Master's thesis report

Drivers' willingness to use Adaptive Cruise Control (ACC)

Implications for future implementation strategies of Autonomous Vehicles

by

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Technische Universiteit Eindhoven
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Colophon

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Implications for future implementation strategies of Autonomous Vehicles

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Mario Santamaria Puga,
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Summary

Introduction

The main problems related to mobility are pointed out in the literature analysis. In order to cope with these problems the research questions and the research design are proposed. A solution through the use of Smart Mobility by means of Adaptive Cruise Control technology is suggested, which might help to increase drivers' comfort as well as improve safety and reduce traffic congestion, thus, upgrading the citizens' quality of life.

Adaptive Cruise Control (ACC) is a system that lies within what is known as Advanced Driver Assistance Systems (ADAS): electronic systems designed to support drivers with different levels of assistance. ACC is capable to automatically adjust the speed of the vehicle by matching the speed of the vehicle ahead and a pre-defined gap-time. In case that there are no vehicles in front, ACC maintains a specific pre-defined speed. Even though the first ACC systems entered the market long time ago and high potential benefits are expected to be achieved with its use, the observed penetration rate is quite low until now. Therefore, these proven facts (or observations) provide an opportunity to study in more detail the users' willingness to use this technology.

Research method

In order to explore which circumstances have an effect on the drivers' willingness to use ACC, a stated choice (SC) experiment is designed and an online questionnaire is used to collect the data. The stated choice is a convenient method to employ due to the fact that hypothetical situations are being analysed. This is done with the aim to answer the main research question (How are different driving conditions influencing drivers' willingness to use Adaptive Cruise Control?). The influence of the driving conditions ion the drivers is analysed in the literature review. The aforementioned information is used to build up the survey instrument, which contains the SC experiment. In addition, information regarding respondents' driving experience and socio-demographic information, as well as questions to determine the respondents' ADAS knowledge and their driving style are asked. Finally, the collected data is analysed with the use of descriptive analysis for the respondents' experiences, and an ordinal regression model for the experiment section.

Results

The description of the results of this thesis are divided among three parts. The first part describes the resulting sample, which is formed by 208 respondents, showing their experiences, socio-demographic characteristics, etc. The second part focuses on the experiment's analyses where a general model and several submodels are analysed. Finally, the last part describes the factors underlying the ACC choice decision and the willingness of the respondents to possess ACC.

The sample of this research is formed by a highly educated group that consists of 68% male and 32 female respondents. Half of the respondents are younger than 30 years old, which considered to be a good age distribution. Their driving experience is evenly scattered through

all the levels, as well as the household distribution, which provides a good sample to analyse the obtained information.

Aside the aforementioned information, the respondents' knowledge level regarding ADAS was also requested, which is used to formulate three groups of individuals depending on their knowledge level ("Low", "Middle" or "High"). Indicating that a group of the users are aware of most of the systems or have used them.

The respondents' driving style is identified and divided in four driving style groups ("Anxious", "Reckless and careless", "Angry and hostile" and "Patient and careful"). The number of respondents are evenly distributed between the four driving style groups that are used to compare the similarities and differences among them.

After that, the general model and several additional models for separate groups are analysed with an ordinal regression model to find out what driving conditions are the ones influencing the users' willingness to use ACC. Following examination of the models, it is observed that there are four out of the seven attributes that are significantly influencing the users' willingness to use ACC. The first one is the "Road condition", which positively influences the users in the case that a "Regular (straight)" road condition is considered. The second one, "Trip distance", has a positive effect when considering long trips compared to short ones. "Level of fatigue" is the third attribute modifying users' willingness to use ACC, where in the case of being 'fresh' is less desired to activate ACC than being tired. Finally, the last attribute is "Visibility" and it is detected that the use of the system it is slightly profiting in a "High (cloudless)" visibility situation.

The last part describes the factors underlying the ACC choice decision-making as possible reasons to turn ON or OFF the ACC. The three factors are safety, comfort and fuel efficiency, which are perceived as positive features for the use of ACC by the respondents. This is evident by the fact that three out of four respondents who selected any of the factors in the suggested situations are "agreeing" to the active use of ACC. Additionally, the willingness of the users to possess ACC in a future car is asked, which indicates that most of the respondents are highly interested in purchasing it.

Conclusions and recommendations

The majority of individuals is willing to use ACC in most of the suggested driving conditions. This is concluded since for the proposed situations the respondents are mainly agreeing (67% "Agree" or "Strongly Agree") with the statement of switching ON the ACC, with a double of positive than negative responses (meaning switching OFF the ACC). Additionally, in order to be willing to use the system, the respondents are also willing to possess ACC in a future car, which indicates a good disposition towards the system.

The results indicate higher levels of users' willingness to use the ACC than the real usage, suggesting that increasing its usage is feasible. As part of the recommendations offered in this research, governmentally subsidising ACC is suggested. This might be done to partially cover the cost of ACC in order to promote the system and raise its penetration rate.

Abstract

Problem: Adaptive Cruise Control (ACC) system is a part of the Advanced Driver Assistance Systems (ADAS), in brief, a time-gap with the car in front and specific speed is maintained by the system, which is pre-defined by the driver. Despite the fact that the first ACC systems were introduced in the market ago and the expected benefits associated with their usage show high potential, the penetration rate of ACC systems has been quite low until now. Therefore, an opportunity for a thorough study into the users' willingness to use this technology is provided.

Objectives: This thesis aims to explore the factors that affect the drivers' willingness to turn ON/OFF the ACC system.

Method: A stated choice experiment is designed and an online questionnaire is used to collect the data, which, main experiment aside, includes the respondents' driving experience and socio-demographic information, and questions to determine the respondents' ADAS knowledge and their driving style. The data from the experiment is analysed with an ordinal regression model.

Results: The respondents (N=208) are mostly agreeing in the active use of ACC for the majority of the proposed factors, with the amount of positive answers being double than the amount of negative ones. The findings point out to specific driving conditions influencing to a higher user' willingness to use ACC; specifically, straight highways or a cloudless situations with high visibility in comparison with the other attribute' levels. The willingness to use ACC during long trips compared to short ones is also increased. Finally, activate ACC with a high level of fatigue rather than when the driver is rested is more feasible. In addition, regarding the factors underlying the ACC choice decision, the three factors (safety, comfort and fuel efficiency) suggested as possible reasons to turn ON or OFF ACC are seen as positive elements.

Conclusion: Based on the results of this research, the majority of the people is willing to use ACC in most of the suggested driving conditions. Additionally, the respondents are also willing to possess ACC in a future car, which indicates a good disposition towards the system.

List of abbreviations

AV	Automated Vehicle, Autonomous Vehicle
ADAS	Advanced Driver Assistance Systems
ACC	Adaptive Cruise Control
SPSS	Statistical Package for the Social Sciences
LKA	Lane Keeping Assist
FCW	Forward Collision Warning
LDW	Lane Departure Warning
FEW	Fuel Efficiency Adviser
APA	Automated Parking Assist
BSW	Blind Spot Warning
CCC	Conventional Cruise Control
TJA	Traffic Jam Assistance
RC	Revealed Choice
SC	Stated Choice

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1. Introduction

Very large urban centres and population growth are exacerbating a problem in mobility, making the duration of commuting trips every year more time consuming, which ultimately reduces citizens' life quality (Schrank, Eisele, & Lomax, 2012). In addition, the existence of satellite or dormitory towns produces a higher need of commuting, from that places to the centre business districts, which is especially significant for the bigger cities (Hui & Lam, 2005).

Smart mobility has promised solutions for this problem by means of more efficient transportation system. However, even though a solution is technologically possible, the potential users must be willing to use it in order to take advantage of its benefits.

1.1. Problem definition

In the existent literature there are papers regarding the user's acceptance of ADAS (Advanced Driver Assistance Systems), and even completely AV (Autonomous Vehicles) in future scenarios (Molin & Marchau, 2004). Even the research of Molin & Marchau is from a long time ago for such a new technology, we can consider that the perceptions and preferences for different Advanced Driver Assistance Systems (ADAS) that were analysed in this research have still some validity. It was concluded that personal goals have the largest impact on the general attractiveness of the system and that drivers prefer a system that does not completely intervene in their driving task.

Recent studies in the field of user acceptance of autonomous vehicles have determined that users are not yet willing to use fully automated vehicles (Megens, 2014), although there is a group that is willing to release all control. Additionally, Voermans (2015) studies what the attributes are that benefit the most from automated driving. Voermans concluded that the best way to introduce this technology is at highways in combination with trips longer than 100 km with a medium traffic density.

However, even though some research has been done in the field of user acceptance of autonomous vehicles, this technology is still in explorative phase and it is not present in the market yet. Therefore, it is hard to get a clear result on the users' willingness to use AV. On the contrary, it is possible to study the responses to a technology that has been in the market for already several years. This is the case of Adaptive Cruise Control (ACC), a technology that within the rest of the ADA systems are considered as the next step towards self-driving cars (Mosquet, et al., 2015)

In addition, the low penetration rate of ACC is something to be concerned about, as after more than 10 years there has not been a relevant increase in its use. The penetration rate has raised from 3.7% in the year 2011 to 6.8% in the year 2013 (Öörni, 2016). Also a 6% has been reached in the U.S. in the year 2015 (Mosquet, et al., 2015). Considering both the low penetration rate and the long period of implementation, this provides a perfect opportunity to examine users' consciousness towards this technology. The reasons behind the low penetration rate are analysed, considering if it is related with drivers' unwillingness towards the use of ACC or a different reason. Therefore, a research is done for this Master thesis with the goal to discover the drivers' willingness to use ACC in different scenarios, for which some research questions are expounded.

1.2. Research questions

The objective of this research is to find out the potential of Adaptive Cruise Control (ACC) technology regarding the willingness of the drivers to activate ACC. Therefore the relation between users and ACC are analysed to determine whether ACC will be used and under what driving conditions. We can understand driving conditions as the environmental conditions that influences the driver as well as internal factors. This research goal can be sum up in the following main and sub-research questions:

How are different driving conditions influencing drivers' willingness to use Adaptive Cruise Control?

To answer the main question, some additional research questions are defined:

1. *What are the characteristics of ADAS, and specifically of ACC?*
2. *What are the expected benefits of ACC for users, society, companies and governments?*
3. *What are the most relevant driving conditions?*
4. *What is the current exposure to these technologies?*

1.3. Research design

The goal of the graduation project is to understand what circumstances increase or decrease drivers' willingness to use ACC. One of the reasons to do so is that this technology has been facing a low penetration rate, which could be produced by users' disapproval. In addition, due to the fact that ACC is currently in the market and has some of the features of AV, a comparison could be carried out between both technologies. Additionally, anticipating possible problems of consumer willingness to use self-driving cars is one of the expectations.

The process started with a literature review, followed by the setup of a stated choice experiment. Afterwards, the analyses of the results are conducted. Finally, conclusions and recommendations are provided. The research model that explains this process can be observed in Figure 1.

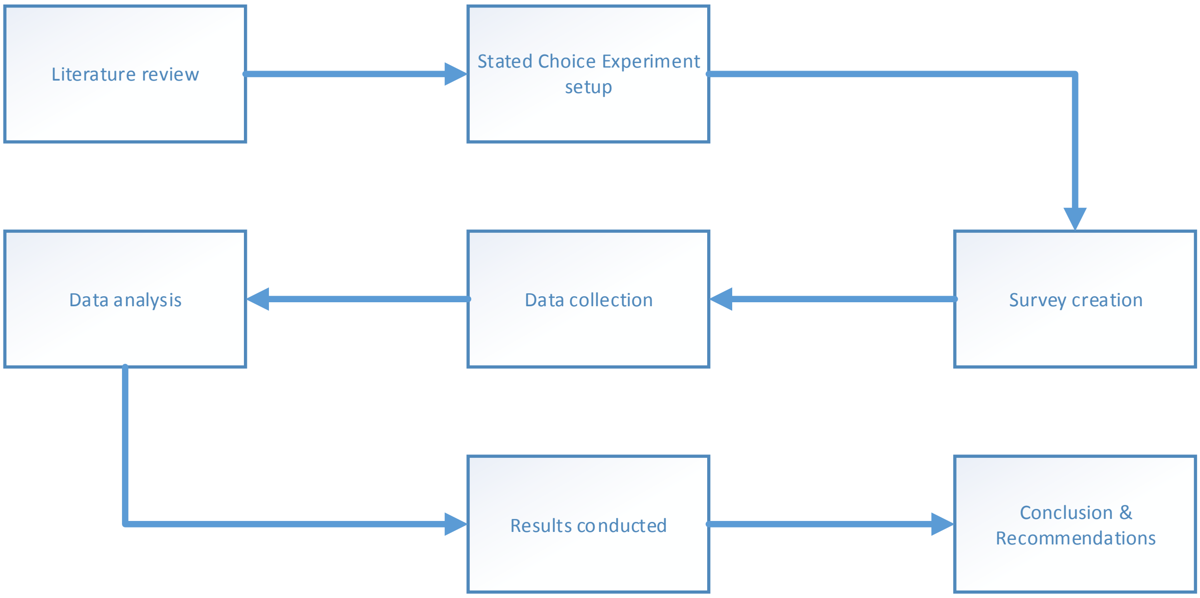

Figure 1. Research model

Literature review

In order to obtain an extensive understanding of the topic, a literature review is conducted to study what are the characteristics of ADAS and more specifically from ACC. Additionally, it is also researched about the expected benefits of this system and what characteristics affect drivers. In addition to the literature research, information of experts in the topic is used to gain insights and create a proper overview of the whole research.

Furthermore, to achieve a good knowledge about the willingness from users to use a system, technology acceptance theory is also researched.

After the literature review is finished, the first two sub-questions can be answered. The material for the literature study is to be collected from scientific journals, reports, books and relevant websites.

Stated Choice Experiment setup and survey creation

From existing research (Megens, 2014), it has been determined that one of the best methods to answer our research question is a stated choice experiment. This is partially due to the fact that the access to the technology itself is limited, as the equipped cars are from a small number and there is no easy access to these resources.

