never
- Other:

6. About how many kilometres did you drive in the last 12 months?

If you are not certain, please give the best estimate you can.

- 0
- 1-1000
- 1001-5000
- 5001-10000
- 10001-15000
- 15001-20000
- 20001-25000
- 25001-35000
- 35001-50000
- 50001-100000
- More than 100000

7. How many accidents you were involved in as a driver in the last 6 months?

Please include al accidents, regardless of how they we caused, how slight they were or where they happened.

8. Below is a list of traits. For each of them, please indicate the extent to which it reflects your current perception of yourself as a driver.

	1 - Not at all	2	3	4	5	6 - Very much
cautious	○	○	○	○	○	○
experienced	○	○	○	○	○	○
nervous	○	○	○	○	○	○
responsible	○	○	○	○	○	○
fast	○	○	○	○	○	○
considerate	○	○	○	○	○	○
rash (reckless)	○	○	○	○	○	○
clear-thinking	○	○	○	○	○	○
self-confident	○	○	○	○	○	○
polite	○	○	○	○	○	○
law-abiding	○	○	○	○	○	○
calm	○	○	○	○	○	○
patient	○	○	○	○	○	○
decisive	○	○	○	○	○	○
risk taker	○	○	○	○	○	○

9. Please answer the following questions on the basis of your usual or typical feelings about driving. Indicate how strongly you agree or disagree with each of the following statements.

Does it worry you to drive in bad weather?

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I am disturbed by thoughts of having an accident or the car breaking down

0 - very rarely	1	2	3	4	5	6	7	8	9	10 - very often
○	○	○	○	○	○	○	○	○	○	○

Do you think you have enough experience and training to deal with risky situations on the road safely?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I find myself worrying about my mistakes and the things I do badly when driving

0 - very rarely	1	2	3	4	5	6	7	8	9	10 - very often
○	○	○	○	○	○	○	○	○	○	○

I would like to risk my life as a racing driver

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Advice on driving from a passenger is generally:

0 - unnecessary	1	2	3	4	5	6	7	8	9	10 - useful
○	○	○	○	○	○	○	○	○	○	○

I like to raise my adrenaline levels while driving

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Do you feel confident in your ability to avoid an accident?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

Do you usually make an effort to look for potential hazards when driving?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I would enjoy driving a sports car on a road with no speed-limit

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

When driving on an unfamiliar road do you become more tense than usual?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I make a special effort to be alert even on roads I know well

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I enjoy the sensation of accelerating rapidly

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

If I make a minor mistake when driving, I feel it's something I should be concerned about

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I always keep an eye on parked cars in case somebody gets out of them, or there are pedestrians behind them

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I feel more anxious than usual when I have a passenger in the car

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I make an effort to see what's happening on the road a long way ahead of me

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

I try very hard to look out for hazards even when it's not strictly necessary

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

When you pass another vehicle do you feel in command of the situation?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

When you pass another vehicle do you feel tense or nervous?

0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
○	○	○	○	○	○	○	○	○	○	○

When you pass another vehicle do you feel tense or nervous?

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

When you're in a hurry, other drivers usually get in your way

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

When I come to negotiate a difficult stretch of road, I am on the alert

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

Do you feel more anxious than usual when driving in heavy traffic?

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

I enjoy cornering at high speed

	0 - not at all	1	2	3	4	5	6	7	8	9	10 - very much
	○	○	○	○	○	○	○	○	○	○	○

Blind Spot Detection System

The following part of the questionnaire relates to the Blind Spot Detection system.

10. How familiar are you with the Blind Spot Detection system?

	not at all	slightly	somewhat	moderately	extremely
	○	○	○	○	○

11. What is a Blind Spot Detection system and how does it function?

12. To which situations does the Blind Spot Detection system apply to?

Continue »

33% completed

Powered by Google Forms

Blind Spot Detection (BSD) system VIDEO

At this point you are kindly asked to watch the following video which describes the Blind Spot Detection system.

Please answer the following questions based on the video's content.

13. I find the video useful in explaining what a Blind Spot Detection system is.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
	○	○	○	○	○

14. What is a Blind Spot Detection system and how does it function?

15. To which situations does the Blind Spot Detection system apply to?

16. How does the system warn the driver?

17. Answer the following questions on the expected usefulness of the system.

I would expect that using the system would...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...increase my driving safety	○	○	○	○	○
...enable me to change lanes and overtake other vehicles more efficiently and safely	○	○	○	○	○
...improve my driving performance	○	○	○	○	○
...help me to avoid collisions	○	○	○	○	○
...help me to enter and exit the highway more safely and easily	○	○	○	○	○

18. Answer the following questions on the expected ease of use of the system.

I expect that...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...my interaction with the system will be clear and understandable	○	○	○	○	○
...the Blind Spot Detection system will be easy to use.	○	○	○	○	○
...it will be easy for me to become skilful at understanding and using the system	○	○	○	○	○

19. Indicate how willing you are to use the Blind Spot Detection system in the following situations:

I am willing to use the system...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...in urban environments (30-50km/h)	○	○	○	○	○
...in rural environments (80km/h)	○	○	○	○	○
...in highway environments (100-130km/h)	○	○	○	○	○
...in highly congested situations	○	○	○	○	○

20. Answer the following questions on the training and testing of the system.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to learn about the system before using it	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce the system in the theoretical part of driving training	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to include driving with the system in the driving test	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce a video such as the one shown above to explain the system to learner drivers	○	○	○	○	○

Please explain why you agree or disagree.

Adaptive Cruise Control (ACC) System

The following part of the questionnaire relates to the Adaptive Cruise Control system.

21. How familiar are you with the Adaptive Cruise Control system?

	not at all	slightly	somewhat	moderately	extremely
	○	○	○	○	○

22. What is an Adaptive Cruise Control system and how does it function?

23. To which situations does the Adaptive Cruise Control system apply to?

« Back Continue »

66% completed

Adaptive Cruise Control (ACC) system VIDEO

At this point you are kindly asked to watch the following video which describes the Adaptive Cruise Control system.

Please answer the following questions based on the video's content.

24. I find the video useful in explaining what an Adaptive Cruise Control system is.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
	○	○	○	○	○

25. What is an Adaptive Cruise Control system and how does it function?

26. To which situations does the Adaptive Cruise Control system apply to?

27. Answer the following questions on the expected usefulness of the system.

I expect that using the system would...

	stronlgy disagree	disagree	neither agree or disagree	agree	strongly agree
...increase my driving safety	◌	◌	◌	◌	◌
...enable me to adjust to the traffic conditions more efficiently and keep a safer distance from the leading vehicle	◌	◌	◌	◌	◌
...improve my driving performance	◌	◌	◌	◌	◌
...help me to avoid collisions	◌	◌	◌	◌	◌

28. Answer the following questions on the expected ease of use of the system.

I expect that...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...my interaction with the system will be clear and understandable	◌	◌	◌	◌	◌
...the Adaptive Cruise Control system will be easy to use	◌	◌	◌	◌	◌
...it will be easy for me to become skilful at understanding and using the system	◌	◌	◌	◌	◌

29. Indicate how willing you are to use the Adaptive Cruise Control system in the following situations:

I am willing to use the system...

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
...in urban environments (30-50km/h)	○	○	○	○	○
...in rural environments (80km/h)	○	○	○	○	○
...in highway environments (100-130km/h)	○	○	○	○	○
...in highly congested situations	○	○	○	○	○

30. Answer the following questions on the training and testing of the system.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to learn about the system before using it	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce the system in the theoretical part of driving training	○	○	○	○	○

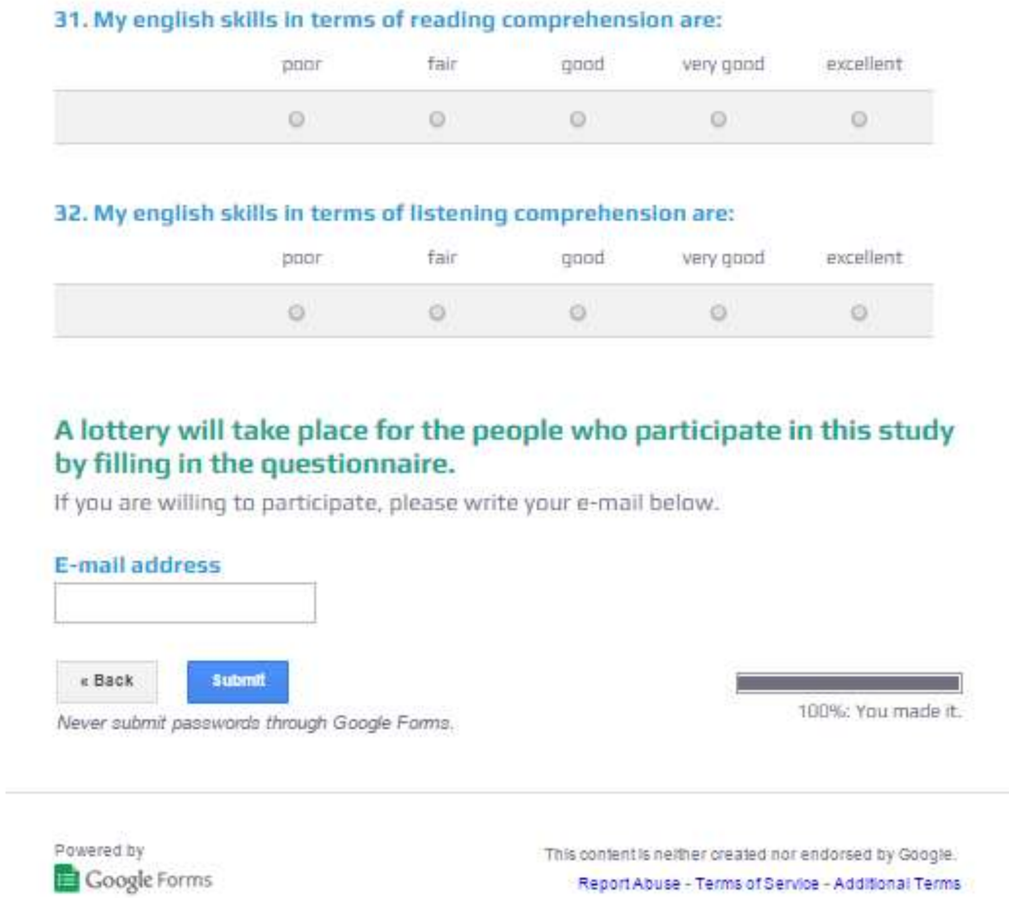
Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to include driving with the system in the driving test	○	○	○	○	○

Please explain why you agree or disagree.

	strongly disagree	disagree	neither agree or disagree	agree	strongly agree
It is important to introduce a video such as the one shown above to explain the system to learner drivers	○	○	○	○	○

Please explain why you agree or disagree.



31. My english skills in terms of reading comprehension are:

	poor	fair	good	very good	excellent
	○	○	○	○	○

32. My english skills in terms of listening comprehension are:

	poor	fair	good	very good	excellent
	○	○	○	○	○

A lottery will take place for the people who participate in this study by filling in the questionnaire.

If you are willing to participate, please write your e-mail below.

E-mail address

« Back Submit

Never submit passwords through Google Forms.

100%: You made it.

Powered by Google Forms

This content is neither created nor endorsed by Google.