Furthermore, stated choice experiment is especially useful to provide insights into problems involving shifts in technological frontiers by making the users react against hypothetical choice situations, which matches the scope of this thesis (Cirillo & Maness, 2013).

Once the required information is obtained from the literature review, several attributes are defined and selected to develop the experiment. These attributes are represented by the different driving circumstances.

Data collection and analysis

A questionnaire with closed questions is set up and distributed to collect the data of this experiment. Once the data is obtained the analysis takes place, which is done with the use of a statistical analysis program. The software "IBM SPSS Statistics 22" is used. The data of the choice experiment is analysed with an ordinal regression model.

Conclusions and recommendations

In the conclusions, the literature review and the results of the experiment are discussed to obtain an answer to the research questions presented. The research objective is assessed and the expected results are compared with the ones obtained. Additionally to the research conclusions, recommendations for the involved stakeholders and future research are given.

1.4. Social and scientific relevance

Social relevance

The governments must be receptive and understand what the needs of the population are. Decide in what are they investing and how can this improve the quality of the inhabitants. In that sense, a research of how ACC is adopted can help the responsible parties to use this information in the decision-making processes and governance structures that, for example, improve traffic flow. Manufacture companies can focus their efforts in specific areas of the system to improve its quality to the requirements of the users. Finally, individuals and society can benefit from any future improvement in the system.

Scientific relevance

Anticipate how the possible users are willing to use new technologies in the field of mobility is necessary and especially crucial for the urban planners. Understand the impact of new technology on the road infrastructure can be useful. From an academic point of view, the research directly contributes to an increase of knowledge regarding this technology and its relationship with the users. Ideally, the knowledge obtained from the results of this research may serve as guidance for future implementation strategies of self-driving cars, considering that could anticipate some of the problems that AV technology could have to cope with.

1.5. Scope

This thesis involves passenger driving in the Netherlands and does not include, freight or public transportation as are considered to have different circumstances, which will modify the results. The Netherlands has several projects that aim to solve mobility, environmental and safety issues, with the use of new technologies in the field of Smart Mobility. In addition, the Dutch regulatory framework allows for the use of the highly extensive and sophisticated public road system as a testing environment, and it is working to create a stable regulatory framework in order to be legal to do tests with autonomous cars. This show the willingness of the Dutch government to have a role in the implementation of these technologies in the upcoming years, making the Netherlands a "living lab" to test any Smart Mobility solution (Connecting Mobility NL, 2016).

1.6. Objective and expected results

The main objective of this research is to explore under what driving circumstances the drivers are willing to use Adaptive Cruise Control. Besides the reasons behind their behaviour is expected to be understood. The conclusions of this research provide a clearer picture of what is influencing drivers' willingness to use ACC and through this, suggest in what ways could the positive features fostered and the negative weakened.

Additionally, this could lead to an increase in knowledge for getting an idea of what could be the opinion of future users of automated vehicles in similar circumstances. This could also help the car manufacturing industry to produce a quicker user acceptance of self-driving vehicle once the technology is ready.

Considering the existent literature it can be said that most of the drivers are more willing to use ACC under certain circumstances. Therefore, certain roads (highways) and traffic conditions (calm) might be more favourable (SWOV, 2010). In addition, Megens (2014) suggest that younger drivers could be more willing to release car control than users who are driving for a longer time and are, in general, less aware of new technology.

1.7. Reading guide

This report is organised with six chapters and several appendices. Chapter 1 contains an introduction in which the problem definition and research questions are formulated. Chapter 2 describes the literature review that has been followed. In chapter 3 the research method that has been used for this thesis is explained. Next, in chapter 4 the results obtained from the experiment are stated. After this, the conclusions and recommendations are included in chapter 5, where the answers to the research questions as well as limitations and recommendations are provided. Finally, the last chapter includes a discussion about the results.

2. Literature review

2.1. Introduction

Efficient and effective transport can help citizens to achieve their needs for mobility without suffering from negative impacts. This can be achieved thanks to the rapid advances in technology, which enable a smarter mobility within the application of successful transport policies. The existent challenges are identified in order to take advantage of all the potential of smart mobility.

Challenges concerning mobility

The first challenge that mobility needs to tackle is the increasing number of accidents, consequence of the increase in the number of vehicles and trips. According to studies from United Nations (2015), the current world population of 7.3 billion will reach 8.5 billion by 2030 and 9.7 billion in 2050. Furthermore, the percentage of population living in the cities is also expected to grow from 54% of the whole global population up to 70 - 75% in 2050 (Dameri, 2014; United Nations, 2015). Related with the number of passenger vehicles, the current 1.2 billion global car fleet could be doubled by 2030 (Dargay et al., 2007). This increase aggravates the traffic congestion and leads to problems of stress, pollution, loss of time, high travel times and costs, and travel fatalities.

Therefore, increasing road safety focusing on a reduction of the number of travel fatalities is important. According to the World Health Organization (2015), there are worldwide 1.25 millions of road traffic deaths per year. In addition, the vast majority of the accidents occur entirely or partially due to human errors (NHTSA, 2008; Thomas, Morris, Talbot, & Fagerlind, 2013).

Finally, there is a need to improve traffic flow for reducing congestion and stress. Effective measures should be taken to avoid an increase of congestion, producing an even slower traffic.

Smart Mobility as the technological solution

In such a complex environment, Smart Mobility can play a key role in improving transport by controlling systems efficiently. Autonomous or self-driving cars promise to be the most significant progress in mobility, completely modifying how people travel and improving user convenience. Increase in safety, lower fuel consumption, higher traffic efficiency, pollution reduction, improved productivity and especially significant user convenience are some of the expected benefits (Litman, 2015; Lang, et al., 2016). In order to reach this level of vehicle autonomy several steps need to be done, starting with Advanced Driver Assistance Systems (ADAS). These are additional electronic devices that are installed in the vehicles for supporting the driver in certain driving situations. ADAS focus on safety aspects, as well as increasing driving comfort. One of those systems is Adaptive Cruise Control (ACC), which history and operational model will be explained further.

Advanced Cruise Control (ACC), also known as adaptive, active or intelligent cruise control, is the evolution from Conventional Cruise Control (CCC) systems. “ACC not only maintains the driver-set vehicle speed but also adjusts the vehicle's speed to that of a preceding vehicle, helping to maintain a pre-selected headway time to the vehicle ahead” (SWOV, 2010). Therefore, ACC can provide a potential solution for some of the problems in the field of mobility. In order to accomplish that, a high penetration rate is required, which until now has been slow since its introduction (Dragutinovic, Brookhuis, Hagenzieker, & Marchau, 2005). Even the models introduced in 2006, have achieved only about 6 percent penetration both in the United States and worldwide after nine years on the market (Mosquet, et al., 2015). In addition, as the cars including this system are in general only high-end personal vehicles create a gap between what is technologically possible and what is accomplished in practice (Marchau & Walker, 2003).

Regarding the level of automation driving (Figure 2) in which ACC can be positioned, this has been identified according to both the Society of Automotive Engineers (2016) and the NHTSA (National Highway Traffic Safety Administration) levels. Considering their definitions, ACC is in any case considered, at least from level 1. Moreover, when the level of ACC is measured combined with other features, such as Lane Keeping Assist (LKA), we can then consider that we are facing level 2 of driving automation.

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* (“system”) monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

Figure 2. Level of automation driving according to SAE

Besides technological and legal scope problems, which will not be part of our scope, the most important challenges that have to be addressed are the human factor challenges. Therefore, this is main focus of this research. Even without considering the case of full automation, when is address the case of partial and high automation, the role of the driver starts to switch from manual controller to become a partially supervisor of the system. Regarding the possible changes in driving behaviour, a very important human factor is user acceptance. This is understood as a "*general agreement that something is satisfactory or right; or as the act of agreeing to an offer, plan, or invitation*" (Cambridge Dictionary, 2017). Analysing the users' willingness to relieve control over an autonomous vehicle and under what driving conditions has been already studied (Voermans, 2015). The different driving conditions apply to both external factors influencing driving behaviours, such as traffic conditions or weather; and internal factors such as stress or trip distance

Related to user acceptance' problem, city planners often tend to focus on sustainable transport objectives and on data measurable impacts, ignoring more complex and hard to quantify impacts, such as policies and human behaviours, which might play a greater role (Garau, Masala, & Pinna, 2016). Additionally, although the impacts of individual policies might be discreet, its effects are accumulative and synergetic.

2.2. Advanced Driver Assistance Systems (ADAS)

Advanced Driver Assistance Systems, most known with its acronym ADAS, represent electronic systems that support the drivers in their driving task. These systems are designed to support the driver with different levels of assistance. The simple systems provides information (e.g. navigation, speed limit), most advance systems also assist the driver (e.g. advanced cruise control, stop-and-go) and the last ones take over all of the driver's tasks (e.g. the automated highway system). One of the essential features of ADAS, as compared to traditional road safety measures, is that it directly intervenes in the driving task, instead of providing an acoustic or visual signal (Marsden, McDonald, & Brackstone, 1999; Dragutinovic, Brookhuis, Hagenzieker, & Marchau, 2005).

ADAS provide support to the driver by performing certain parts of the driver's task. In that sense, an automatic gearbox could be considered a form of ADAS, nonetheless, the term is associated with different type of systems. An overview of ADAS can be seen in Figure 3.

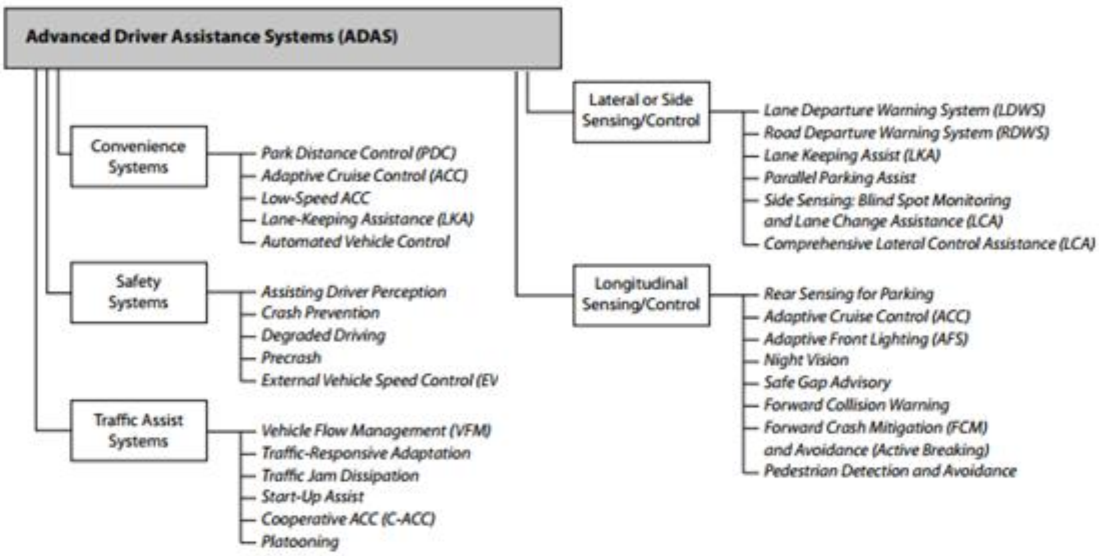

Figure 3. Overview of ADAS, retrieved from Riener (2009)

Adaptive Cruise Control (ACC)

ACC is designed to automatically adjust the vehicle speed adaptively to a forward vehicle. More information regarding this system is given in the next section (2.3), for which it is not extended in this paragraph.

Conventional Cruise Control (CCC)

CCC is designed to maintain a steady (constant) speed as set by the driver. Also more information regarding this system is given in the next section.

Lane Departure Warning (LDW)

This system is designed to decrease the possibilities of the vehicle getting out of the road or crossing into a different lane with the accident risk that this assumes. LDW uses a camera that recognizes the lane marks and warn the driver when the vehicle begins to move out of its lane without using the blinker signal. In more advance models small corrective actions without any driver input are possible. When there are no lane markings the system does not work, and would have difficulties with adverse weather. In addition, the system is generally inactive until the vehicle passes a speed of 65 km/h (Dimitrakopoulos, 2016).

Automatic Emergency Braking (AEB)

Part of the systems grouped as "Safety systems" by Riener (2009), these systems use a combination of cameras and lasers with radar to detect vehicles in front. Therefore is able to detect an impending forward crash and automatically brakes are applied to avoid the crash or reduce its severity, unless the driver does it first (Dimitrakopoulos, 2016). Is especially useful to reduce moderate and severe rear-end crashes.

Forward Collision Warning (FCW)

The technology behind this system consists of sensors that measures distance, angular position and relative speed of the obstacles. When the system finds an obstacle and detects that there is a risk of imminent crashing, alert the driver to so that can use the brake or swerve in time (Anders & Fang, 2006).

Fuel Efficiency Adviser (FEA)

This system analyse fuel consumption while you drive, providing multiple data regarding the car consume, such as average km per litre or the current trip cost. With this information the driver is able to drive more efficiently, even though the interpretation of the data has to be done by the user.

Automated Parking Assist System (APA)

This device moves a vehicle from a traffic lane into a parking spot, performing all types of parking, from parallel to perpendicular or angle parking. This is achieved due to its coordinated control of the steering wheel and speed, using the information provided by cameras and sensors to ensure that there are no collisions with the other vehicles and park within the available space (Paromtchik & Laugier, 1996).

Anti-Lock Bracking System (ABS)

This system that is now compulsory to be included in the vehicles is designed to maintain the vehicle's wheels from locking up during hard braking. Individual wheel speed sensors are used to detect brake lock-up and avoid it and assist the driver to retain steering control, which otherwise the manoeuvre would become impossible as the wheels would skid (Anders & Fang, 2006).

Blind Spot Warning (BSW)

Using a variety of sensors this system provides the driver with information regarding detected vehicles located to the driver's side and rear which are difficult or impossible to be seen by other means. Some systems activate a sound alarm if they presence an object within a blind spot, others provide cameras to transmit the blind spot image (Laukkonen, 2017).

Traffic Jam Assistance (TJA)

This system (sometimes called stop & go) can be considered as a complement to ACC. Is designed to follow the vehicle ahead and automatically operate the accelerator and brakes in congested traffic conditions, such as traffic jams or people's daily commuting. This system only works at speeds below 70 km/h (Anders & Fang, 2006).

Downhill Assist Control System (DAC)

This system is equipped in some large vehicles with the purpose to help the driver to maintain the vehicle's speed at 3-7 km/h during downhill driving. The systems automatically deactivates once the driver activates the brake (Anders & Fang, 2006).

2.3. Adaptive Cruise Control

To put the research into context, the history of ACC is explained. This is followed by the differences between CCC and ACC. Finally, ACC operational mode is described.

ACC history

The first generation of ACC systems has been available on the market (even though only in high-end car models) since the latest years from the 20th century: 1995 – Japan, 1998 – Europe and 2000 – North America (Bishop, 2005). Despite the long period of exposure, its use has not been highly extended. The quality of the system has improved over the years, enjoying right now from a high investment. This investment is to some extent due to the competition of the companies for creating self-driving cars and having an investment return at the same time (IHS Automotive, 2015; PwC Strategy&, 2016).

The ACC systems that are currently in widespread use are able to brake for the car driver, bringing the vehicle to a standstill, and recover the speed automatically once the road is free.

Cruise Control evolution (CCC-ACC-CACC)

There are currently in the market two systems with more or less similar characteristics as one is the evolution from the previous one. These are Conventional and Adaptive Cruise Control. In addition, a new system is being researched, which is called Cooperative Adaptive Cruise Control. However, this research is kept in the range of ACC and does not consider CACC, as this system is still in development and would have the same problems to be studied as an AV could have.

The first system is called Conventional Cruise Control and only maintains the speed of the vehicle at the driver-set vehicle desired speed. The second one is Adaptive Cruise Control, which is the evolution from the first one and is also known with the names of active or intelligent cruise control. The most substantial difference between both systems is that the latter not only maintains the driver-set vehicle speed but modifies its speed for that of the preceding vehicle, assisting to keep a pre-selected headway time to the vehicle ahead (Anders & Fang, 2006). ACC uses a frontal radar/laser sensor to detect the vehicles in front and adjust the speed and headway by controlling the fuel flow or slightly braking. The active braking performed by ACC can get up to maximally 30% of the vehicle's maximum deceleration. This is called braking authority and it is typically from an order of 0.25g, being the full braking in a typical car of 1.0g (Bishop, 2005; SWOV, 2010).

Considering only the difference between different ACC systems, the first models introduced in the market assists the driver at relatively higher speeds, whereas the newest systems with Stop-and-Go feature can be used as well at low speeds and should have the capability to completely stop the vehicle and resume its speed after the road is free (Sanggyum, 2012). In addition, the quality of the different models can be seen in aspects such as the time gap that is possible to select.

Finally, the latest evolution of cruise control systems is called Cooperative Adaptive Cruise Control (CACC) and is currently under investigation. The main difference is that CACC uses communication between the vehicles and/or between the vehicle and the road structure. This communication allows the control system on any single vehicle to get information about other vehicles in a platoon like the acceleration, the velocity or the brake control command (Sanggyum, 2012).

ACC operational mode

Considering what is said by the International Organization for Standardization (ISO) (2010), the main function of ACC is to control the vehicle speed adaptively to a forward vehicle. The ACC controller sends instructions to actuators for conducting its longitudinal control strategy. In addition, it provides status information to the driver.

ACC allows a driver to set the desired speed as in normal cruise control; if a vehicle immediately ahead of the equipped vehicle is moving at a slower speed, the throttle and braking of the host vehicle are regulated to match the speed of the slower vehicle and the selected time headway or gap. The desired speed is automatically re-attained when the roadway ahead is unobstructed, either from the slower vehicle ahead leaving the lane or the driver of the host vehicle changing to a clear lane. These operating modes are illustrated in Figure 4. Currently, the systems on the market monitor the forward scene using either radar or lidar (laser radar), whereas future systems may also use machine vision (Bishop, 2005).

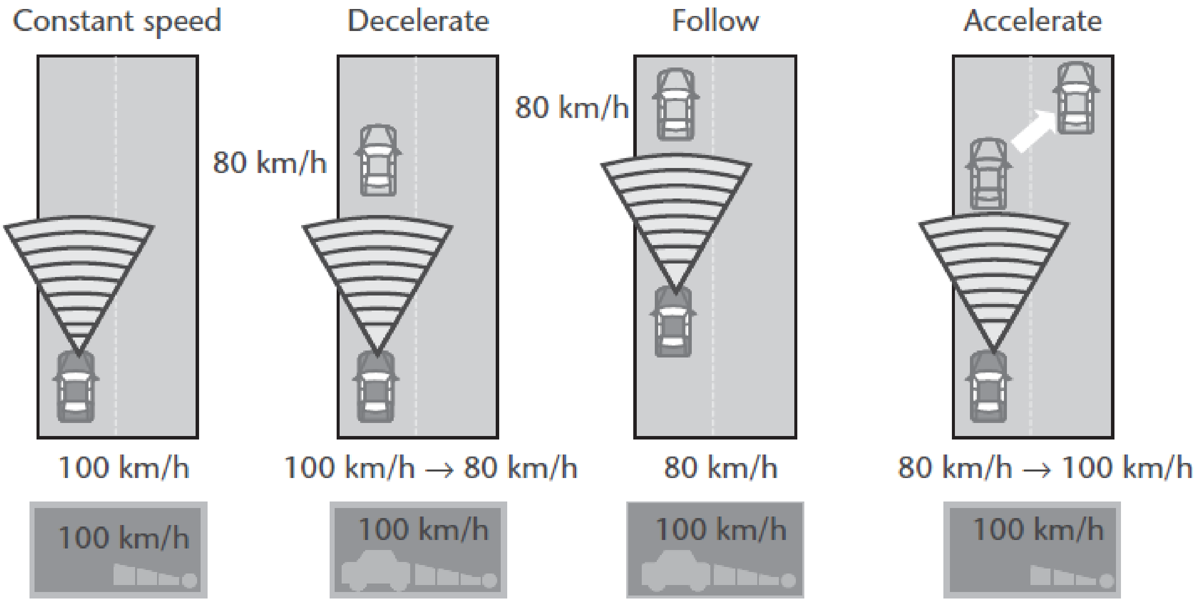

Figure 4. Operating modes for ACC (Source: Nissan)

The driver always decides whether the ACC system is turned ON or OFF. In addition, the desired velocity and the desired time headway are also determined by the preference of the driver. The desired velocity refers to the velocity that the vehicle will adopt when there is no vehicle or obstacle in front. The time headway represents the time after which the lead and the host vehicle will collide if the lead vehicle suddenly stops and the host vehicle maintains its original velocity. Gaps are based on time headway, with typical selections ranging from 1.0 to 2.2 seconds. The time headway determines the desired relative distance to the lead vehicle (Sanggyum, 2012).

From a more technical point of view, the system is composed of an observer, an upper-level controller, and lower level controllers (Figure 5). The observer directly utilises measured feedback signals, such as angular velocities of each wheel and acceleration, to estimate unmeasurable parameters such as the vehicle mass, the aerodynamic coefficient, and the road slope. Information about the lead vehicle are also measured by sensors such as the radar and vision sensors. With measured feedback signals, all this information are utilised in the upper controller. The upper-level controller analyses the information and decides the desired states of the host vehicle and produces the desired acceleration of the host vehicle accordingly. The desired acceleration commands from the upper-level controller manage the lower level controllers such as the engine control unit, the transmission controller and the brake controller. However, the vehicle may not behave as predicted by the controller because there are uncertain environmental parameters such as the road slope, the rolling resistance, and the aerodynamic resistance as well as uncertainties in the vehicle dynamics. To overcome such uncertainties the performance of the vehicle is measured and provided to the control system as feedback signals (Sanggyum, 2012).

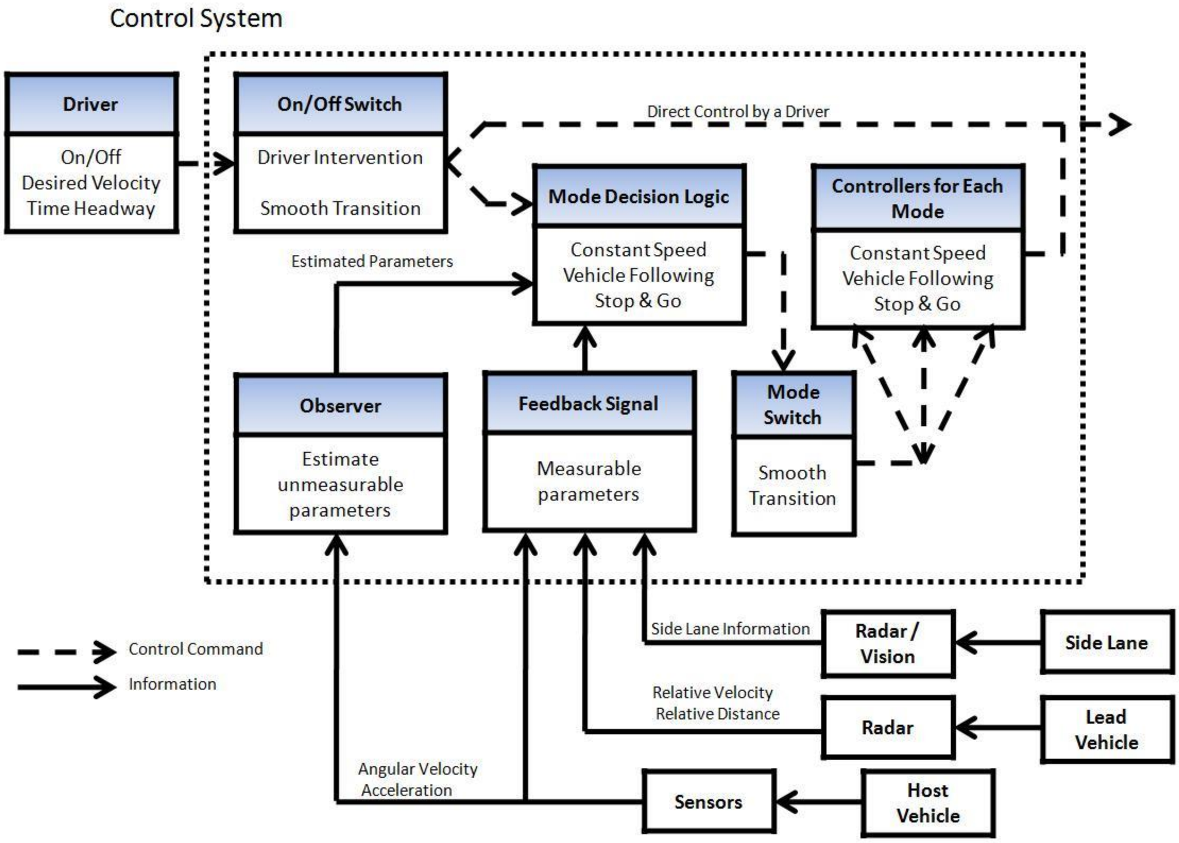

Figure 5. Retrieved from Sanggyum *(2012)*, overall ACC system structure

Currently most of the ACC models operates only above a certain speed threshold, usually from the order of 40 km/h. Moreover, due to the fact that the braking authority of the system is limited, in the cases where the distance between vehicles is closing very rapidly and additional braking is required to avoid a crash, the driver is alerted to intervene (Bishop, 2005).

Stop-and-Go ACC or Traffic Jam Assistance are the most advanced systems and are able to operate in congested traffic as well. After the traffic flow return into a regular speed, Adaptive Cruise Control is then used. This system was introduced for the first time into the Japanese market in 2004 (Toyota, 2009).

2.4. Implications for society: expected benefits

The main objective of this research is to explore under what driving circumstances the drivers are willing to use Adaptive Cruise Control. But in contrast to the long period time in which ACC is available in the market, low levels of awareness in the consumers are reported. According to McDonald, et al. (2016), only 35% of respondents knew ACC, which was the lowest awareness from the reported ADAS. Additionally, FCW also reported a low awareness (56%). This is relevant because both systems are at several models integrated as a unique system, which combination is considered to have the greatest potential to avoid or mitigate crashes (Li & Kockelman, 2016).

ACC systems have been developed as assistant driving systems to reduce or remove the drivers' longitudinal driving workload. In addition, are considered as a step into the progressive path leading to a future automated system (Xiao & Gao, 2010). For that reason, from all the stakeholders involved, the users are the ones that benefit the most from ACC, mainly due to the fact that the manufacturers want to know what elements create a higher interest to the users. Taking into account that ADAS assist the drivers during the primary driving task, it can be understood why the user are mainly benefiting. According to *PReVENT* (2009), ADAS inform and warn the driver, provide feedback on driver actions, increase comfort and reduce the workload by actively stabilising or manoeuvring the car.

There are 4 main areas in which ACC is expected to affect the current driving performance:

- Driving comfort;
- Traffic efficiency;
- Traffic safety;
- Fuel consumption.

The main expected benefit from ACC is the increase in driving comfort for the driver. Several studies have been conducted in which it has been shown that a higher workload is experienced by participants in the manual condition, confirming that automation with ACC is associated with a workload reduction. This reduction of the workload in the ACC condition might be a cause of concern in very low traffic levels (leading to over relaxation that could lead to accidents), whereas it would be a welcome relief under very high traffic levels. It is likely that ACC will have its highest performances in high demand situations as a probable means of relieving driver stress and workload (Stanton & Young, 2005; Vollrath, Schleicher, & Gelau, 2011).