Report Abuse - Terms of Service - Additional Terms

Both questionnaires can be found on-line in:

Learner drivers:

https://docs.google.com/forms/d/1Tuqo6qIQE03SgSg7etQHDFnTQFT-SgzCorfK5Ky2F00/viewform

Experienced drivers:

https://docs.google.com/forms/d/1a2_bgtiIivHBFSGUQHWJusIiu-2Eq5yO9rQzHru3URY/viewform

Videos snapshots

Since the videos that have been used as the basis of the questionnaires cannot be presented in this report, snapshots of them are provided in order for the reader to get and impression of their content (operation of the systems, areas of application, graphics, etc.)

Blind Spot Detection System

Figure 1. Blind Spot area.

Figure 2. Demonstration of the BSD system's signals. 1st & 2nd: Visual, 3rd: Haptic

Figure 3. Demonstration of the BSD system's operation in different situations.

Adaptive Cruise Control System

- **Operation**

Figure 4. Demonstration of the ACC system's set up.

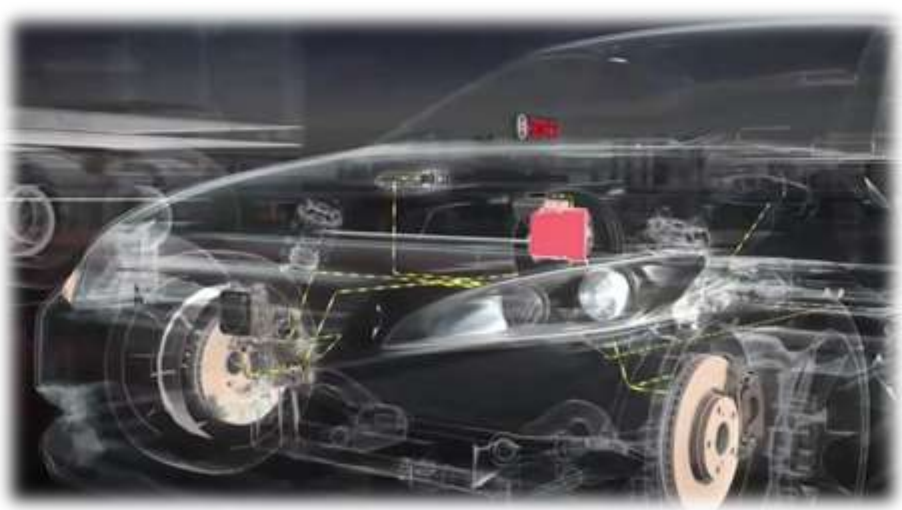


Figure 5. Description of the ACC system's technical operation.

- **Highway environment**

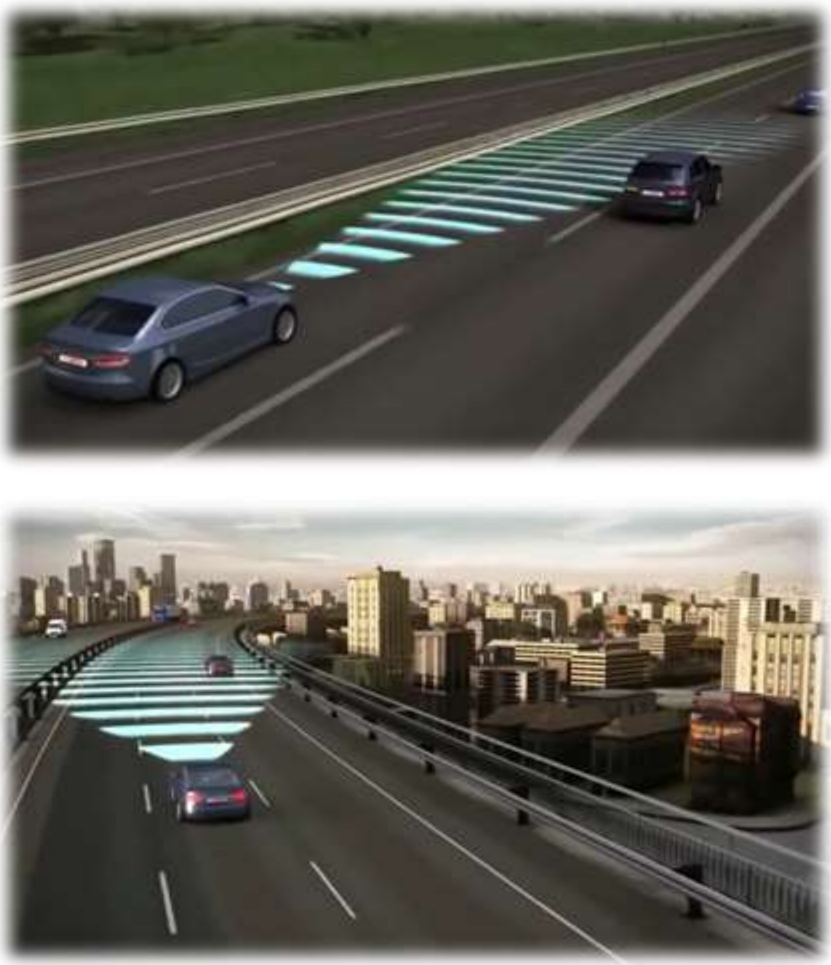


Figure 6. The use of the ACC system in highways. No vehicles ahead.

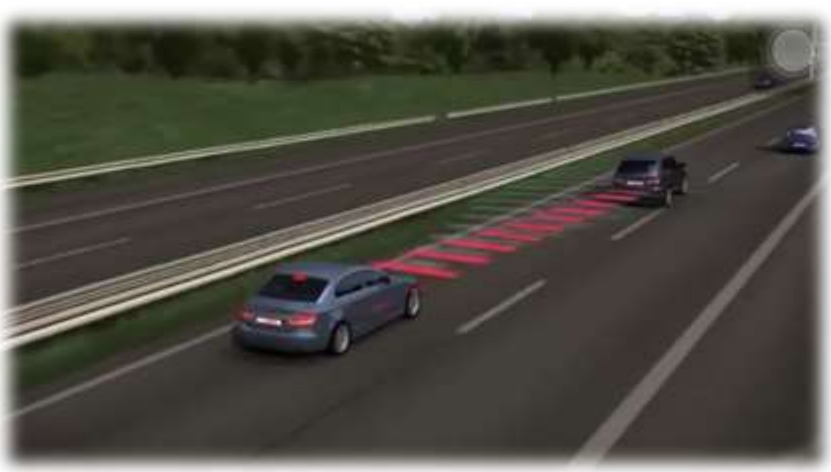


Figure 7. The use of the ACC system in highways. Radar sensors detecting vehicles in front.

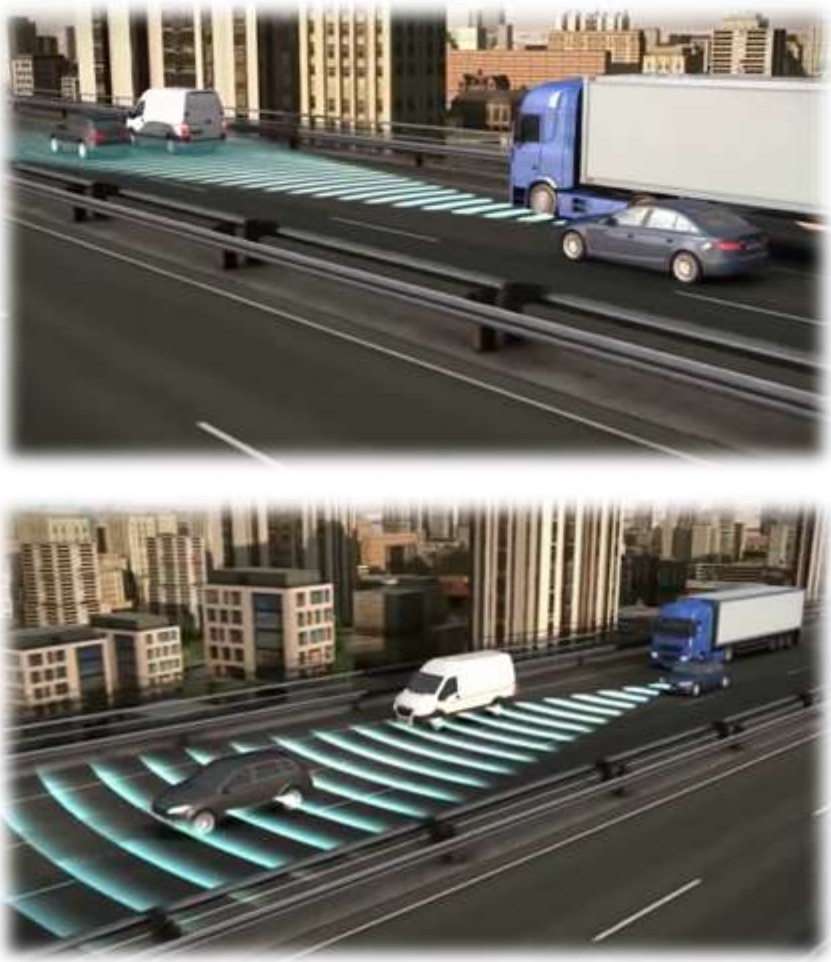


Figure 8. The use of the ACC system in highways. Vehicles ahead.

- **Congested environment**

Figure 9. The use of the ACC system in stop and go traffic.

Figure 10. The use of the ACC system in zero km/h.

Figure 11. The use of the ACC system in congested situations.