Even though has to be kept in mind that ACC is a comfort based driving aid and that the system is not designed to improve road capacity, there are other aspects in which ACC can improve the current driving performance. First of all, ACC can moderate road capacity if headways of 0.8 seconds or less are possible to be achieved. In that case small increases in capacity are possible (Schakel, Gorter, Winter, & Arem, 2017). Otherwise, if longer time-headway settings are adopted (e.g., 2.0 seconds) this is indeed reducing the roadway capacity. Longer time-headway are the typical configuration from ACC, which mean that right now the traffic efficiency is being decreased with its use. In addition, due to the fact that the recommended headway distances from most governments is higher than 1.0 seconds, this creates a legal problem in the case of an accident with ACC activated and keeping your vehicle at a lower distance.

Previous experiments have showed that the driving behaviour with ACC leads to positive effects in terms of traffic efficiency. Driving with ACC reduces the speed variability, which harmonises traffic. In addition, if traffic flow is more coordinated the number of accidents that occur can be moderated, increasing safety (Hoedemaeker, 2000). Moreover, road safety improves as sudden emergency braking conditions can be avoided as situation in which the vehicle in front is too close are reduced (VDA, 2015). This can be beneficial for all users, society and governments.

The use of ACC might be considered beneficial because it could prevent the drivers from the 'tailgating' practice. A positive effect on speed and time headway with the use of ACC has already been demonstrated (Piccinini, Francesco, Rodrigues, Leitão, & Simões, 2014). Based on the research from Piccinini, et al. (2014), ACC showed a potential to improve road safety, concerning the speed and time headway maintained by the drivers. The speed of the surrounding traffic and the minimum time headway settable through the ACC seems to have an important effect on the road safety improvement achievable with the system. Finally, the security in a difficult situation such as driving with fog can be increased, due to the fact that ACC could enhance safety because the ACC's radar functions would support users' driving. Nevertheless, this would only denote an increase in safety if the driver remains attentive in order to intervene if necessary (Winter & Arem, 2016).

The last benefit in terms of traffic safety appears due to a better performance due to the fact that more homogeneous driving speeds are achieved with the use of ACC (Marsden, McDonald, & Brackstone, 2001). Furthermore, a reduction in harmful exhaust emissions as an additional result of the reduction in acceleration variation can be attained (Marsden, McDonald, & Brackstone, 1999; SWOV, 2010).

Regarding the last factor, the fuel consumption can improve (reducing the consume), which is seen through simulation and experimental results performed on a dynamic test bench, in which a great reduction not only in fuel consumption but also in engine raw emissions when comparing the controlled with the preceding vehicle was shown (Schmied, Waschl, & Re, 2015). However, there are also reasons to believe that an increase in fuel consume is produced with the use of ACC. This happens due to the fact that with long headways time, other vehicles can get into your vehicle and the forward one, making the system to use the brake and the throttle more times than with manual driving.

Finally, intuitively, if a traffic congestion reduction and a traffic capacity increase are given, this should indirectly benefit the environment. Unfortunately, only a few research studies have addressed this benefit. However, according to Xiao & Gao (2010), ACC systems do benefit the environment by reducing fuel consumption and vehicle emissions.

2.5. Influence of driving conditions

The last part of the literature review describes the driving conditions that determine the willingness of the drivers to use ACC. After Adaptive Cruise Control is implemented in compliance with users' preferences a higher usage rate is expected to take place. Therefore, in order to identify what driving conditions should be considered in the choice experiment, first has to be determined the most relevant for ACC users.

The way in which the users perceive new technology directly affects the way in which it is introduced into the market. ACC is a technology that has primarily sold by the car manufacturers as a comfort function, relieving some of the stress on the driver (Sanggyum, 2012; VDA, 2015). However, this might not be the main focus of the users and this is why all different possibilities are studied.

The first paragraph explains the external driving conditions (environment) and how the driver is influenced. The second paragraph discusses the internal driving conditions. Finally, the last paragraph describes what the personal characteristics are.

2.5.1. External driving conditions

This section considers all the aspects that cannot be influenced by the driver, and are given by the specific moment in which the trip takes place.

Road type

The type of road in which the driving takes place has, in between other influences, a direct impact in the speed and an indirect impact on the type of trip. The influences of different types of road in user acceptance of AV have been already tested in different papers (Megens, 2014; Voermans, 2015). The most common division for this attribute is to divide with three distinguished levels, which are:

1. Highway;
2. Main (urban) road;
3. Local (rural) road.

Speed limit

Additionally, in a similar division than with the road type can be directly considered not the type of road in which you are driving, which is related to a certain number of lanes, speed, etc., but the speed limit. Using the research from Sagberg (1999), this attribute can be similarly divided in three levels:

1. 100 km/h or higher;
2. 60-90 km/h;
3. 50 km/h or lower.

Traffic intensity

The traffic intensity has an obvious influence on the driver' behaviour; has a negative relation between density and speed, and subsequently with safety. The number of violation of drivers exceeding the speed limits is increased if the traffic density enables it (Hakkert, Gitelma, Cohen, Doveh, & Umansky, 2001).

According to the capacity levels given by the Transportation Research Board (TRB) (2010), these are generally divided in six levels of service. TRB considers "A" as the highest quality of service and describes it as "Traffic flows freely with little or no restrictions on speed or manoeuvrability". Also, "F" is considered the worst level, which takes place when a very congested traffic with traffic jams is found (considerable delays). In order to reduce the number, the levels of traffic density are reduced to three and these are the given labels:

1. Very high (Traffic jam: almost stopped);
2. Normal (Average to high density);
3. Low density (Calm, easy to overtake).

Road condition

The influence from the road condition in the user has not been analysed yet in the ambit of Adaptive Cruise Control. Even though, an existent research analyses the influence of different road conditions in the users' preferences regarding road lighting (van Kampen, 2015). In a similar way, two scenarios can be considered:

1. Regular (Straight road);
2. Difficult (Exit lane, sharp curve or a junction).

Visibility through weather conditions

The driving task might be influenced by weather conditions, increasing its risk when a vehicle driver faces adverse weather, such as rain, fog or snow. According to Mesken (2012), the driving behaviour of the vehicle users is adjusted to the weather, but not enough to compensate the higher risks. Supported by different researches (Bijleveld & Churchill, 2009; van Kampen, 2015), this attribute has been divided into three different levels:

1. High (Clear, cloudless);
2. Medium (Rainy, snowy);
3. Low (Foggy).

Lighting

The effects of road lighting have been analysed in several studies (Wanvik, 2008; van Kampen, 2015), showing that the task requirements are highly influenced by the lighting. To analyse the effects of each lighting condition, three levels are proposed:

1. Daylight;
2. Nightlight with lighting switched ON;
3. Nightlight with lighting switched OFF.

Time interval

Similarly to the previous attribute, the time in which the trip takes place can have an influence in the user behaviour. Considering the research from Sagberg (1999), this attribute can be divided in two levels:

1. Midnight–06:00 h;
2. 06:00 h- Midnight.

2.5.2. Internal driving conditions

This section considers all the aspects that are influenced by the driver him/herself.

Road familiarity

The knowledge that the user has from a particular road can influence its behaviour, affecting the way in which they drive (e.g. being slower if it is unknown or having more trust if it is familiar). This attribute has been used in other similar researches as well (Megens, 2014; Voermans, 2015). In that sense, three differentiated levels can be used.

1. Very familiar (daily trip);
2. Somehow familiar (sometimes trip);
3. Unfamiliar (new destination).

Level of fatigue

In general, fatigue affects task performance. According to the European Commission (2009) fatigue produces a "reduction in alertness, longer reaction times, memory problems, poorer psychometric coordination, and less efficient information processing". In addition, this is an attribute that has been previously used in other studies (van Kampen, 2015). In order to rank this attribute with three differentiated levels the Samn-Perelli 7-points scale for measuring fatigue is taken as a guideline (Millar, 2012). Therefore, reconverting the seven levels into a scale of three levels:

1. Low (Very alert, wide awake);
2. Middle (A little tired, less than fresh);
3. High (Fatigued/sleepy, difficult to concentrate).

Trip distance

The research of Etemad et al. (2012) suggests that a filtering criterion of trip distance is used to analyse the use of a navigation system depending on the trip length. The study proofs that the trip distance influences the behaviour of the driver, requiring more concentration the longer trips. The distribution of trip lengths that is used is the following:

1. Long (> 100 Km);
2. Medium (20 – 100 Km);
3. Short (< 20 Km).

Reason of the trip

There is always one or multiple reasons to drive from one place to another. Existent research have analysed what are the most common reasons for driving, considering what is the trip purpose. Using the research of Mackett (2003), three of the most common motives behind have been used to divide this attribute.

1. Commuting;
2. Groceries/shopping;
3. Social/pleasure.

Number of passengers

The last attribute that is considered is the presence of passengers in the vehicle. Travelling alone or with people affects the driver's attention, having both positive (bigger responsibility for the driver) and negative influences (being distracted by the passenger/s) (Tefft, Williams, & Grabowski, 2012). This attribute is divided into the following two levels:

1. Travelling alone;
2. Travelling with 1 or more passenger.

2.5.3. Personal characteristics

Finally, more information about the driver him/herself should be identified. The driving experience of the user, the driving style, and socio-demographic information such as gender, age or education are important to properly analyse the results (CheckMarket, 2013). That way the factors with a bigger influence can be examined.

Driving experience and mileage

The experience from a driver can be measured taking into consideration the years of driving experience and also their annual mileage. There is a strong relationship between the experience of the driver and the skills that are obtained.

Results from the study of Nabatilan, Aghazadeh, Nimbarte, Harvey, & Chowdhury (2011) conclude that the novice drivers pay more attention to the dashboard area (36%) than to the front and centre view (14%). On the other hand, the experienced drivers fixated more on the front and centre (39%) than compared to the dashboard area (12%).

Age and gender

In several researches the difference in driving behaviour is studied taking into consideration differences in age and gender of the drivers (Holland, Geraghty, & Shah, 2010; Zainuddin, 2015).

Regarding the age, research has repeatedly found a correlation between driver age and accident risk. In addition, as people grow old their driving style and skills are also changing.

Considering the gender side, the aforementioned researches show that males have, in comparison with females, a greater propensity to drive aggressively and take risks. In contrast, the results also point out a higher level of focus on the road from males compared with females.

2.6. Human factor issues regarding ADAS/ACC

Any newly developed technology not only influences individuals' people life but can also bring changes to society. This is the reason why the possible human factor issues regarding ADAS are analysed.

The research from Dragutinovic et al. (2005) suggests negative effects on driver behaviour regarding ADAS. These negative effects are seen in different aspects. The first aspect is the warning system design of these systems. When any of these systems provide too many warning signals this can result in user' rejection. This might be the case when a system is overly sensitive and increase the workload of the driver instead of increasing the comfort and safety (Anders & Fang, 2006).

Regarding the quality of an ADAS, additionally to a good algorithm, a well-designed driver interface is also needed, as this affects both a quick user response and ultimately its system' acceptance (Lee, Hoffman , & Hayes, 2004). For example, a loud auditory warning produces a quick driver response time but in the case that this happens with a high frequency (over sensitivity or false alarms), also would reduce its acceptance or even shutting down the system if possible. Therefore, this effect should be minimized.

In the book from Bishop (2005), the importance of a well-balanced ADAS is highlighted in order to get an effective system. The reason behind this is that if the driver is over confident with the system this can reduce his/her attention. On the other hand, under trust in the system prevents the driver from taking notice of the warnings or to directly deactivate it. This suggest that the design of an ADAS system interface should contribute to maintain the driver active and alert. An additional issue regarding over confidence take place if the driver uses the additional safety margin for increasing the risks or pay less attention to the driving task that when driving without ADAS.

Finally, the research of Saad (2004) points out the importance of other elements besides those previously commented. Therefore, individual characteristics such as driver's age, gender, degrees of driving experience or personality traits, are highlighted for the drivers' behavioural adaptation to different ADAS. In addition, the "driving style" factor is mentioned for assessing the different impacts on systems such as ACC. This is defined as the driver characteristic that typifies the personal way of driving (speed, safety margins, attention, etc.) and described as a relatively stable.

2.7. Driving style

The driving style refers to the manner in which drivers drive and is defined by different factors such as speed, headway, and habitual level of concentration and confidence. Another way to define the driving style is the extent to which each factor is characteristic of each driver, which means, what are the driver's typical behavioural patterns (Miller & Taubman - Ben-Ari, 2010).

In the research from Rowe et al. (2015), a relation between driving style and crash involvement, ordinary violations and errors committed is proved. In addition, Taubman-Ben-Ari et al. (2016) research show how self-report instruments are consistent and point toward a predictable way with measures of actual drives. Therefore, the validity and reliability of this method as a tool for research and evaluation purposes is proved.

Hence, in order to determine the driving style of car drivers, the research of Taubman-Ben-Ari & Skvirsky (2016) is used. This study proposes a Multidimensional Driving Style Inventory (MDSI) as the method to determine driver's driving styles. Due to the fact that it has been used during 10 years can be considered a consistent research. In addition, according to Hooft van Huysduynen et al. (2015), the MDSI is useful to understand the influence of driving style on drivers' willingness to use ADAS. Considering that what influence one group may not work at all for another group, but can be used for individuals from the same group, profiling drivers may help to identify common characteristics between each group of drivers.

As previously stated, the research of Taubman-Ben-Ari & Skvirsky (2016) is used, and the following four types of driving styles identified through the use of 44-factor-scale questionnaire.

- **Factor 1. Anxious driving style**: "Reflects feelings of alertness and tension, as well as ineffective engagement in relaxing activities during driving"
- **Factor 2. Reckless and careless driving style**: "Refers to deliberate violations of safe driving norms and the seeking of sensations and thrills while driving. It is characterised by driving at high speeds, passing in no-passing zones, and driving while intoxicated"
- **Factor 3. Angry and hostile driving style**: "Refers to expressions of irritation, rage, and hostility while driving, along with a tendency to act aggressively on the road, including cursing other drivers, honking the horn, or flashing headlights"
- **Factor 4. Patient and careful driving style**: "Reflects well-adjusted driving behaviours, such as planning ahead, paying full attention to the road, displaying patience, courtesy, and calm behind the wheel, and obeying the traffic rules"

2.8. Conclusions

Through the literature review, the answers from the first and second sub-research questions are answered. Additionally, it provides the necessary background to generate an experiment design with the sufficient information required, such as the influence of multiple driving conditions, which allows answering the additional sub-research questions and finally the main one.

The first sub-research question ("*What are the characteristics of ADAS, and specifically of ACC?*"), is answered through the information provided in Sections 2.2 and 2.3. The characteristics of Advanced Driver Assistance Systems are described and a selection from the most relevant and representative systems are given. These electronic systems can support the driver in several of their driving tasks, such as convenience systems (e.g. ACC or LKA), safety systems (e.g. AEB), lateral control systems (e.g. LKA) or longitudinal control systems (e.g. FCW or ACC). Additionally, more emphasis is given for ACC, a system that even though is present in the market during a long period of time, has not achieved a high penetration rate.

The second sub-research question ("*What are the expected benefits of ACC for users, society, companies and governments?*"), is answered through the information provided in Section 2.4. the main areas in which ACC is expected to influence any of the aforementioned stakeholders are driving comfort, traffic efficiency, traffic safety and fuel consumption. There is a general agreement in that the first one (driving comfort) is achieved in any case with the use of ACC. However, there are still some discrepancies for the other three. Is expected that the traffic efficiency improves but only under specific circumstances, having otherwise the opposite effect. In regards of the traffic safety almost all the authors agree that the use of ACC can increase safety, keeping in mind that the driver should remain attentive in order to intervene if necessary. The last aspect (Fuel consumption), can provide positive or negative results as well.

Besides obtaining the necessary information to answer the first two sub-research questions, the most relevant driving conditions that are used in existent literature are obtained. With this full list of attributes the suitability to use some of them to reach the research goal will be discussed. There are some attributes that are not convenient to be used as is further discussed.

The first consideration is made considering that, as seen in the literature, ACC has primarily a comfort function with fluent or interrupted traffic in highways. For this reason, the only type of road that is analysed are the **highways**. In addition, in order to clarify the most as possible the experiment, the most common type of trip that is done according to the literature study is exclusively used, removing all the others from a possible scenario. Therefore, **commuting**, which is the most representative type of trip is used. Finally, by doing these simplifications an additional attribute can be taken out of the experiment. This is the case from the "Road familiarity", which is neither considered due to the fact that a combination of a trip that takes place for commuting in a highway is, in essence, familiar.

Finally, the research on human factors shows the importance of several factors influencing drivers' behavioural adaptation to different ADAS. Amongst those factors, individual characteristics such as driver's age, gender, degree of driving experience, and personality traits (such as driving style) are highlighted.

3. Experiment design

The following chapter describes the research method that is used during this graduation thesis. The theory behind the choice data experiments is described and, in addition, an explanation of how this Stated Choice Experiment is constructed is discussed.

3.1. Stated choice experiment

In this research, the work of Hensher, Rose & Greene (2015) in their book "*Applied Choice Analysis*" will be followed. Therefore, the information included in this section is based on the information given by the aforementioned author.

For the construction of the experimental design there are two possibilities, Revealed Choice (RC) and Stated Choice (SC) data. RC data refer to situations where the choice is made in real market situations; in contrast, SC data refer to situations where a choice is made by considering hypothetical situations. SC data are especially useful when considering the choice among existing and new alternatives since the latter are not observed in RP data. In addition, lower budget and less time from the respondents is necessary as those are not required to face a real situation, but only to be presented with a hypothetical scenario. These are the reasons why Stated Choice is used. Hence, the respondents are required to decide about their willingness to use ACC in different hypothetical driving situations.

The basis of an SC experiment is an experimental design, which involves the observation of the effect of one dependent variable, a response variable, given the manipulation of the levels of one or more other independent variables. This manipulation occurs by design, determining what manipulations to make.

The steps followed to create a Stated Choice experiment are shown in the next paragraphs of this section and are summarised in Figure 6.

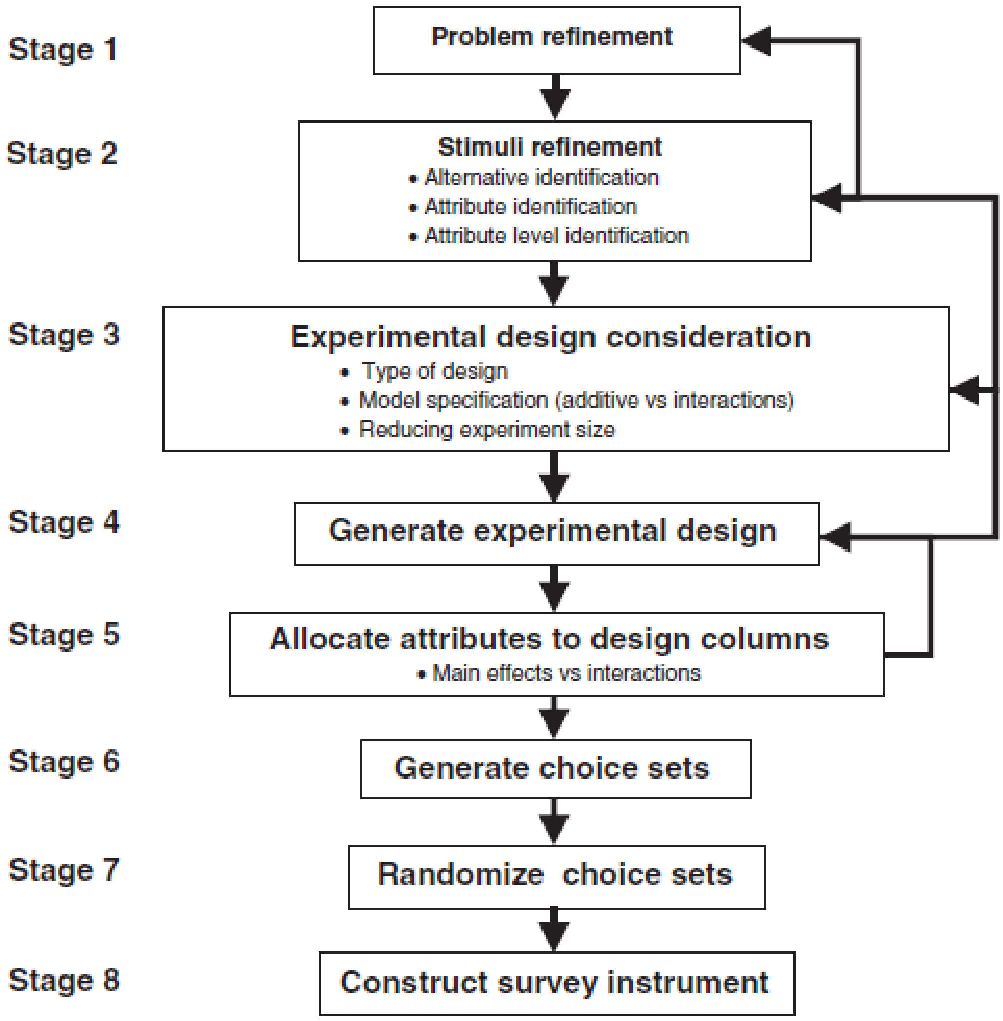

Figure 6. Experimental design process, retrieved from Hensher, Rose, & Greene (2015)

3.1.1. Stage 1: Problem definition refinement

The first stage towards deriving the SP choice experiment is to "*refine the understanding of the problem being studied*". Hence, it begins by defining the problem clearly by determining the research questions that are needed, as well as those that are irrelevant and can be avoided.

In our case, the objective of the research is to find out the potential penetration of Adaptive Cruise Control (ACC) technology regarding the acceptance of its users. Therefore, the main research question is defined to determine whether ACC is accepted and in what conditions:

How are different driving conditions
influencing drivers' willingness to use Adaptive Cruise Control?

After the research problem is properly refined the next stage of the design process can start, which is the refinement of the stimuli to be used in the experimental design.

3.1.2. Stage 2: Stimuli refinement

The stimuli refinement is divided into two parts, starting with the alternatives identification and refinement and finally the refinement of the list of attributes and attribute levels.

The first part involves defining a list of limited alternatives available to the decision makers. The alternatives in this case are the multiple driving conditions that are creating the hypothetical driving scenarios. In that list, all the alternatives are identified in order to achieve the global utility maximising rule. Afterwards, some of the alternatives from the list have to be rejected, avoiding a large number of alternatives to create a study with a convenient number. Finally, if the list is up to 10 alternatives it is possible to not discard any at all.

The second part involves determining the attribute levels of each of the alternatives. A different weight is attached to different levels, having a correlation in between them. Additionally, an attribute level label is given, represented by words in a qualitative way. Finally, the number of attribute levels of each attribute is decided, being the main difference that when only 2 levels are given there is a linear utility relationship, whereas there is a non-linear relationship when there are 3 or more.

After the aforementioned steps are conducted by following a literature review (Section 2.5) and expert knowledge feedback, a complete table with the attributes and attribute levels is obtained (Table 1). In total there are seven attributes, five of which have a 3-levels dimension, and the other two have 2-levels.

Due to the fact that ACC has primarily a comfort function with fluent or interrupted traffic in highways, the first consideration is to **only analyse** one type of road, which are the **highways**, leaving all the others out of this research. Additionally, the most representative type of trip done when using a highway is **commuting** (SWOV, 2013), reason why the other trip reasons are not considered. Finally, an attribute such as road familiarity is not considered due to the fact that it can be easily argued that a commuting trip is essentially familiar to the driver.

Table 1. Attributes and attributes levels

Attributes	Levels	Labels
Traffic intensity	1	High (Traffic jam)
	2	Medium (Interrupted flow)
	3	Low (Free flow)
Road condition	1	Regular (Straight road)
	2	Difficult (Exit lane, sharp curve…)
Visibility through weather conditions	1	High (Clear, cloudless)
	2	Medium (Rainy, snowy)
	3	Low (Foggy)
Lighting in the road	1	Daylight
	2	Nightlight with lighting ON
	3	Nightlight with lighting OFF
Level of fatigue	1	Low (Very fresh)
	2	Middle (A little tired)
	3	High (Very tired)

Trip distance	1	Long (> 100 Km)
	2	Medium (20 – 100 Km)
	3	Short (< 20 Km)
Nº passengers	1	Travelling alone
	2	1 or more passenger

3.1.3. Stage 3: Experimental design considerations

At this stage, the code that is used is chosen. The original code given to the previous table (Table 1) is the design code which has to be converted into a dummy or effect coding in order to analyse the data. The design code assign to each attribute level a unique number starting with 1 until L, being L the number of levels of each attribute. In that case, SPSS adopts as the base variable the one with a higher number. With dummy and effect coding, the difference remains in the coding of the base variable. For dummy code, 0 is adopted, whereas for effect coding -1 is used. The coding difference from these designs can be seen in Table 2.

Table 2. Comparison of design and dummy/effect coding

Number of levels	Design code	Dummy coding		Effect coding	
2	1	1		1	
	2	0		-1	
3	1	1	0	1	0
	2	0	1	0	1
	3	0	0	-1	-1

Therefore, the way of coding the levels of the variables is chosen. In this case, a dummy coding is used due to the fact that with SPSS the design code is directly reconverted into a dummy coding. Additionally, the last level is taken as the base category, which means that the level used as a base category is the second one for those with 2 levels; and the third one for the categories with 3 levels.

Taking the full factorial design into consideration, there are in total 972 different treatment combinations ($3^5 \cdot 2^2 = 972$). This is due to the fact that there are 5 attributes with 3 levels (3^5), 2 attributes with 2 levels (2^2), and it is an unlabelled experiment. Due to the fact that responding to this amount of sets would be nearly impossible, a reduction of the number of choice sets is necessary. There are four strategies to reduce the number (Hensher, Rose, & Greene, 2015), namely:

1. Reduce the number of levels used within the design;
2. Use fractional factorial designs;
3. Block the design;
4. Use a fractional factorial design combined with a blocking strategy.

As the first strategy cannot be used, due to the fact that the attributes and attribute levels have already been fixed, a fractional factorial design is used in combination with a blocking strategy.

By using a fractional factorial design, only a fraction of the total combinations is considered. In order to do that, orthogonality must be achieved, meaning that each possible pair of attribute levels appears an equal number of times over the design. In addition, the possible main effect (direct independent effect of each attribute upon the response variable, choice) and interaction effects (obtained when two or more attributes are combined, which would not have been observed if considered individually), have to be considered. Finally, the degrees of freedom have to be defined (meaning how much information is present in the design and how much is required to estimate a model).

In addition, the design is blocked. This involves dividing the whole design into 3 different blocks and giving each one to a different respondent. The result of that is that 3 different decision makers are required to complete the full design. Hence, for a design of 18 combinations, each decision maker receives 6 out of the 18 treatment combinations. In this case, a similar strategy is used, as instead of giving six fixed set to each respondents, the program that is used randomly allocate six treatment combinations to each decision maker. This is done in an organised way which ensures that all alternatives are answered a similar number of times.

3.1.4. Stages 4 and 5: Generating experimental designs

Even though using software to generate experimental designs is not the best method, obtain effective designs is possible. Therefore, with the use of statistics program SPSS the fractional factorial design is created, and 18 alternatives instead of the originally 972 are generated. In Table 3 the matrix with all 18 options that are used for this experiment can be seen.