Appendix II

Pilot study brief results

Number of participants: Learner drivers: 5, Experienced drivers: 5

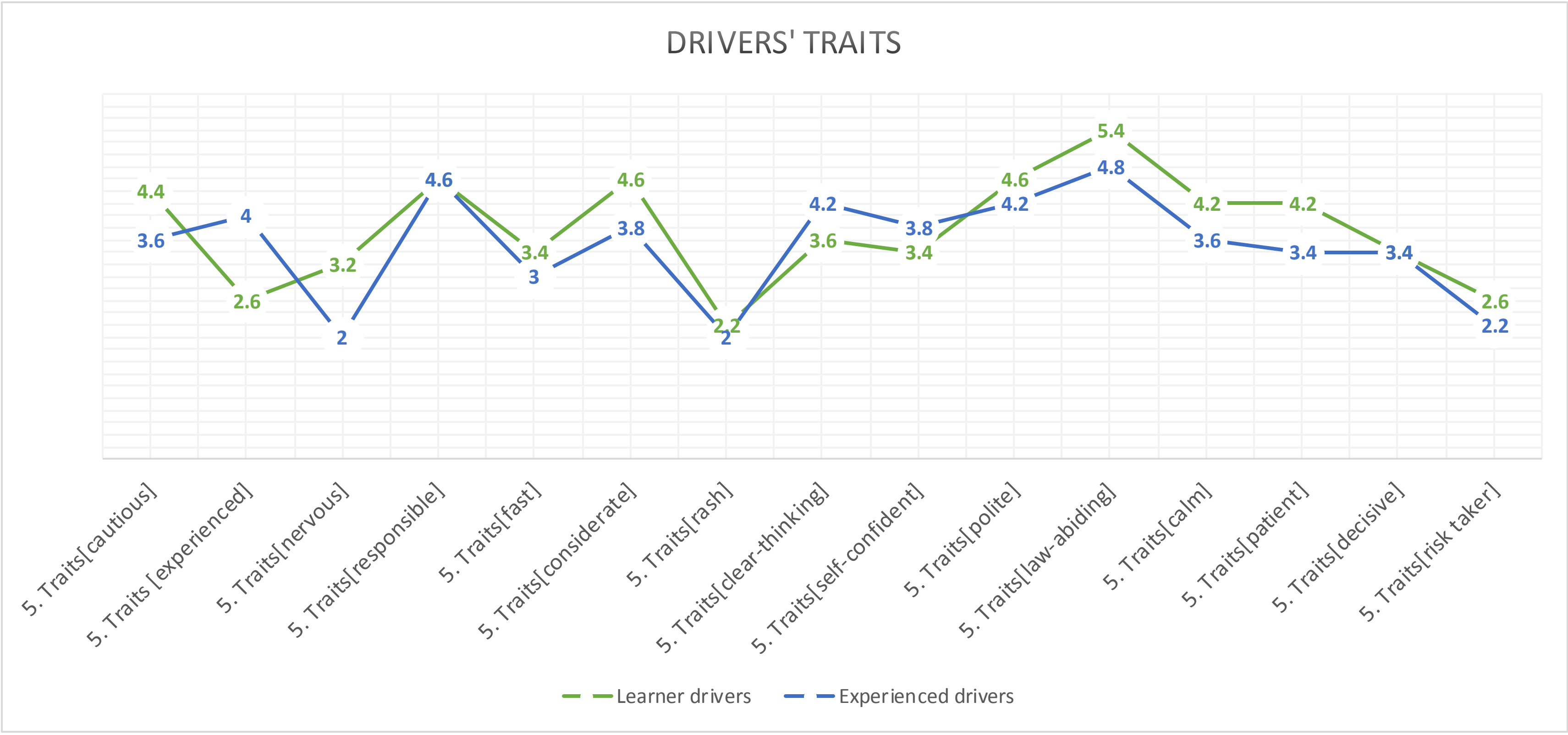


Figure 12. Differences in driver traits between learner and experienced drivers (Results from the Driver Image Inventory).

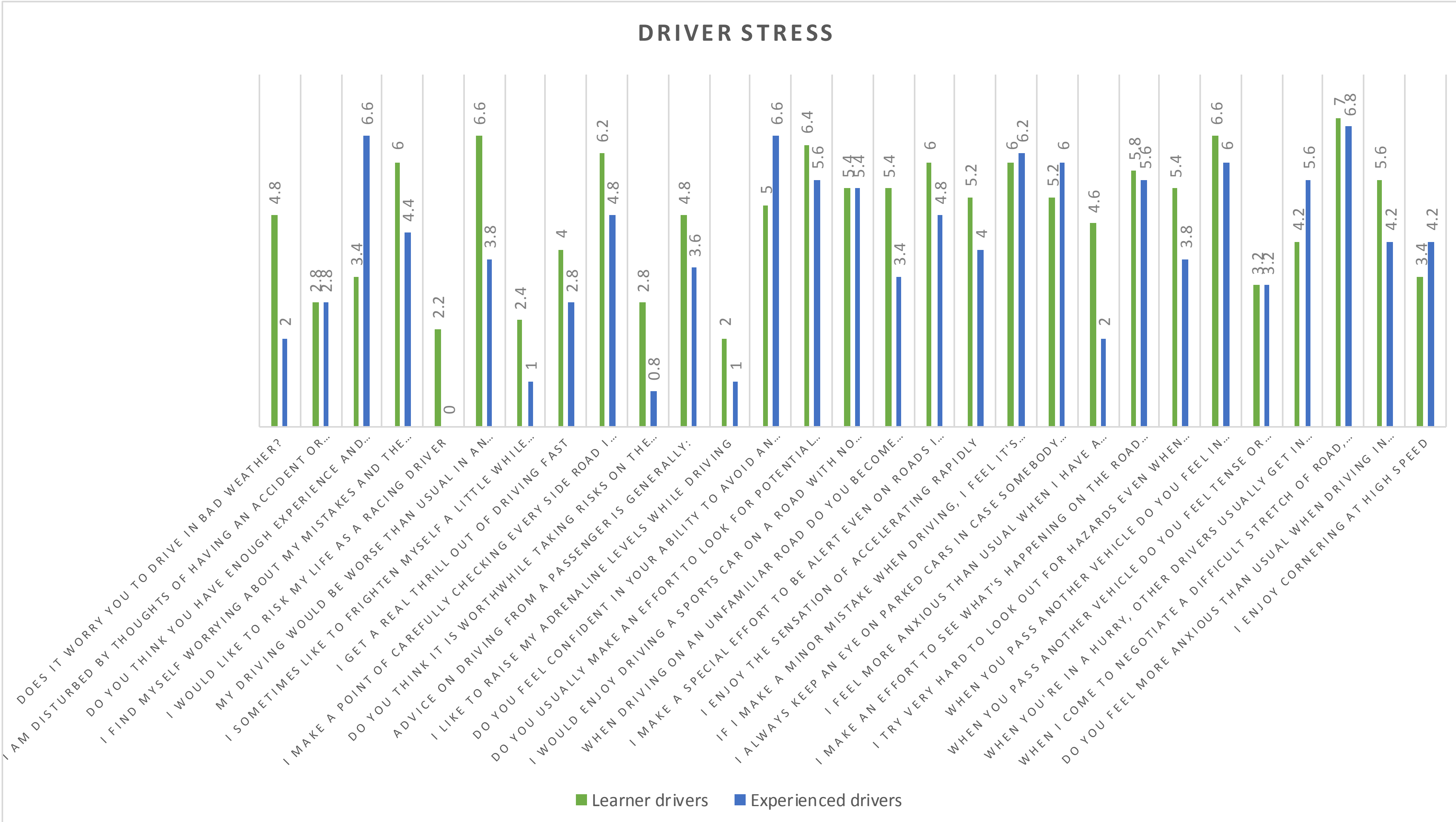


Figure 13. Differences in driver stress between learner and experienced drivers (Results from the Driver Stress Inventory).

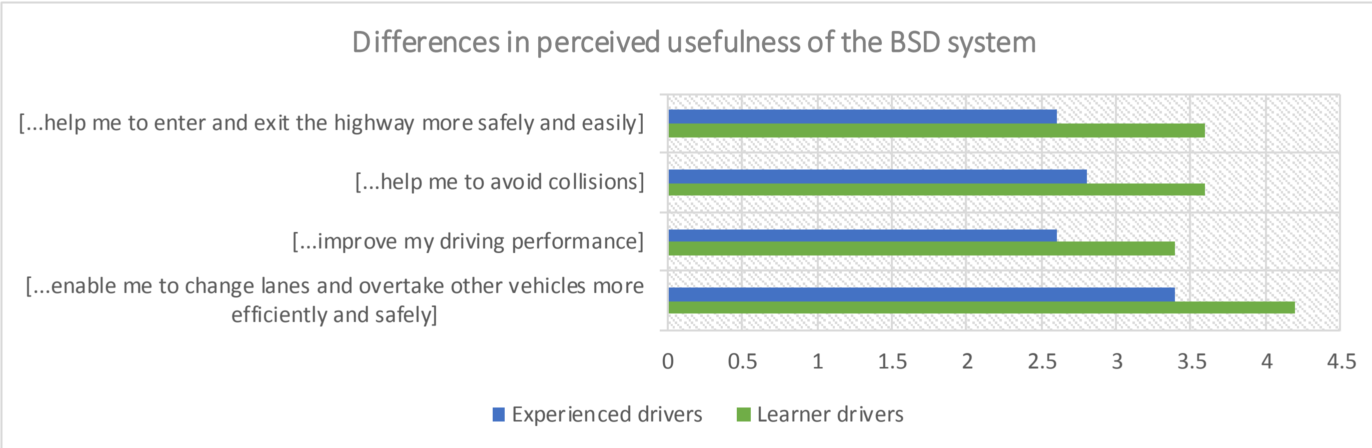


Figure 14. Perceived usefulness of the Blind Spot Detection system in different cases.

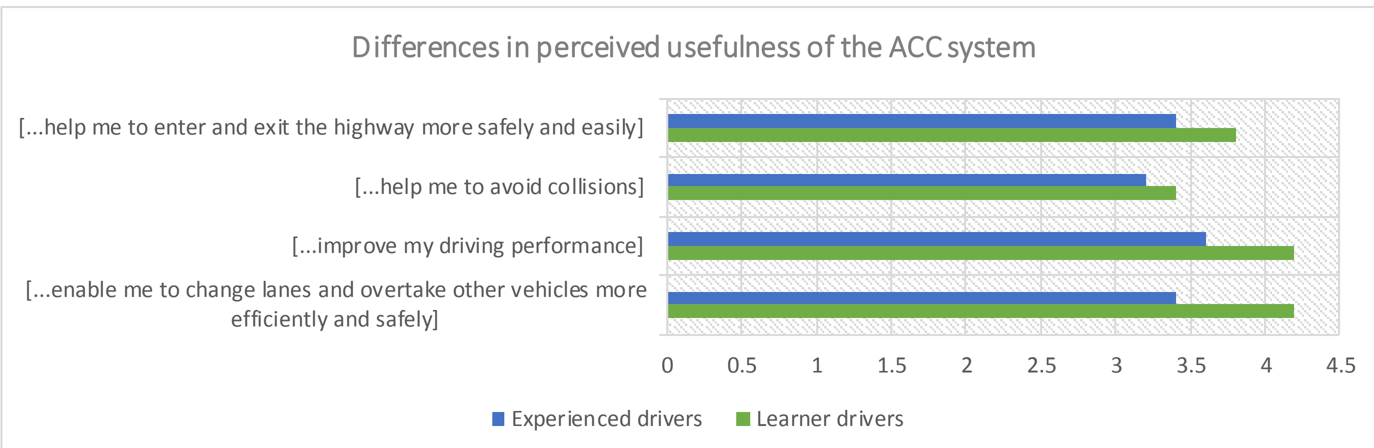


Figure 15. Perceived usefulness of the Adaptive Cruise Control system in different cases.

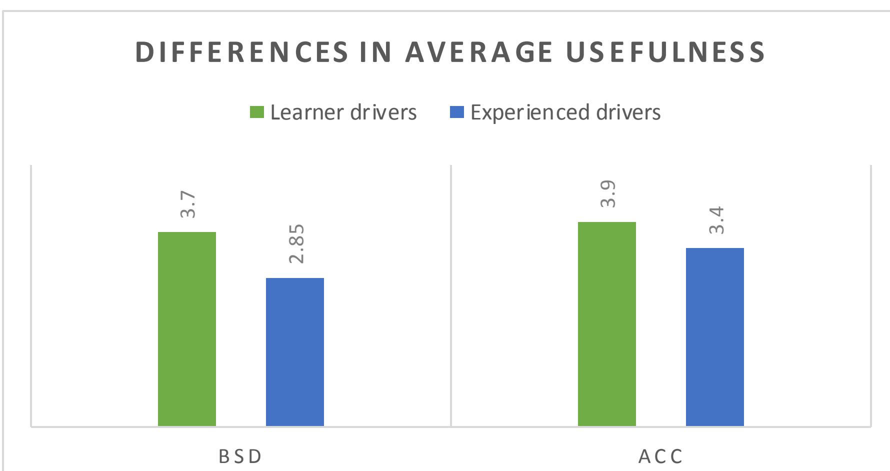


Figure 16. Average perceived usefulness of the Blind Spot Detection and Adaptive Cruise Control system.