Table 3. Alternatives with attribute levels

Alternatives	Attributes						
	Traffic	Visibility	Lighting	Fatigue	Distance	Rcondition	Passengers
1	1	1	1	1	1	1	1
2	1	2	2	3	2	2	2
3	1	3	3	2	3	1	1
4	2	1	2	2	2	1	1
5	2	2	3	1	3	1	2
6	2	3	1	3	1	2	1
7	3	1	3	3	2	1	1
8	3	2	1	2	3	2	1
9	3	3	2	1	1	1	2
10	1	1	3	2	1	2	2
11	1	2	1	1	2	1	1
12	1	3	2	3	3	1	1
13	2	1	1	3	3	1	2
14	2	2	2	2	1	1	1
15	2	3	3	1	2	2	1
16	3	1	2	1	3	2	1
17	3	2	3	3	1	1	1
18	3	3	1	2	2	1	2

3.1.5. Stage 6: Generate choice sets

Discrete choice models are required to accomplish three conditions. Each choice situation consists of "*exhaustive* and *finite* set of *mutually exclusive"* alternatives. This implies that the data is captured and there exists some natural limit to the number of alternatives presented. In this case there is basically a choice set of 1 alternative from which the decision makers are able to reflect. The reason behind that is the importance to qualitative against quantitative data in discrete choice models, being of higher importance to know *what* is chosen rather than *how much*.

3.1.6. Final Stage: Construct survey instrument

The final step is to create a questionnaire in order to collect the data from this Stated Choice experiment. For that purpose, an online survey tool that was developed by the Eindhoven University of Technology called "Berg Enquête System" is used. This has some advantages in comparison with other similar systems. The first one is that the information remains private from external organisations providing similar survey systems. The second advantage is that it is possible to randomise the choice sets of the stated choice experiment and provide to each of the respondents 6 different alternatives, keeping track of how many times has each one been replied in order to collect a similar amount of answers from all 18 alternatives.

3.2. Survey instrument

The survey is divided into 4 parts. The first one comprises questions about the driving experience and technology exposure. The second part consists of questions about driving style. The third part contains the main experiment. In the last part, several questions regarding socio-demographic information are presented.

Besides these four parts, before starting the questionnaire there is an additional question to know if the respondent has a driving licence or not. This is done in order to filter out those respondents who are not part of the target group (drivers). When a negative answer is given, the respondent is lead out of the survey and a message thanking for their participation and explaining why they are not part of the target group is displayed.

3.2.1. Part 1: Driving experience and technology exposure

First, two short questions are asked to figure out the respondents' experience with driving. Two questions are asked in this part, the first one to know during how many years they have been driving and the second one to identify their weekly or annual mileage. An explanation of how to easily calculate this number is also shown (Figure 7).

Section 1: Driving experience.

What is your driving experience?

- 5 years or less
- 6-15 years
- 16-29 years
- 30 years or more

What is your weekly mileage*?

- I don't know
- Less than 200 Km (≃ 10,000 Km per year)
- 200 – 400 Km (≃ 10,000 – 20,000 Km)
- 400 Km or more (≃ 20,000 Km per year)

* As a rule of thumb, double the average kilometres you travel from home to work per day. Then multiply this number for 7 days a week.

Figure 7. Driving experience questions (Questionnaire screenshot)

Secondly, the exposure and knowledge of current technology is asked. This is done by requesting what is their knowledge about 8 different ADAS. Therefore, they are asked whether they DO or DO NOT know the system and if in addition to knowing it they have also USED it. Besides the name of the system, a short explanation of what the system does is provided. Hence, information about the current knowledge of the following systems is expected to be collected.

- **Forward Collision Warning (FCW)** – Designed to alert the driver to a hazard ahead so that he/she can brake or swerve (deviate) in time
- **Lane Departure Warning (LDW)** – Designed to warn the driver when the vehicle begins to move out of its lane
- **Fuel Efficiency Adviser (FEA) –** Analyse fuel consumption while you drive, providing feedback to drive more efficiently
- **Automated Parking Assist (APA) –** Autonomous car-manoeuvring system that moves a vehicle from a traffic lane into a parking spot
- **Blind Spot Warning (BSW)** – Designed to detect other vehicles located to the driver's side and rear (back)
- **Conventional Cruise Control (CCC)** – Designed to maintain a steady (constant) speed as set by the driver
- **Adaptive Cruise Control (ACC)** – Designed to automatically adjust the vehicle speed adaptively to a forward vehicle
- **Traffic Jam Assistance (TJA)** – Designed to follow the vehicle ahead and automatically operate the accelerator and brakes within slow driving in traffic jams

The expectation is that users with a higher knowledge and use of one or more ADAS are more willing to use another system. This could mean that the chances that a driver who is familiar or has experience with these systems might have a higher interest than those who do not have any previous experience.

3.2.2. Part 2: Driving style

As explained in the literature review (Section 2.7), the research of Taubman - Ben-Ari & Skvirsky (2016) is used to determine the driving style of the users.

From the original 44-factor-scale questionnaire a reduction to only 16 questions is done. This includes 3 to 5 questions for each of the four driving styles. The reduction is done in order to decrease the workload of the respondents. Discovering the driving style of each respondent is not the main goal of this experiment but to use this information to know more about the type of respondent in the sample. The selection of questions is done considering those that had a higher F-score, avoiding questions that are similar and choosing those considered more relevant for the researcher.

The list of questions is asked to the respondents requesting them to “Read each item and rate the extent to which it fits their feelings, thoughts, and behaviour during driving”. A “6-point Likert scale” ranging from never (1) to always (6), in the same way that is done in the original experiment (Taubman - Ben-Ari & Skvirsky, 2016). In the Appendices the list of questions asked for each driving style can be found. Additionally, an example of the questions for the first group can be seen in Figure 8.

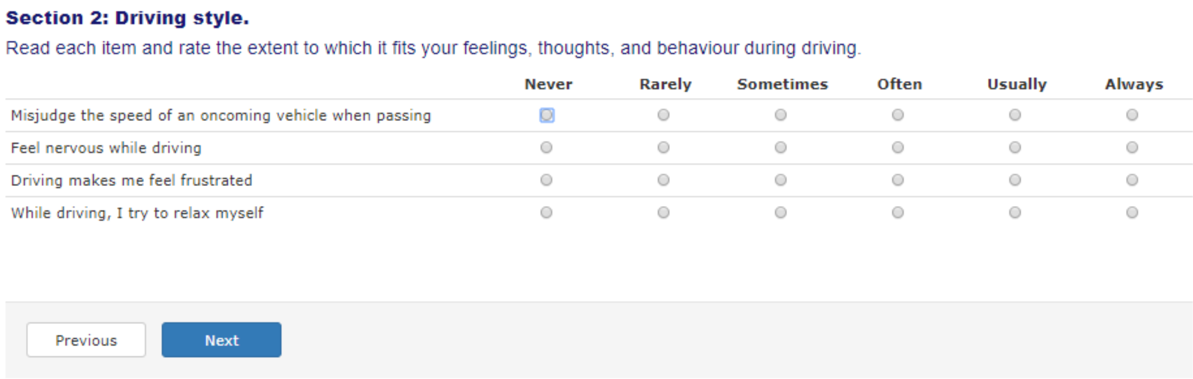

Figure 8. Driving style questions (Questionnaire screenshot)

3.2.3. Part 3: Stated Choice Experiment

In this part, the choice experiment is presented to the respondents. Before starting the experiment, the goal of the research is explained. In addition, in order to make the respondents familiar with the way in which the experiment is organised and the operational mode of Adaptive Cruise Control, an explanation is given.

First of all, an explanation of how the experiment works is given. The task of the respondents is to reflect their opinion regarding the use of ACC in several hypothetical driving situations. These situations are defined by seven attributes, each of them with 2 or 3 levels, which are showed in a table that contains the overview of the driving conditions that are going to be analysed on the choice experiment. This table is similar to the one included at Section 3.1.2 (Table 1). In addition to the written explanation, a short video is displayed in order to get the respondent more familiar with how ACC works.

Besides this, other additional remarks to learn more about the system can be displayed on demand. In that space, the most frequently system limitations faced by ACC users as well as the main benefits are presented.

Finally, an example question is presented, asking the respondents to read the table that defines the details of a specific trip situation and asking to consider their opinion regarding the active use of ACC. They should imagine themselves in a hypothetical situation in which they are **commuting** in a **highway** with a car **equipped with ACC and Stop-and-Go**. Next, they are asked to respond how they would act in the presented situation. In Figure 9, the example that was shown to all the respondents to get them familiar with the way of presenting the information and what was required to be answered in each part is presented.

Attributes	Situation
Traffic intensity	**Medium (No congestion)**
Road condition	**Difficult (Exit lane, sharp curve...)**
Visibility through weather conditions	**Low (Foggy)**
Lighting	**Daylight**
Level of fatigue	**Low (Very fresh)**
Trip distance	**Short (< 20 Km)**
Travelling with	**1 or more passengers**

In the presented situation ***I would turn ON ACC***	**Strongly Disagree** **Disagree** **Agree** **Strongly Agree**
Is your choice regarding the Turning ON/OFF of ACC related to (select all that apply)	***Increase/Decrease Safety*** ***Increase/Decrease Comfort*** ***Improve/Reduce Fuel efficiency***

Figure 9. Choice experiment example question

This example question was followed by 6 different alternatives from the complete set, which are selected by the algorithm of the survey system. The main task of this mechanism is to ensure that a similar number of responses are given to each of the 18 alternatives.

The 4-level scale ("Strongly Disagree" – "Strongly Agree") has been chosen instead of one with an even number of responses, which therefore include a "Neutral" answer. This is done in order to force the respondents to take a decision in all the cases and provide useful information with all the alternatives.

Additionally, the choice of these three elements is based on the conducted literature review (Section 2.4), considering the areas from which the user might be more benefited.

3.2.4. Part 4: Socio-demographic information

In this last part, questions regarding the socio-demographic information are included. The reason to ask about this information is to study the relationship between those factors and the user willingness to use ACC, as it has been observed at multiple researches that there is a link between lifestyle and personality.

Table 4. Socio-demographic information

Socio-demographic factor	Level	Label
Gender	1	Male
	2	Female
Age	1	18 – 29 years
	2	30 – 49 years
	3	50 – 64 years
	4	65 years or more
Education level	1	Low (secondary school or lower)
	2	Medium (professional education)
	3	High (college / university)
	4	I prefer not to answer this question
Annual household income	1	€15,000 or less
	2	€15,000 – €30,000
	3	€30,000 – €60,000
	4	€60,000 or more
	5	I prefer not to answer this question
Household situation	1	One-person
	2	Multiple people without children
	3	Multiple people with children
Nationality	1	Dutch
	2	Other (name it)

In addition, one last question is asked to analyse to what extend the respondent would be interested in having Adaptive Cruise Control in their next car. Hence, this is asked with a 5-level scale, to analyse this level of willingness, choosing if they would be "Not at all interested", "Slightly interested", "Moderately interested", "Very interested" or "Extremely interested" in having ACC in their next car.

3.3. Data collection and sample size

The questionnaire is made in English and distributed using the internet in order to reach a wider audience. The respondents are briefly informed about the aim of the project, followed by an explanation of what the questionnaire consists of.

The questionnaire has been distributed through LinkedIn and Facebook groups, as well as on Twitter. Is it important to mention that part of the total responses were collected through the personal network of supervisors, whom as an expert in the field of Smart Mobility might have attracted respondents who are enthusiastic of this topic as well. This has to be taken into consideration in the case of a possible bias.

A hyperlink was sent within a short description explaining what the survey was about, specifying the average time and the possibility to win a free Gift card in order to encourage respondents reply. This resulted in 234 total responses, out of which 22 were people without driving license and 212 with driving licence that therefore could reply the whole questionnaire. In addition, the answers from 4 of the respondents with driving license were removed from the sample due to the fact that were considered to be non-realistic, as the total time used was extremely short and had replies that did not make sense. Hence, a total amount of **208** valid responses are obtained (Figure 10).

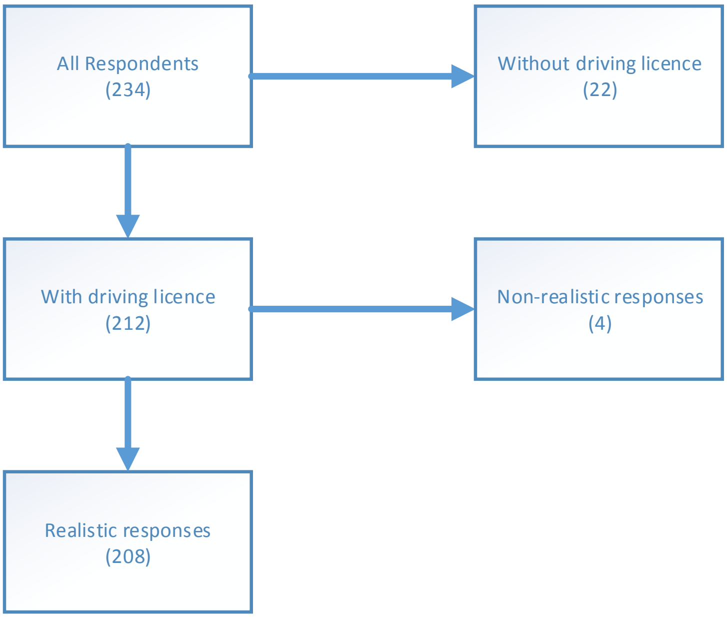

Figure 10. Distribution of responses

In order to determine if it is a good sample to guarantee the consistency of the experiment, the study of Orme (1998) is applied. This size can be calculated considering that the required sample size is equal to:

$$N \geq \frac{500 \cdot L_{max}}{t \cdot a}$$

Where
L_{max} = largest number of levels of any of the attributes
t = number of alternatives per choice set
c = number of choice sets

Within this experiment, "L_{max}" is 3, "t" is 6 and "a" is 3. However, for this experiment the required number of respondents to fill in 1 whole set is 3, the number has to be multiplied by 3. In our case:

$$N \geq \frac{500 \cdot 3}{6 \cdot 3} \cdot 3 = 250$$

We have a total of 212 complete questionnaires obtained. Even though the number is not reached, this number is close enough to the one proposed, which can be considered as sufficient to ensure the reliability of the experiment. However, this number might be not sufficient to analyse the differences between target groups.

3.4. Data analysis

In this section are explained the methods that have been used to analyse the collected data. In our experiment, the stated choice experiment is rated with four levels of acceptance (Strongly Disagree, Disagree, Agree and Strongly Agree). The fact that it is possible to rank these values in a specific order, but it is not possible to calculate the real distance between each of them, means that the variables are ordinal. Therefore, to analyse this experiment, an Ordinal Regression Model will be used, making it possible to describe, predict and explain the relationship between the variables.

3.4.1. Descriptive analysis

The first part is to analyse through a descriptive analysis all the collected data. This is the first step in order to obtain a full understanding of the data and comprehend how the sample is represented. Besides that, present the data in a way that is easy to understand to all the readers is important. This is done through the use of tables, graphs or any other visual format. During this research, the analyses are done with the use of the software package SPSS and the support of Excel for the visual representation.

In addition, this allows easily comparing our results with those of previous research on similar topics (e.g. user knowledge about ADAS) or checking if the sample group is comparable with the total population, etc.

Finally, all relevant variables should be listed with means, standard deviations, the number of respondents (Bedeian, 2015). In addition to be necessary as input for others who may wish to reproduce (and confirm) a study's results, as well as perform secondary analyses (Zientek & Thompson, 2009).

3.4.2. Ordinal Regression Model

This method has a common use in social sciences, especially at surveys in which the use of Likert scales is common, which is the case of this experiment. The Ordinal Regression Model is "essentially sets of binary regressions that are estimated simultaneously with constraints on the parameters" (Scott Long, 2012). This would be a problem if the calculations had to be done by hand, but currently, the software (SPSS) is making the calculations, and this is why the greatest challenge is its interpretation.

For a theoretical explanation of the model, the study of Scott Long (2012) is followed. The model can be originated from a regression on an unobserved, continuous variable y_i^*:

$$y_i^* = \beta_0 + \beta_i \chi_i + \varepsilon_i$$

The ordinal logit model assumes that ε is logistic, its mean 0 and its variance $\pi^2/3$. The continuous y_i^* is divided into observed, ordinal categories using the thresholds τ_0 through τ_J:

$$y_i = j \quad if\ \tau_{j-1} \leq y_i^* < \tau_j\ for\ j = 1\ to\ J$$

Where τ_0 = -∞ and τ_J = +∞. In our case, with four levels of acceptance, this would be the measurement model:

$$y_i = \begin{cases} 1 \rightarrow \text{"Strongly disagree"} & if\ -\infty \leq y_i^* < \tau_1 \\ 2 \rightarrow \text{"Agree"} & if\ \tau_1 \leq y_i^* < \tau_2 \\ 3 \rightarrow \text{"Disagree"} & if\ \tau_2 \leq y_i^* < \tau_3 \\ 4 \rightarrow \text{"Strongly agree"} & if\ \tau_3 \leq y_i^* < +\infty \end{cases}$$

3.5. Model's goodness of fit

For assessing whether the model fits the observed data and is able to predict it, the model's fit has to be calculated. The evaluation of the model's quality can be done through different parameters estimation, such as log likelihood, likelihood ratio and R^2.

Log likelihood

In multiple regression analysis, to assess whether a model fits the data the observed and predicted values of the outcome can be compared. Likewise, in logistic regression, the observed and predicted values are used to assess the fit of the model with this measure (Field, 2009).

$$log\ likelihood = \sum_{i=1}^{N} \left[Y_i \ln(P(Y_i)) + (1 - Y_i) \ln(1 - P(Y_i)) \right]$$

Where:
Y_i = outcome for the *i*th person
$P(Y_i)$ = probability that Y occurs for the *i*th person

The log likelihood indicates the amount of unexplained information that can be found in the model. Large values indicate poorly fitting statistical models, as with a large value of the log-likelihood, more unexplained observations can be found.

Likelihood ratio

This method is based on maximum-likelihood theory. It explains the performance of the proposed model compared to the null hypothesis model. The resulting statistic is, therefore, based on comparing observed frequencies with those predicted by the model (Train, 2002). The likelihood ratio index is defined as:

$$LRS = -2\left(LL(Intercept) - LL(Final)\right)$$

The log likelihood is always negative and is simply two times the difference between the constrained and unconstrained maximums of the log likelihood function. If this value exceeds the critical value of chi-square with the appropriate degrees of freedom, then the null hypothesis is rejected.

R-squared (R2)

The R^2 measures the amount of unpredictability in one variable that is shared by the other. The formula to calculate is the following:

$$R^2 = 1 - \frac{-2LL(Final)}{-2LL(Intercept)}$$

R^2 shows if the model is able to reproduce (predict) the observed choices.

In order to value if it is a good indicator or not, we need to know that its value lies between 0 and 1. According to Hensher, Rose, & Greene (2015), if the value is at least 0.1 for a discrete choice model, it represents a decent model. When the value of the pseudo-R2 lies between 0.2 and 0.4 it means that it has a good fit. Finally, if the R^2 is equal to 1, it means that the decision makers' choice can be predicted perfectly.

4. Results

In this chapter, the results obtained from the analyses of the collected data are presented. The sample of respondents is studied by doing a descriptive analysis of the socio-demographic information and experiences. The results are used to create different user groups for analysis. After, the main model and some sub-models are analysed with an ordinal regression method. Finally, the influence of safety, comfort and fuel efficiency in the ACC choice is given.

4.1. Descriptive analysis results

First of all a frequency table from the driving experience and socio-demographic information (Table 5) is shown to have a comprehensive picture of the entire respondents' circumstances before analysing one by one the most interesting frequency tables. The numbers of this table are obtained from the answer of the 208 respondents that completely filled the questionnaire and were not removed.

There are some groups with a similar number of responses in every attribute level, which provide the possibility to create a subdivision for analysing sub-groups (such as nationality or household situation). In contrast, other groups do not provide any possibility for a sub-group division (such as education).

Table 5. Driving experience and socio-demographic information frequency table

	Label	Frequency (nº)	Percentage (%)
Weekly (Annual) mileage	I don't know	20	9.6
	Less than 200 Km (10,000 Km per year)	91	43.8
	200 - 400 Km (10,000 - 20,000 Km)	39	18.8
	400 Km or more (20,000 Km per year)	58	27.9
Driving experience	5 years or less	59	28.4
	6-15 years	67	32.2
	16-29 years	52	25.0
	30 years or more	30	14.4
Gender	Male	142	68.3
	Female	66	31.7
Age	18-29 years	104	50.0
	30-49 years	75	36.1
	50-64 years	29	13.9
Nationality	Dutch	119	57.2
	Other	89	42.8
Education	Low education (secondary school or lower)	1	.5
	Medium (professional education)	4	1.9
	High education (college / university)	201	96.6
	I prefer not to answer this question	2	1.0
Income	€15,000 or less	48	23.1
	€15,000 - €30,000	21	10.1
	€30,000 - €60,000	32	15.4
	€60,000 or more	64	30.8
	I prefer not to answer this question	43	20.7
Household	One-person	69	33.2
	Multiple people without children	68	32.7
	Multiple people with children	71	34.1

The most relevant aspects of the previous table are commented to illustrate what kind of respondents there are in this sample. First of all, regarding the factors that describe the driving experience, a comparisson (Figure 13) between both factors is evaluated besides its frequency tables (Figure 11 & Figure 12).

Most of the sample is formed by people who drive less than 10,000 Km per year (43.8%). The distribution of driving experience is evenly distributed in the first three levels. The last group has a low percentage of respondents (14.4%), which is expected as the number of people from the older age group is also lower.

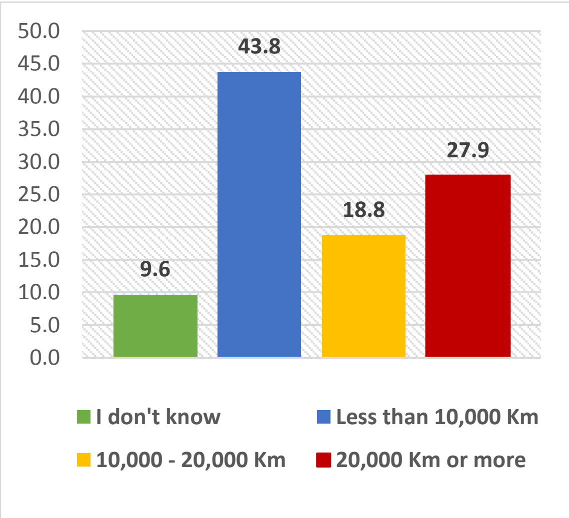

Figure 11. Annual mileage frequency distribution (Percentages)

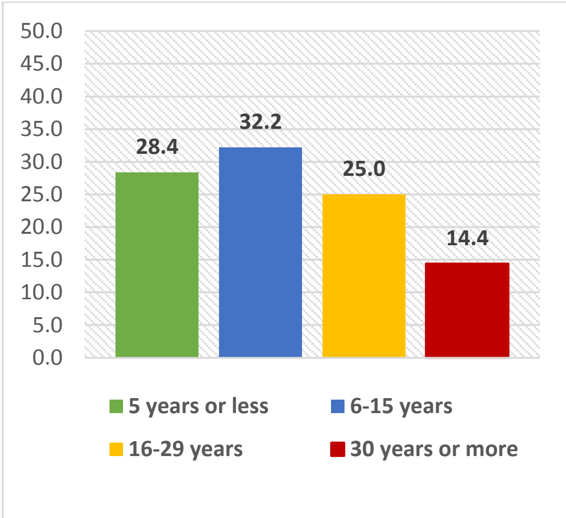

Figure 12. Driving experience frequency distribution (Percentages)

At Figure 13 can be seen that from those who responded “I don’t know” there are exclusively drivers with low experience (less than 15 years). Similarly, from the group driving less than 10,000 km the most of the drivers have a low experience as well. In contrast, the group of more than 20,000 Km per year is formed almost exclusively for drivers with a high experience (more than 16 years). Finally, the middle group (10,000 to 20,000 km/year) has a more or less balanced distribution.

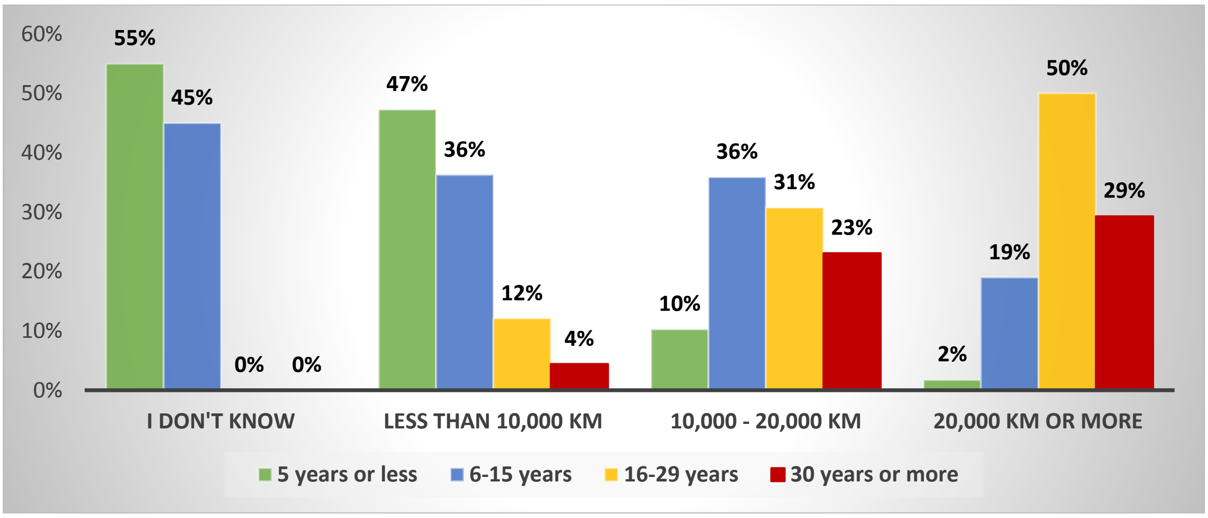

*Figure 13. Mileage * Driving experience Crosstabulation graph*

Secondly, the gender and age of the respondents are analysed. Similarly as for the driving experience, a comparison (Figure 16) between both factors is evaluated besides their frequency tables (Figure 14 & Figure 15).

The male is over-represented compared with what is found in the world population distribution which is nearly 50% for each gender. This can be explained by an in general higher number of males interested in the automotive field in comparison with women.

Regarding the age distribution, there are 50% for "Young" respondents and another 50% for "Older" people (considering both 30-49 and 50-64 groups together). However, there are no respondents in the 4th cluster (65 years or more). This last issue, as well as the whole age distribution (more respondents from younger groups), can be a direct consequence of the method employed to distribute the survey (Online), as the people who have a higher use from the internet are the youngers.

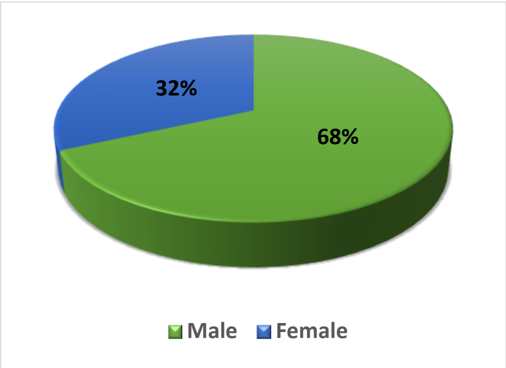

Figure 14. Gender frequency distribution (Percentages)

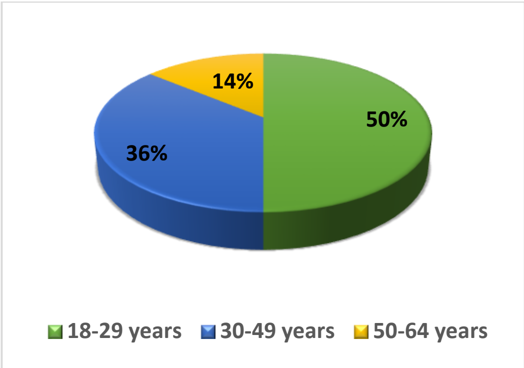

Figure 15. Age frequency distribution (Percentages)

With the use of the age/gender crosstab (Figure 16), can be seen that the distribution from this sample is not representative with the exception of the first age group (18-29 years). In contrast, for the other age ranges there is a huge difference in gender, where the presence of male respondents is much higher than for females. This is not a good representation considering that the world population distribution is evenly distributed (United Nations, 2017). A possible explanation is that more men are interested in the topic and therefore willing to reply a survey. In addition, if we could compare the distribution with one from drivers' distribution, it might be that more males than females appear.