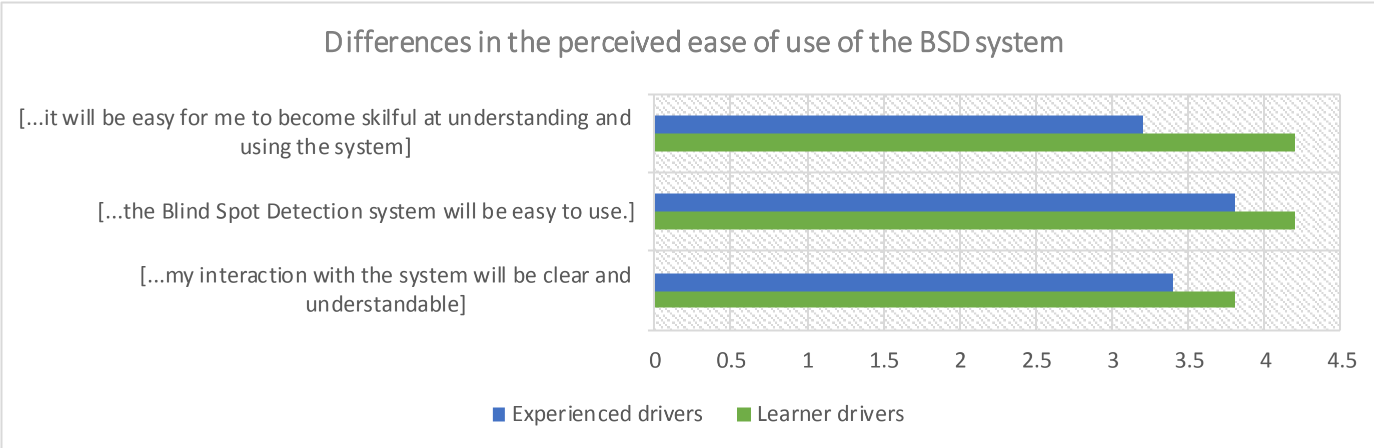


Figure 17. Different aspects of the perceived ease of use of the Blind Spot Detection system.

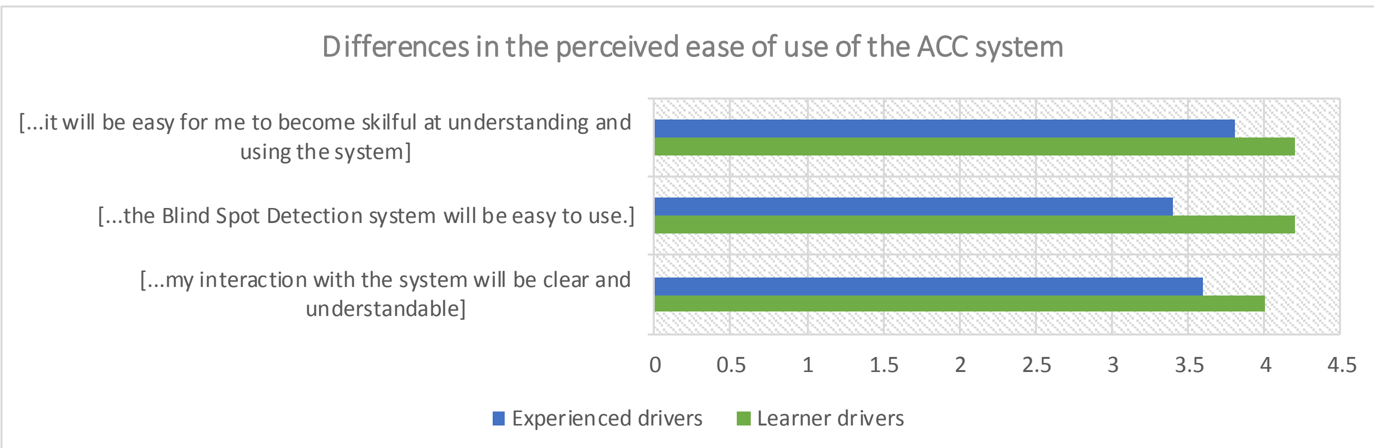


Figure 18. Different aspects of the perceived ease of use of the Blind Spot Detection system.

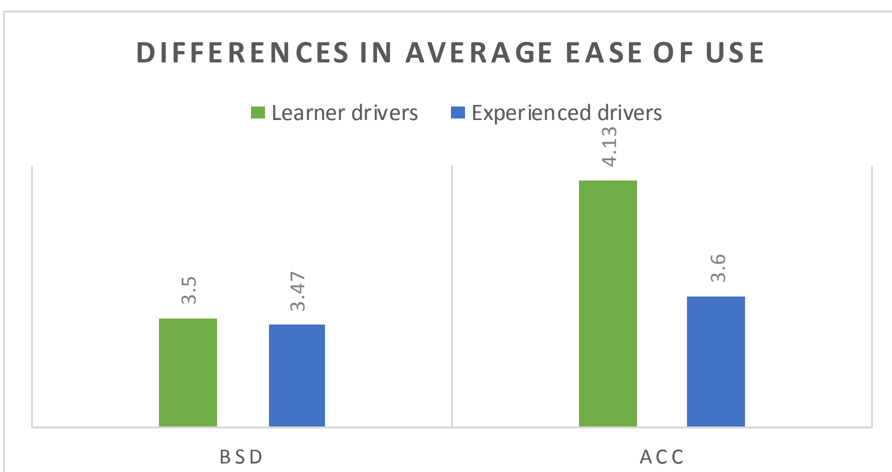


Figure 19. General perceived ease of use of the Bind Spot Detection and Adaptive Cruise Control system.

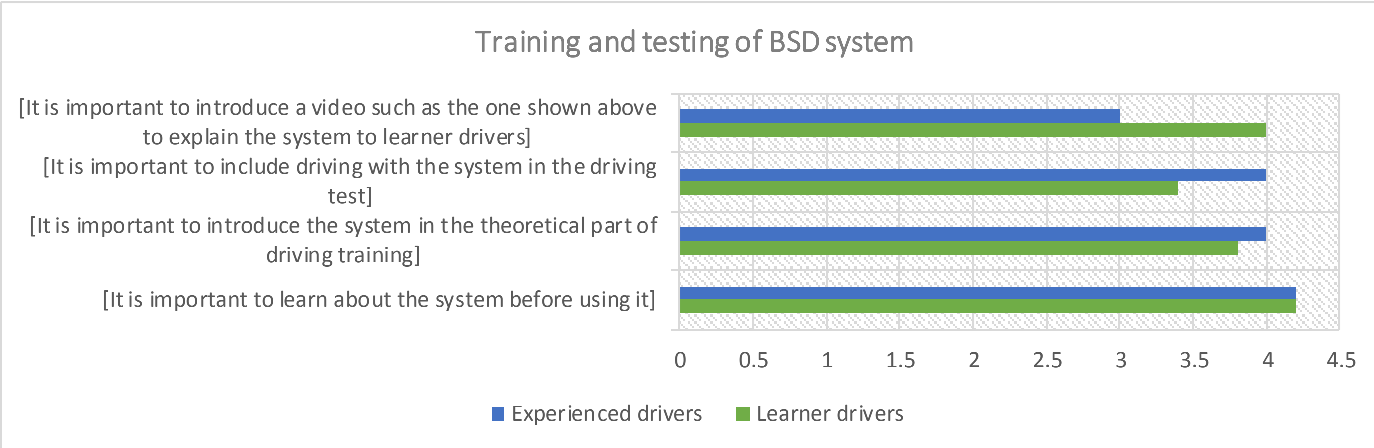


Figure 20. Different aspects on the training and testing of the Blind Spot Detection system.

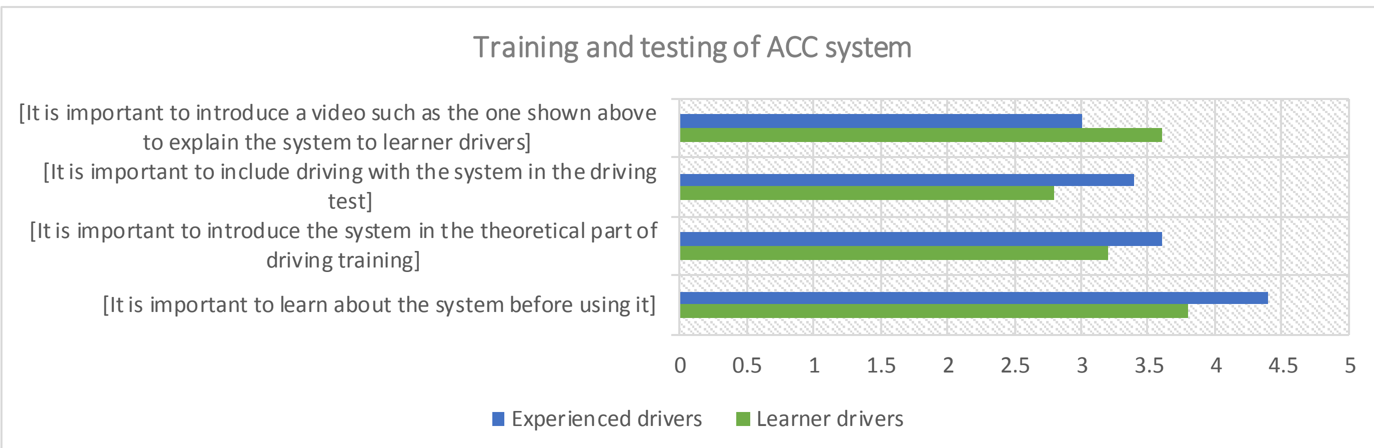


Figure 21. Different aspects on the training and testing of the Blind Spot Detection system.

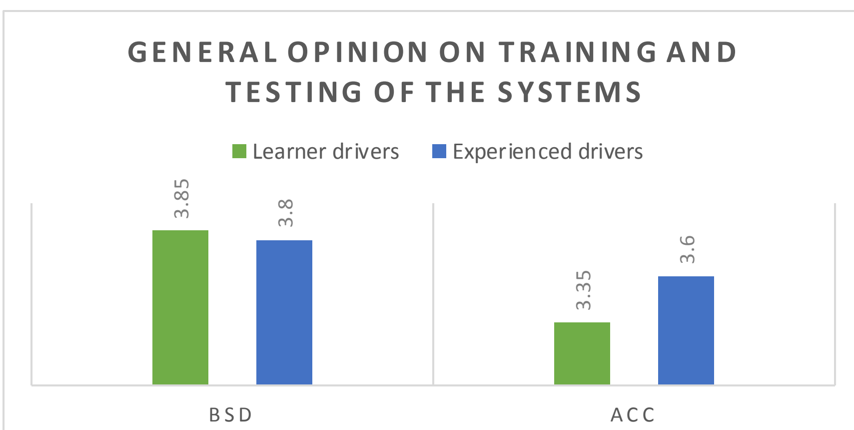


Figure 22. General opinion on the introduction of the Blind Spot Detection and Adaptive Cruise Control system to training and testing.

Appendix III

Interviews protocol and design

Interviews

Organisation and Content

Anastasia Tsapi

Delft, 2015

Defining the interview

The number of participants in the interview has to be such that in-depth knowledge on the topic is gained. Usually the number of people needed for a personal interview is smaller than the respective number of group interviews (focus groups), so less than 8 people are considered sufficient.

The ideal amount of time to set aside for an interview is **less than one hour**. Beyond that interviews are usually less productive. The interviewees' position has to be clear, without going into unnecessary details.

Designing questions

The questions should be:

- Short and to the point
- Focused on one dimension each
- Unambiguously worded
- Open-ended or sentence completion types

The questions are divided into 3 categories, being:

1. **Introductory question**. These questions are used to introduce interviewees the topic of discussion.
2. **Key questions**. These questions comprise of a number of exploratory questions, which investigate in depth the topic of the study.
3. **Ending question**. The question is used before ending the interview session. Its aim is to check to see if anything is missing from the already conducted discussion.

Recruitment of interviewees

Interviewees' inclusion/exclusion criteria should be established upfront and based on the purpose of the study. Homogeneity is key to maximizing disclosure among interview participants. For this reason, the recruitment of them has mainly taken place in the Technical University of Delft. The recruitment of the questionnaire participants has been carried out with the following ways.

- Announcements in different locations in CITG and EWI faculties and Central Library building of TU Delft;
- Announcement in screens from the Service Desk in CITG faculty building and De Haagse Hogeschool (located in TU Delft campus);
- Online questionnaire distribution in sports' groups, student associations, faculty groups and in social media group pages;
- Online questionnaire distribution in social media pages of *TeamAlert* organisation. The organisations action is related to raising the awareness of young drivers' responsibility in traffic. This is achieved through original campaigns and road safety projects, some of which are funded from the Ministry of Infrastructure and Environment. TeamAlert interacts with young people between 12 and 24 years, offering educational projects for people up to 18 years and informational ones for people between 16 and 24 (http://www.teamalert.nl/home/);
- The recruitment of learner drivers, has also been conducted outside TU Delft. Learner drivers have been recruited with the assistance of CBR (Centraal Bureau Rijvaardigheid), the Driving Test Organization in the Netherlands. The general purpose of the study has been described by CBR to a

number of driving schools, the owners of which agreed to communicate the need to their students and deliver the questionnaire.

After filling in the questionnaire, the training participants that have showed willingness to participate in the interviews have been isolated. Aiming to gather interviewees with different points of view, the final candidates have been selected and asked to participate in the interviews.

Conducting the interviews

Introduction

During the introduction, the moderator has to explain the purpose of the study as well as the rules of participating in the interview. At this point participants should be reminded about the workshop's confidentiality and their right to leave the procedure whenever they feel it.

WELCOME

Thanks for agreeing to be part of this interview. I appreciate your willingness to participate.

INTRODUCTION
Introducing myself

PURPOSE OF THE INTERVIEW
The reason I am having this interview is to find out more about the attitude of learner drivers towards in car driving assistance systems.
Since you belong to this group of people, I need your input and would like you to share your honest and open thoughts with me.

GROUND RULES

1. I WANT YOU TO DO THE TALKING.
I would like you to openly talk about your thoughts and considerations.

2. THERE ARE NO RIGHT OR WRONG ANSWERS
Every person's experiences and opinions are important.
I would like to hear a wide range of opinions.

3. WHAT IS SAID IN THIS ROOM STAYS HERE
I want you to feel comfortable sharing when sensitive issues come up.

4. I WILL BE TAPE RECORDING THE GROUP
I want to capture everything you have to say.
I don't identify anyone by name in our report. You will remain anonymous.

<u>Introductory Questions:</u>

1. *What is your name?*
2. *How many driving lessons have you taken so far?*
3. *Do you have a driving licence for a motorbike?*

You have been taking driving lessons to get your driving licence.

4. *What are the driving tasks in which you need maximum assistance?*

Main discussion

The main discussion comprises of the key questions, which are used to gain in depth understanding on the core problem for which the interview takes place. There should be 5 key questions in order to have the appropriate time to elaborate on each one without being in a hurry.

In this document the questions apply for both of the examined systems but there will be probably two separate sessions, one for each system, and the questions will refer to one system only.

I am going to ask you few questions regarding your opinion on the technological developments to increase driving safety.

Before that, I will show you 2 videos, describing two systems. The videos have already been introduced to you in the questionnaire, but it is important that you have a clear impression about the systems we are going to discuss.

As a first step, I will ask you questions about the Blind Spot Detection system. The second part of the interview will involve questions about the Adaptive Cruise Control system. In the third part you will be asked questions about the combination of the systems. In the end of the interview, you will be free to add information on topics you think they were not covered sufficiently or give other related comments.

<u>Part 1: Blind Spot Detection system</u>

At the moment, the Blind Spot Detection system is not present in the driving training and testing.

5. *What do you think about the usefulness of the BSD system in assisting you to carry out the tasks you need maximum assistance with?*
6. *Are there any other tasks you think the system would be useful for?*
7. *What are, in your opinion, the advantages and disadvantages of adding the Blind Spot Detection system in the driving learning and testing procedure of young drivers?*
8. *Suppose that the BSD is part of the training and testing procedure. How would you like to be trained and tested on the BSD system?*
9. *Of all the things we discussed, what, in your opinion, is the most important aspect regarding the introduction of the Blind Spot Detection system to training and testing?*

<u>Part 2: Adaptive Cruise Control system</u>

At the moment, the Adaptive Cruise Control system is not present in the training and testing of drivers.

10. *What do you think about the usefulness of the ACC system in assisting you to carry out the tasks you need maximum assistance with?*
11. *Are there any other tasks you think the system would be useful for?*
12. *What are, in your opinion, the advantages and disadvantages of adding the Adaptive Cruise Control system in the driving learning and testing procedure of young drivers?*
13. *Suppose that the BSD is part of the training and testing procedure. How would you like to be trained and tested on the ACC system?*
14. *Of all the things we discussed, what, in your opinion, is the most important aspect regarding the introduction of the Blind Spot Detection system to training and testing?*

<u>Part 3: Combination of the systems</u>

15. *What is, in your opinion, the effectiveness of the combination of these two systems in assisting the driver both during driving training and after getting the driving licence?*
16. *If you could choose, with which sequence would you introduce the systems?*

17. *What makes you oppose to the introduction of the BSD (or ACC) in T&T, while being positive in the introduction of ACC (or BSD) in drivers' education?*

Apart from the main questions, a number of probe questions can be used to make things clearer if an answer is not specific enough. Examples of probe questions are:

- Can you talk about that more?
- Help me understand what you mean.
- Can you give an example?

End of the discussion

This is the point where the interview session is almost finished. It should be clear that all points are covered and the interviewee's opinion and aspects have been presented on the table.

To achieve this, a final question is used to reflect on the entire discussion and make the participant offer their positions on the topics of central importance to the study.

<u>Summary/Ending question.</u> Having got the participant's last view on the discussion, a brief summary of the conversation is presented to them. This is the final question to the interviewee before thanking them for their presence and contribution to the study.

<u>*Part 4: Final remarks*</u>

- *Is there something you would like to add in what is already discussed?*

<u>Thanking the participants.</u> Thank the participants for their time, presence and their contribution to the study. Provide them the bonus card or the small award that has been agreed.

Practical matters

The following issues have to be arranged in order to successfully conduct an interview:

1. Book a room with a table, board and screen
2. Arrange coffee / lunch
3. Have paper, pens, pencils available
4. Prepare Consent forms
5. Code participants and have different papers for keeping notes for each participant (avoid having them seeing their names in my notes).

Informed Consent Form for Experimental Participants

Please read the following information carefully. You can also request a copy for future reference.

Experiment: Research Interview

Moderator: Anastasia Tsapi

Affiliation: Delft University of Technology

DESCRIPTION: You are invited to participate in a research study that investigates the use of Advanced Driver Assistance Systems. In the interview, you are asked to provide your opinion on the relevant topic.

As an interviewee you will be asked a number of questions and you will be given the chance to express your views on the topic.

Data will be extracted from this session; this will enable me to study the use of the in-car systems by different learner drivers' opinions. This data will only be used for the purposes of this research and will be confidential and anonymous.

RISKS AND BENEFITS: There are no risks taken by your participation in the interview session.

Beyond the symbolic compensation that you will receive together with some knowledge about specific in-car assistance systems, there are no other benefits to participation.

TIME INVOLVEMENT: Your participation will take approximately 45 minutes.

SUBJECT'S RIGHTS: If you have read this form and have decided to participate in this interview session, please understand your participation is voluntary and you have the right to withdraw your consent or discontinue participation at any time without penalty. Your individual privacy will be maintained in all published and written data resulting from the study.

If you agree with the above-stated conditions and are willing to participate in the experiment, please sign below. By signing the form, you confirm that you meet the following conditions:

- You are at least 18 years old.
- You have read the above consent form, understood it and you agree to it.
- You want to participate in the above-mentioned interview.

Name:

Date: Signature

Appendix IV

Data Analysis and Results

Driver Self-Image Inventory

All steps of the analysis carried out for the Driver Self-Image Inventory have been given in detail in Chapter 4 of the present report. At this point, the final result of the analysis is presented, being the Individual Factor scores.

Individual factor scores

The individual factor scores represent the perception the drivers have about their driver self-image. Taking into account that the items are scaled from 1 (not at all) to 6 (very much), the values represent the extent to which a driver perceives themselves as confident, courteous and impulsive while driving.

It has to be noted that Table 37 is the result of a multiplication of 2 matrices, the data matrix (raw respondents' answers) and the factor score matrix, which is produced by SPSS. Its calculation has taken place in EXCEL.

Table 37. Individual Factor scores. Driver Self-Image Inventory

Individuals	Factors			Individuals	Factors		
	Confident driver	Courteous driver	Impulsive driver		Confident driver	Courteous driver	Impulsive driver
1	4	5	3	**45**	4	6	4
2	3	5	3	**46**	3	4	3
3	3	5	3	**47**	4	4	3
4	3	5	4	**48**	4	4	3
5	3	5	3	**49**	3	6	2
6	4	4	3	**50**	1	5	2
7	4	5	3	**51**	1	3	2
8	3	6	4	**52**	0	4	3
9	4	6	3	**53**	1	5	2
10	2	4	4	**54**	2	4	2
11	3	5	3	**55**	1	5	3
12	4	5	2	**56**	3	6	3
13	4	5	3	**57**	0	2	4
14	2	4	2	**58**	2	3	3
15	3	5	3	**59**	2	5	3
16	3	2	4	**60**	1	5	4
17	4	5	3	**61**	1	5	2
18	4	5	2	**62**	3	5	3
19	3	5	3	**63**	4	6	2
20	3	3	3	**64**	3	5	4
21	3	5	3	**65**	3	4	1
22	3	4	2	**66**	2	5	3
23	3	5	3	**67**	3	5	3
24	3	4	3	**68**	2	4	3
25	3	4	3	**69**	3	5	3

26	3	5	3	**70**	2	4	2
27	3	5	3	**71**	0	3	2
28	3	5	4	**72**	1	4	2
29	3	4	3	**73**	3	4	2
30	4	6	3	**74**	3	5	3
31	4	5	4	**75**	1	5	3
32	4	6	3	**76**	3	5	3
33	3	5	3	**77**	1	4	2
34	4	6	2	**78**	1	5	3
35	3	4	3	**79**	1	4	3
36	3	5	3	**80**	1	6	3
37	4	4	3	**81**	3	6	3
38	3	6	3	**82**	3	5	4
39	4	4	4	**83**	1	4	2
40	4	4	2	**84**	1	5	3
41	3	5	4	**85**	2	5	2
42	3	4	3	**86**	2	4	3
43	4	5	2	**87**	3	5	2
44	3	5	3	**88**	1	4	2

Driver Stress Inventory (DSI)

The following paragraphs include information on the sequential steps that were made in order to prepare the Driver Stress Inventory for further analysis.

Factor Analysis

First, the results of the Direct Oblimin rotation (Table 38), which led to the replacement of the method by Varimax rotation, are shown. After running the analysis with Varimax rotation, a number of different solutions, containing a different number of factors, have been found. The rotated factor matrix (Table 40) presents the loadings of each item on the different factors. It can be seen that "Badweath" loads positively to the 1st factor and negatively to the 3rd one, while both loadings are higher than the absolute value of 0.4. Nonetheless, in the extraction of individual factor score, the item is only considered to load on the first factor, since this loading is higher than the other.

Table 39 depicts the results of the Ricolfi Compromise measure calculations, which have been made in order to find the best possible solution. It can be seen that the best compromise measure is found for the 3-factor solution, although the parameters of efficiency or adaptation are lower than in the other two solutions.

Table 38. Results of Direct Oblimin rotation for the Driver Stress Inventory.

Deleted Items	Extracted Factors	Correlated Items
VehPass, ExtrRisk, AccAvoid, AdvPass, NoSpeed	5	1-4 (0.376)
	4	-
	3	-
	2	-

The rotated factor matrix (Table 40) presents the loadings of each item on the different factors. It can be seen that "Badweath" loads positively to the 1st factor and negatively to the 3rd one, while both loadings are higher than the absolute value of 0.4. Nonetheless, in the extraction of individual factor score, the item is only considered to load on the first factor, since this loading is higher than the other.

Table 39. Compromise measure results for the Driver Stress Inventory.

Observed Variables (M)	# Factors (F)	Efficiency e	Adaptation a	Compromise Measure	Excluded items
23	4	0.676	0.684	0.462	VehPass, ExtrRisk, AccAvoid, AdvPass, NoSpeed
23	**3**	**0.753**	**0.632**	**0.476**	
23	2	0.833	0.379	0.316	

Table 41 displays the level of correlations between the factors, showing that not only the correlations are below the threshold value of 0.32 but also that all factors present almost no correlations between each other. Thus, Varimax solution proves to be the appropriate method for the factor score extraction. Table 42 presents the Cronbach's alpha values, after the formation of the three factors. Finally, the results of Regression (factor scores) are shown in Table 43. These values have been the basis for the calculation of the individual factor scores, which has been conducted in EXCEL and is seen in Table 44.

Table 40. Results of the rotated Factor Matrix. Driver Stress Inventory.

	Factor		
	1	**2**	**3**
TenseUR	0.745		
Breakdown	0.728		
OTakeNer	0.695		
WorryMist	0.682		
Badweath	0.679		-0.418
HeavTraff	0.609		
Rentcar	0.540		
Frighten	0.507		
AnxiPass	0.485		
ConceMis	0.470		
AheadRoa		0.811	
HazaEffo		0.776	
ParkCar		0.671	
HazaHard		0.634	
AlertEff		0.624	
DifStretch		0.557	
SideChec		0.529	
CornHSpeed			0.793
RapAccel			0.696
FastThril			0.693
Adrenali			0.566
WorthRis			0.470
RaceRisk			0.441

Table 41. Factor Score Covariance Matrix. Driver Stress Inventory.

Factor	1	2	3
1	0.894	0.008	-0.006
2	0.008	0.877	0.040
3	-0.006	0.040	0.859

Table 42. Reliability analysis for the resulted factors.

	Factor 1 "Dislike of Driving"	Factor 2 "Hazard Monitoring"	Factor 3 "Thrill seeking"
Cronbach's alpha	0.861	0.838	0.798

Table 43. Factor Score Coefficient Matrix. Driver Stress Inventory.

	Factor		
	1	2	3
Badweath	0.214	0.091	-0.205
Breakdown	0.173	0.022	-0.033
WorryMist	0.139	-0.041	0.049
RaceRisk	0.001	-0.009	0.015
Rentcar	0.040	0.002	0.027
Frighten	0.105	-0.019	0.071
FastThril	0.058	0.027	0.250
SideChec	-0.006	0.082	-0.044
WorthRis	0.058	-0.074	0.064
Adrenali	0.043	-0.049	0.121
HazaEffo	-0.018	0.232	-0.009
TenseUR	0.191	-0.004	0.052
AlertEff	0.050	0.150	-0.090
RapAccel	-0.013	0.026	0.162
ConceMis	0.098	0.002	0.055
ParkCar	-0.034	0.158	-0.022
AnxiPass	0.046	-0.001	0.050
AheadRoa	-0.122	0.343	-0.003
HazaHard	0.032	0.108	0.032
OTakeNer	0.171	-0.004	-0.049
DifStretch	0.032	0.110	-0.022
HeavTraff	0.077	0.003	0.024

Table 44. Individual Factor scores. DSI.

Individuals	Factor			Individuals	Factor		
	Dislike of Driving	Hazard Monitoring	Thrill-seeking		Dislike of Driving	Hazard Monitoring	Thrill-seeking
1	4	6	2	45	0	7	6
2	5	9	1	46	2	8	4
3	5	9	6	**47**	1	9	6
4	6	11	7	**48**	0	7	2
5	3	8	2	**49**	3	7	1
6	3	6	7	**50**	5	8	-2
7	3	10	1	**51**	5	7	-1
8	2	9	6	**52**	9	9	0

9	3	10	7	**53**	8	12	-2
10	3	10	8	**54**	2	6	4
11	4	8	0	**55**	10	6	5
12	-1	10	1	**56**	7	11	3
13	3	9	7	**57**	7	7	4
14	4	4	1	**58**	6	7	4
15	3	4	4	**59**	6	4	2
16	7	8	4	**60**	6	7	7
17	3	8	5	**61**	9	8	1
18	4	6	0	**62**	6	4	5
19	3	7	1	**63**	-1	8	0
20	3	7	2	**64**	1	8	8
21	4	8	3	**65**	0	3	0
22	2	8	1	**66**	7	11	2
23	4	9	-3	**67**	2	12	5
24	0	9	0	**68**	6	7	2
25	2	5	5	**69**	6	7	6
26	7	7	0	**70**	4	5	1
27	4	6	1	**71**	2	2	0
28	5	9	4	**72**	7	6	5
29	5	6	6	**73**	3	9	4
30	-1	9	2	**74**	2	7	3
31	5	9	7	**75**	6	6	1
32	1	9	4	**76**	5	8	0
33	1	10	8	**77**	3	6	-1
34	4	8	2	**78**	6	9	-1
35	5	5	3	**79**	10	9	2
36	1	8	6	**80**	6	8	2
37	2	5	5	**81**	7	9	1
38	1	12	-2	**82**	3	9	6
39	0	10	4	**83**	5	10	3
40	0	7	1	**84**	5	4	1
41	1	11	2	**85**	6	11	2
42	6	8	7	**86**	5	6	3
43	0	6	1	**87**	3	8	6
44	2	3	0	**88**	4	6	2

ADAS related analysis

At this point the results of the separate steps in the factor analysis are given. The same procedure has been followed for both systems. Specifically, the internal consistency of the answers for the sub-questions has been checked with the Reliability Analysis, which led to the conclusion that all items can participate in the factor analysis. Since the factor analysis has been carried out for each factor separately, no rotation was chosen for the interpretation of the loadings. In addition, there was no need in employing Ricolfi's procedure for the compromise measure calculation, considering that there was only one possible solution in all cases.

After the clustering analysis, more aspects of the systems are examined with the assistance of statistical tests. In this part, the systems are examined under the same section.

Blind Spot Detection system (BSD)

Three factors, called "Perceived Usefulness", "Expected Ease of Use" and "Training and Testing" represent the three sets of questions that are found in the questionnaire.

Reliability Analysis

Although the number of items per factor is already small, Reliability Analysis had to be implemented. Table 45 shows that the deletion of any items was not necessary, since such exclusion would not have led to a higher value of Cronbach's alpha, with the initial being 0.873, 0.855 and 0.669 for the 3 factors respectively.

Table 45. Reliability Analysis results for the BSD system.

Factor	Item	Cronbach's Alpha if Item Deleted
"Perceived Usefulness"	Perceived usefulness for traffic safety	0.838
	Perceived usefulness for lane changing	0.827
	Perceived usefulness for improvement of driving performance	0.865
	Perceived usefulness for collision avoidance	0.839
	Perceived usefulness for entering and leaving the highway	0.861
"Expected Ease of Use"	Interaction with the system is expected to be clear	0.834
	System is expected easy to use	0.757
	Driver is expected to become skillful in understanding and using the system	0.803
"Training and Testing"	Importance of knowing the system before using it	0.638
	Importance of introducing the system in the theoretical part of training	0.604
	Importance of introducing the system in the drivers' test	0.497
	Importance of using a video as a teaching tool	0.642

Factor Analysis

Running separate factor analyses for each set of questions, Table 46 presents the factor coefficients that have been calculated through regression. Repeating the already described procedure for the derivation of the individual factor scores, the final matrix is shown in Table 47.

Table 46. Factor Coefficient Matrix for the BSD system.

Factor 1 "Perceived Usefulness"	Score
Perceived usefulness for traffic safety	0.239
Perceived usefulness for lane changing	0.343
Perceived usefulness for improvement of driving performance	0.138
Perceived usefulness for collision avoidance	0.265
Perceived usefulness for entering and leaving the highway	0.141
Factor 2 "Expected Ease of Use"	
Interaction with the system is expected to be clear	0.212
System is expected easy to use	0.545
Driver is expected to become skillful in understanding and using the system	0.285
Factor 3 "Training and Testing"	
Importance of knowing the system before using it	0.153
Importance of introducing the system in the theoretical part of training	0.175
Importance of introducing the system in the drivers' test	0.619
Importance of using a video as a teaching tool	0.165

Table 47. Individual Factor Scores for the BSD system.

	Factor				Factor		
Individuals	Perceived Usefulness	Expected Ease of Use	Training and Testing	**Individuals**	Perceived Usefulness	Expected `Ease of Use	Training and Testing
1	5	5	4	**45**	3	4	2
2	3	4	3	**46**	4	4	3
3	5	4	5	**47**	5	5	2
4	5	5	3	**48**	4	4	4
5	4	5	5	**49**	3	4	3
6	5	5	2	**50**	5	3	3
7	4	5	3	**51**	4	3	4
8	4	5	4	**52**	6	5	5
9	5	5	2	**53**	5	4	4
10	4	0	3	**54**	4	5	4
11	4	5	4	**55**	4	4	3
12	3	4	4	**56**	4	5	5
13	4	5	3	**57**	4	4	4
14	6	4	5	**58**	5	4	3
15	3	4	3	**59**	0	0	0
16	4	5	3	**60**	4	4	5
17	4	4	3	**61**	6	5	5
18	5	5	3	**62**	3	3	4
19	4	4	4	**63**	1	1	1
20	4	4	5	**64**	5	4	4
21	4	4	3	**65**	5	5	5
22	4	4	4	**66**	5	4	5
23	4	4	4	**67**	5	5	5
24	2	4	3	**68**	3	4	2
25	5	5	4	**69**	5	4	3
26	5	5	4	**70**	4	2	3
27	4	5	4	**71**	5	4	4
28	6	5	3	**72**	4	5	2
29	4	4	4	**73**	5	5	5
30	4	4	2	**74**	5	5	4
31	6	5	3	**75**	4	5	4

32	4	5	4	**76**	4	4	4
33	5	4	2	**77**	4	4	4
34	4	3	5	**78**	4	3	2
35	5	4	2	**79**	4	5	3
36	4	3	4	**80**	0	0	0
37	4	3	4	**81**	5	5	3
38	4	4	4	**82**	4	4	3
39	3	4	4	**83**	6	4	5
40	3	3	3	**84**	4	4	4
41	6	5	2	**85**	5	4	3
42	5	5	2	**86**	0	5	4
43	5	5	4	**87**	2	4	1
44	5	4	4	**88**	5	4	5

Adaptive Cruise Control (ACC)

The ACC part of the questionnaire consisted of the same set of questions, which presented minor differences related to the applications of the system. So, three factors, called "Perceived Usefulness", "Expected Ease of Use" and "Training and Testing" represent the three sets of questions that are found in this part of the questionnaire.

Reliability Analysis

In comparison with the BSD system, the "Perceived Usefulness" factor comprised of 4 instead of 5 items, while some statements are different due to the different nature of the systems. Table 48 shows that the deletion of any items was not necessary, since such exclusion would not have led to a higher value of Cronbach's alpha, with the initial being 0.814, 0.805 and 0.708 for the 3 factors respectively.

Table 48. Reliability Analysis results for the ACC system.

Factor	Item	Cronbach's Alpha if Item Deleted
"Perceived Usefulness"	Perceived usefulness for traffic safety	0.764
	Perceived usefulness for efficiently adjusting to the traffic situations	0.773
	Perceived usefulness for improvement of driving performance	0.785
	Perceived usefulness for collision avoidance	0.743
"Expected Ease of Use"	Interaction with the system is expected to be clear	0.714
	System is expected easy to use	0.731
	Driver is expected to become skillful in understanding and using the system	0.752
"Training and Testing"	Importance of knowing the system before using it	0.727
	Importance of introducing the system in the theoretical part of training	0.530
	Importance of introducing the system in the drivers' test	0.648
	Importance of using a video as a teaching tool	0.629

Factor Analysis

The factor analysis for each of the three factors resulted in the factor coefficients (Table 49) that have been calculated through regression. The final individual factor score matrix is presented in Table 50. The matrix will be used in further steps, like correlation analysis.

Table 49. Factor Score Coefficient Matrix for the ACC system.

Factor 1 "Perceived Usefulness"	Score
Perceived usefulness for traffic safety	0.524
Perceived usefulness for efficiently adjusting to the traffic situations	0.513
Perceived usefulness for improvement of driving performance	0.468
Perceived usefulness for collision avoidance	0.625
Factor 2 "Expected Ease of Use"	
Interaction with the system is expected to be clear	0.381
System is expected easy to use	0.373
Driver is expected to become skillful in understanding and using the system	0.303
Factor 3 "Training and Testing"	
Importance of knowing the system before using it	0.096
Importance of introducing the system in the theoretical part of training	0.621
Importance of introducing the system in the drivers' test	0.166
Importance of using a video as a teaching tool	0.216

Table 50. Individual Factor Scores for the ACC system.

Individuals	Factor			Individuals	Factor		
	Perceived Usefulness	Expected Ease of Use	Training and Testing		Perceived Usefulness	Expected Ease of Use	Training and Testing
1	4	5	4	**45**	2	4	2
2	4	4	4	**46**	4	4	3
3	4	3	4	**47**	6	5	2
4	4	4	3	**48**	4	3	3
5	4	4	4	**49**	3	4	3
6	4	4	1	**50**	3	3	1
7	4	4	2	**51**	4	3	4
8	5	5	5	**52**	6	5	5
9	4	4	2	**53**	4	3	4
10	3	0	2	**54**	3	5	4
11	3	3	4	**55**	3	4	2
12	3	4	4	**56**	4	5	5
13	5	5	3	**57**	4	3	4
14	4	3	4	**58**	3	2	4
15	2	3	4	**59**	0	0	0
16	3	4	2	**60**	4	4	4
17	4	4	3	**61**	4	5	4
18	5	5	3	**62**	3	4	4
19	4	4	3	**63**	0	0	0
20	2	4	3	**64**	3	4	4
21	5	4	3	**65**	4	5	4
22	3	3	4	**66**	6	4	4
23	4	4	4	**67**	4	5	4
24	2	4	3	**68**	4	4	3
25	4	4	4	**69**	4	4	2
26	5	5	3	**70**	3	4	3
27	4	3	4	**71**	4	4	3
28	5	5	3	**72**	4	4	4
29	4	4	4	**73**	5	5	5
30	4	3	2	**74**	4	4	4
31	6	5	4	**75**	4	3	5
32	4	5	4	**76**	4	4	2
33	3	4	2	**77**	4	4	4

34	6	5	5	**78**	5	5	4
35	4	4	3	**79**	6	5	5
36	4	3	4	**80**	0	0	4
37	4	2	4	**81**	6	5	3
38	4	3	5	**82**	0	0	0
39	3	3	4	**83**	4	4	4
40	4	3	3	**84**	3	2	3
41	6	5	2	**85**	4	4	3
42	2	2	2	**86**	5	5	4
43	4	4	4	**87**	4	4	1
44	4	4	4	**88**	4	5	5

Usefulness and Willingness to use

Two of the ADAS related questions were devoted to the topics of usefulness and willingness to use the systems by the participants. For both systems, the participants were provided with a set of different alternatives to rate from 1 to 5 (strongly disagree to strongly agree) how much they agreed with the given statements regarding usefulness and willingness to use.

Concerning usefulness, for the BSD systems the drivers were asked to state how useful they thought it would be in improving the level of traffic safety and their driving performance. Moreover, they needed to think about the usefulness of it in helping them when changing lanes, in collision avoidance and in entering/exiting a highway. In the ACC related question, lane changing and entering/exiting a highway were replaced by the system's assistance in adjusting to the traffic situations by maintain a safe distance headway.

Table 51. Statistically significant results in usefulness of the BSD system. Experienced drivers.

	D. Performance-D. Safety	**D. Performance-Overtaking**	**D. Performance-Collision Avoidance**	**D. Performance-Merging in highway**
Z	-4.347^{b}	-3.646^{b}	-4.442^{d}	-3.010^{d}
Asymp. Sign. (2-tailed)	0.000	0.000	0.000	0.003

* ^{b}: based on positive ranks
* ^{d}: based on negative ranks

Friedman's test has been employed in order to assess the extent to which the answers on the statements differed between each other. The test has been conducted separately for each group, aiming to identify any significant differences in the perceived usefulness subject to the factors mentioned above. Table 51 and Table 52 depict the significant results of the post hoc Wilcoxon signed-rank tests and the Bonferroni correction ($p<0.008$) for the BSD system (experienced drivers) and the ACC system (both groups) respectively. Pairs where no significance was found are not presented in the results.

As far as the willingness to use is concerned, the same statements were used for the two ADAS. To be more specific, 6 pairs of driving environments were tested for statistical significance, being Urban-Rural, Urban-Highway, Urban-Congested, Rural-Highway, Rural-Congested and Highway-Congested (roads). Table 53 and Table 54 displays the pairs where significant differences were found in terms of the drivers' willingness to use. 4 out of 6 pairs of driving environments displayed significant differences in case of the BSD system, whereas only one of the relationship between road environments was not found statistically significant in case of the ACC.

Table 52. Statistically significant results in usefulness of the ACC system.

		D. Performance-Adjustment in traffic situations	D. Safety-Adjustment in traffic situations	D. Performance-Collision Avoidance
Training drivers	**Z**	-3.269[b]	-2.985[d]	-
	Asymp. Sign. (2-tailed)	0.001	0.003	-
Experienced drivers	**Z**	-4.150[b]	-	-2.909[d]
	Asymp. Sign. (2-tailed)	0.000	-	0.004

* [b]: based on positive ranks
* [d]: based on negative ranks

Besides the road environments for which differences in the willingness to use the systems are found, experienced drivers seem to considerably differentiate their willingness to use the ACC between urban and congested environments. The last finding seems to be quite bizarre, since congested environments are almost always related with urban ones. However, it can be assumed that a distinction is made by the experienced group between the two cases.

Table 53. Statistically significant results in willingness to use the BSD system.

		Urban-Highway	Urban-Rural	Highway-Rural	Highway-Congestion
Training drivers	**Z**	-3.549[d]	-3.394[d]	-	
	Asymp. Sign. (2-tailed)	0.001	0.003	-	
Experienced drivers	**Z**	-3.167[d]	-	-4.092[d]	-3.546[b]
	Asymp. Sign. (2-tailed)	0.002	-	0.000	0.000

* [b]: based on positive ranks
* [d]: based on negative ranks

Table 54. Statistically significant results in willingness to use the ACC system.

		Urban-Highway	Urban-Rural	Highway-Rural	Highway-Congestion	Urban-Congestion
Training drivers	**Z**	-3.987[d]	-3.385[d]	-2.769[d]	-3.003[b]	-
	Asymp. Sign. (2-tailed)	0.000	0.001	0.006	0.003	-
Experienced drivers	**Z**	5.401[d]	-4.550[d]	-3.649[d]	-4.104[b]	-3.072[d]
	Asymp. Sign. (2-tailed)	0.000	0.000	0.000	0.000	0.002

* [b]: based on positive ranks
* [d]: based on negative ranks

Training and testing in more depth

Wanting to gain in depth knowledge on the drivers' perception about the inclusion of the BSD and ACC systems, their open-ended responses on the respective questions have been analysed. Figure presents the opinion of both groups about the acquisition of knowledge before using the systems in real traffic conditions. The respondents' answers have been divided in four main categories, being YES, NO, NEUTRAL and OTHER. To begin with the first category of answers, participants who considered that it is important to have certain knowledge about the systems before their first use were included in this category. Opponents of this view were included in the "NO" category. Moreover, the proportion of participants who neither agreed nor disagreed with the given statement comprised the "NEUTRAL" category. Finally, answers that could not be assigned to a certain category constituted the "OTHER" category. The first two categories of answers were divided in more groups which explain the reasons why the drivers answered yes or no. The different types of explanations for the positive answers focused on the importance of being familiar with the systems to appropriately use them, the importance of being aware of all the limitations of the systems and the importance of avoiding to over-rely on the systems. In the end, participants also thought that it is crucial to have knowledge of the system in order to be correctly prepared to deal with hazardous situations in general.

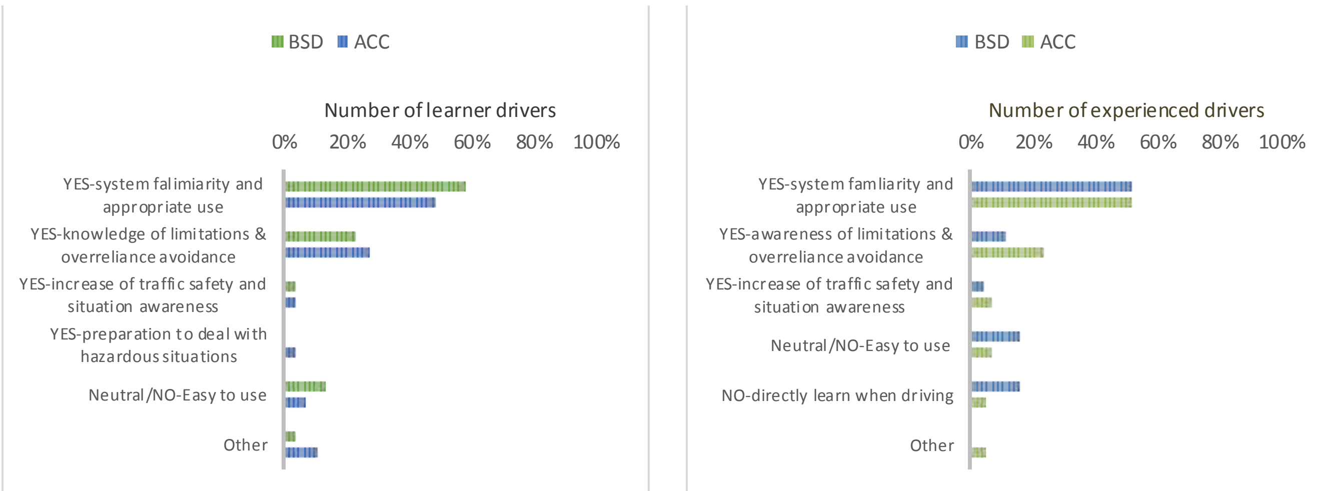


Figure 23.Importance of learning about the systems before using them. Left: Learner drivers, Right: Experienced drivers

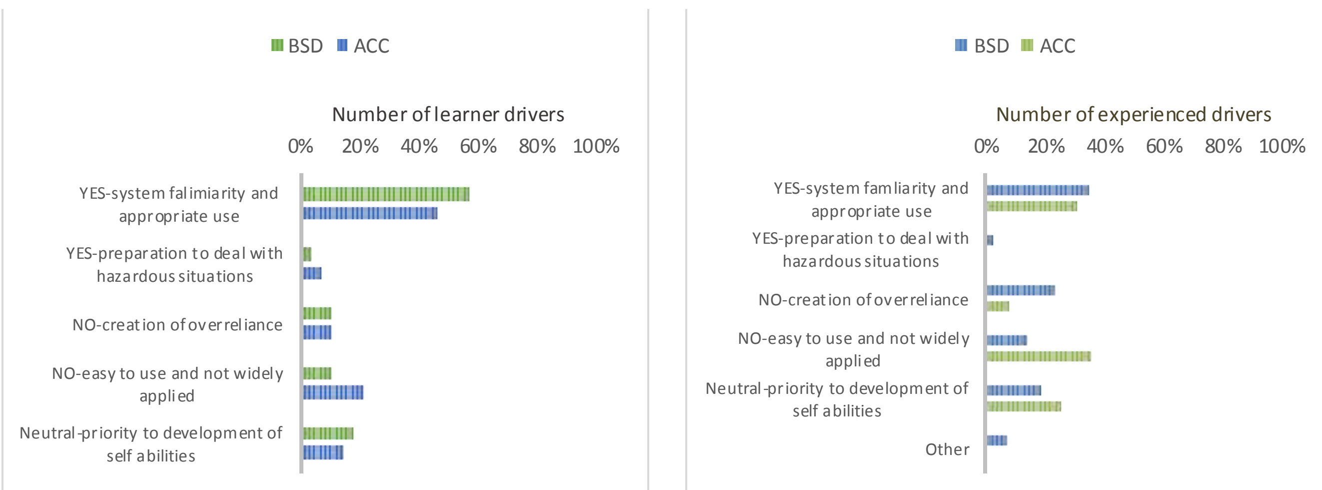


Figure 24. Importance of introducing the systems in the theoretical part of training. Left: Learner drivers, Right: Experienced drivers

On the other hand, the negative answers for having general knowledge of the systems emphasized on the fact that the systems are so easy to use that they can be learned while driving.

Regarding the importance of introducing the systems in drivers' training, similar sub-groups were formed for the positive answers, while an explanation was added for the ones who disagreed with such an innovation, being the opinion that the systems are not so widely applied to be necessarily needed in drivers' classes. The same categories represented the answers regarding the establishment of the systems in driving exams.

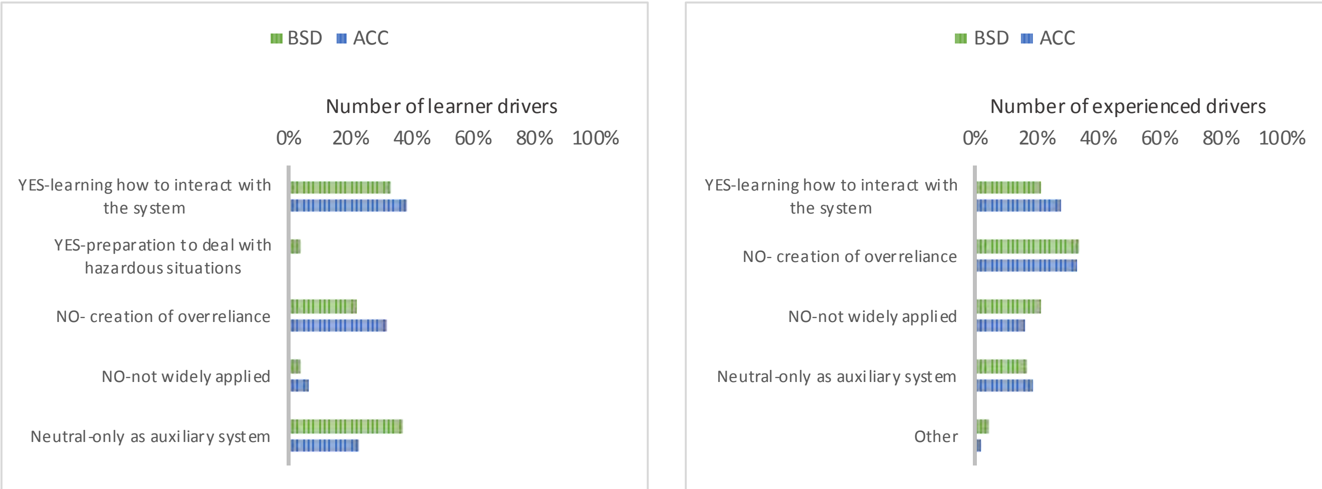


Figure 25. Importance of introducing the systems in the driving test. Left: Learner drivers, Right: Experienced drivers

Finally, people who agreed that a video could be used as a teaching tool generally reckoned that a visual tutorial is a great addition to the teaching methods, since it describes the systems' function, use and application in a direct, comprehensive and vivid way. Meanwhile, a variety of explanations were used for the negative responses. These included statements like "*the application is different from the video*" and "*manual is enough*".

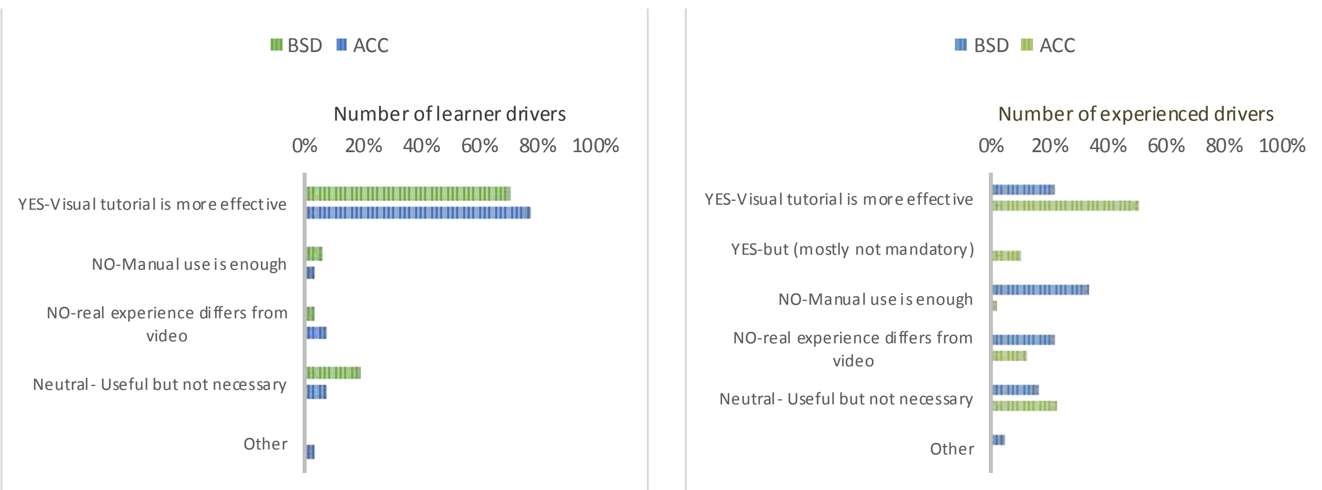


Figure 26. Importance of introducing a video as a teaching tool. Left: Learner drivers, Right: Experienced drivers.

Concerning the differences in the answers between the systems, more than 60% of the training and experienced drivers stated that it is necessary to gain general knowledge about both the BSD and ACC systems before employing them in real traffic conditions. Their main explanation was the fact that the more familiarity increases, the more correct the use of the system becomes. The introduction of the systems in driving classes was perceived differently between the two examined groups. Although the percentage of positive answers remained approximately 60% for the training participants, a rough decrease of 20% was noticed for the group of experienced drivers, who have been opposing to this innovation invoking the limited use of the systems in real life and the auxiliary character of the systems, which makes them a secondary need. However, a considerable fall of positive attitude towards both systems was recorded when participants were asked to reflect on the system's introduction to drivers' exams. The decline was small in comparison with the previous question for the experienced drivers, but relatively large (around 20%) for the training group.

Finally, the use of a video as a supplementary teaching tool raised different opinions among the groups and the systems. Training drivers would welcome such an addition in the teaching methods regardless the system. In contrast, only one fifth of the experienced drivers considered such a change as useful in providing knowledge about the BSD system, whereas the respective percentage for the ACC reached 60%. According to this group of participants, the BSD system is rather simple compared to the adaptive version of cruise control that requires more attention and involvement of the driver.

Associations between Driver Stress and ADAS related attitude

Table 55 and Table 56 depict the type of relationships found between the driver stressors, resulting from the Factor analysis of the Driver Stress Inventory, and the opinion of the two groups of drivers about the importance of including the BSD and ACC systems in drivers' training and testing procedures.

Table 55. Pearson correlation between training driver self-images and attitude towards ADAS in training and testing.

		Dislike of Driving	Hazard Monitoring	Thrill seeking
Positive attitude towards the introduction…	**of BSD in training and testing**	-0.013	0.115	0.052
	of ACC in training and testing	0.248	0.143	0.031

* Correlation is significant at the 0.01 level (2-tailed)

** Correlation is significant at the 0.05 level (2-tailed)

A significantly negative relationship is found between Thrill seeking and the considerations of the experienced drivers regarding the systems' involvement in drivers' education. Therefore, the higher the tendency of the experienced drivers to search for thrill and adventure while driving, the lower the importance of being trained and tested for the BSD (r=0.420**, p=0.003) and the ACC (r=-0.358*, p=0.013) system is.

Table 56. Pearson correlation between experienced driver self-images and attitude towards ADAS in training and testing.

		Dislike of Driving	Hazard Monitoring	Thrill seeking
Positive attitude towards the introduction…	**of BSD in training and testing**	0.109	-0.191	**-0.420****
	of ACC in training and testing	0.042	-0.099	**-0.358***

* Correlation is significant at the 0.01 level (2-tailed)

** Correlation is significant at the 0.05 level (2-tailed)