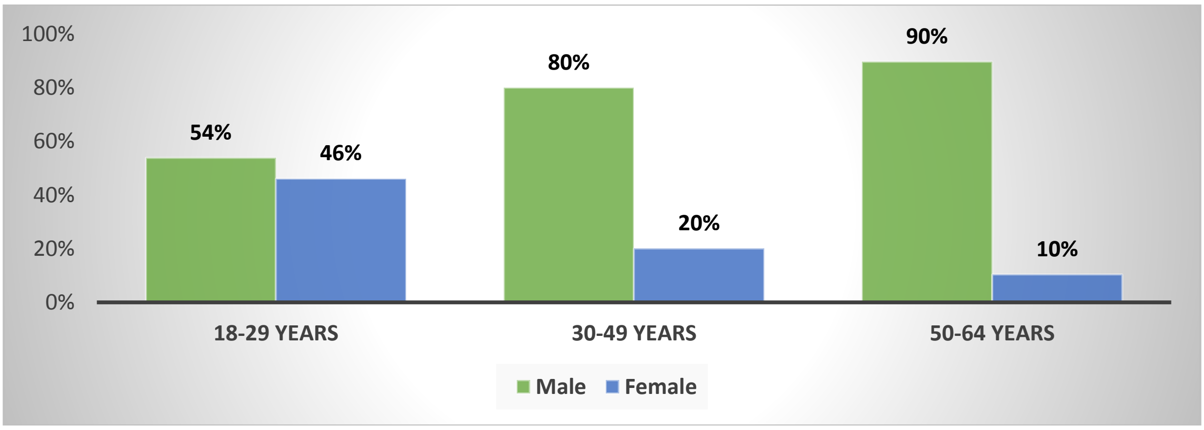

*Figure 16. Age * Gender Crosstabulation*

For the nationality distribution (Figure 17), several nationalities have been put together as their presence was too small to become possible to properly represent them in the graph. The most represented country is The Netherlands, with 57% of the total, resulting in 43% of other nationalities from all over the world. The areas that are more represented besides from The Netherlands are other European countries with 25% and Asian countries with 10%. This distribution makes possible to divide the respondents in between two groups (Dutch and Non-Dutch nationality), to analyse the differences and similarities between them.

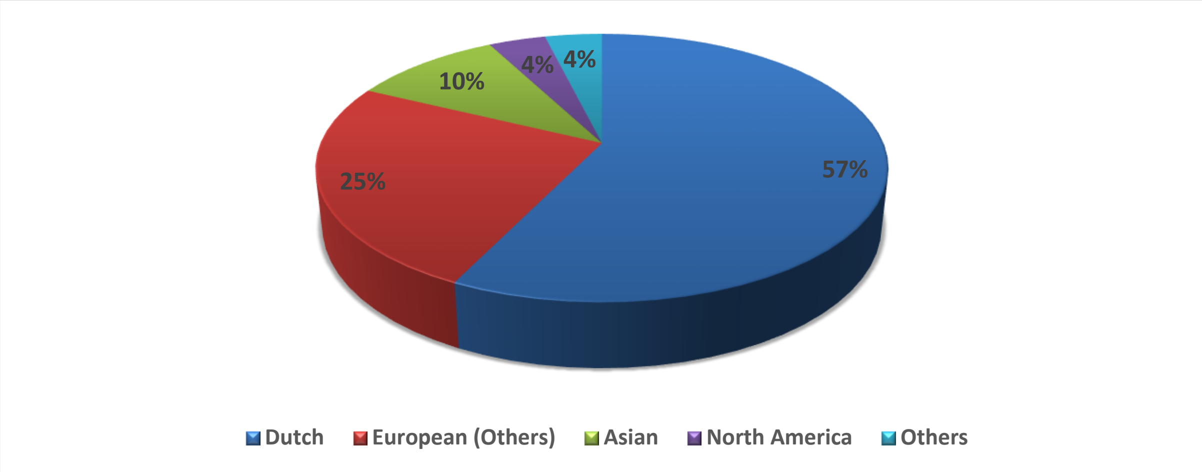

Figure 17. Nationality frequency distribution (Percentages)

From an education level perspective there is a distribution totally unbalanced, where the only and main conclusion obtained is that the sample of respondents of this survey has a high level of education (96.6%).

The household type has an almost equal distribution at all three ranges (Figure 18), reason why it is possible to analyse three sub-models with each of the series.

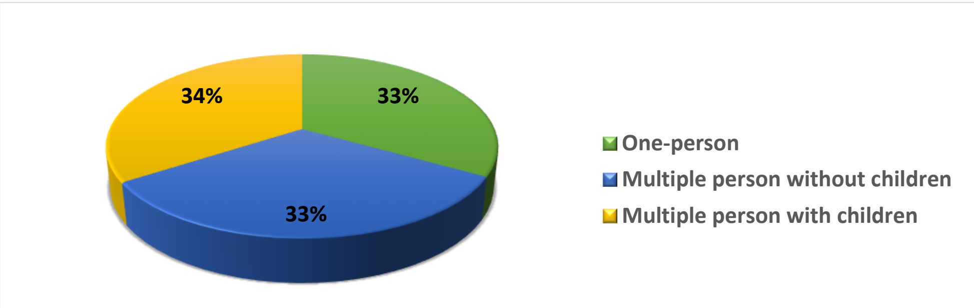

Figure 18. Household frequency distribution (Percentages)

Finally, the income and household type are compared with a crosstab (Figure 19). From this analysis is inferred that those who earn more than €60,000 are mainly families with children, which are one of the biggest groups of the respondents of this survey. At the other side of the table, we find another important group of people who earn less than €15,000, which is mainly formed by one-person households and couples (Multiple people without children) and which are most probably from a young age as well.

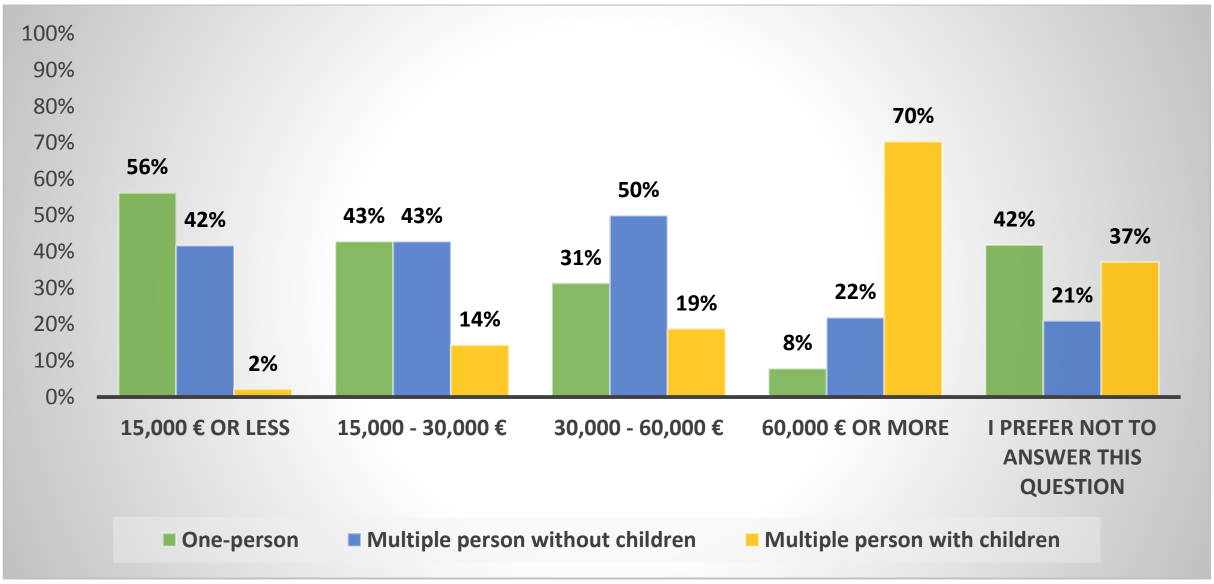

*Figure 19. Income * Household crosstabulation*

4.2. Technology exposure

In the second part of the survey, whether they knew eight different advanced driver assistance systems was asked. Additionally, it was also asked if besides knowing any of the systems, they had ever used them. The information obtained from this part can be seen in Figure 20, where for each system the percentage of respondents who do not know about the system is shown (green bars), who know about it but never used it (blue bars) and who besides knowing it has used it (yellow bars).

Observing the graph, there are several things that have to be highlighted. First of all, there is around a 20 to 25% of people who do not know any of the systems, with some exceptions. The first one are the cases of APA and CCC, technologies which a surprising 94-95% of the people whether know or have used the systems. On the contrary to that high knowledge, the Traffic Jam Assistance has the least awareness with a 46% of people who do not know anything about it. The reason behind that numbers might be related to the fact that some technologies have been in the market during a long period (CCC) whereas there are others such as TJA that are quite recently introduced.

Other interesting facts are that even though the Automated Parking Assist is the technology with the highest percentage of people who knows it (73%) has also one of the lower use (21%). This might be an indicator that this technology is not accepted by the users, as they are not doing the jump from being aware to actually make use of it.

Finally, these results are compared to a previous research (Voermans, 2015) to see the difference in user awareness from two years ago to the current state. In general the most of the ADAS have increased the user knowledge. However, as this information could be biased by the data sample obtained, no additional remarks are done.

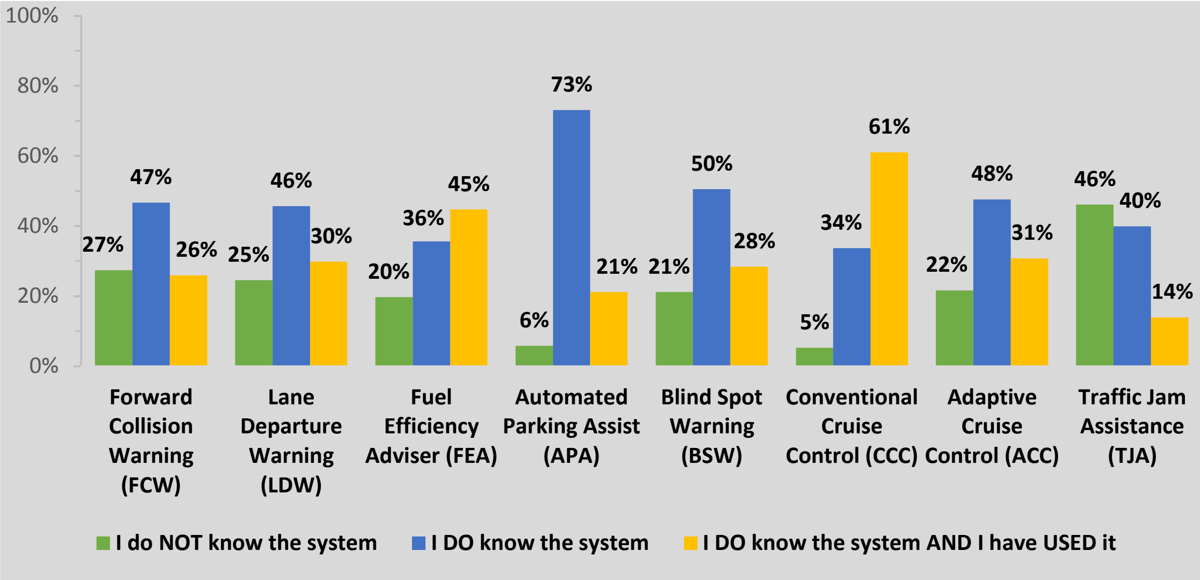

Figure 20. Systems' knowledge graph (Percentages)

Respondents' systems knowledge clusters

Additionally, the previous information have been used to create three different groups of people according to their knowledge and use of the systems. In order to do that, a cluster analysis was done with the use of SPSS, this means that those users that are more similar to each other are put in the same group (or cluster), which in this case have been given the meaning of "Low", "Middle" and "High" awareness level.

In Figure 21 the type of algorithm that was used ("TwoStep") can be seen, as well as the number of inputs (8 ADAS) and the number of clusters that this analysis has provided (3 groups). Next to it the "Predictor importance" can be seen (Figure 22), which shows the weight that has been given to each factor by the program. The least important factor is APA (≈ 0.2) and the most important one is FCW (1.0). Finally, the three clusters are created, assigning a specific group to every respondent. The sample is evenly spread in the 3 groups, being the ratio of sizes (large cluster to smallest cluster) of 1.39, which indicates a good distribution. The influence of each of the factors on each of the clusters can be seen at the appendices (Appendix II. Cluster Comparison).

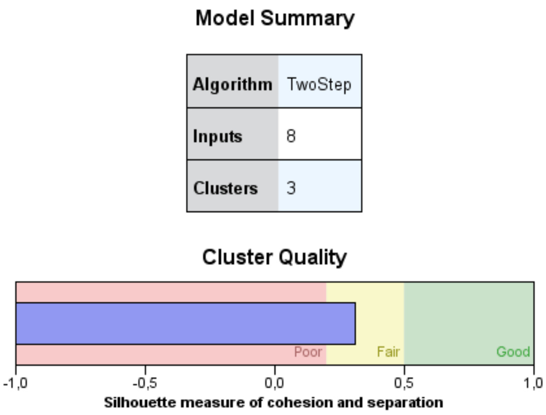

Figure 21. Model summary from cluster analysis

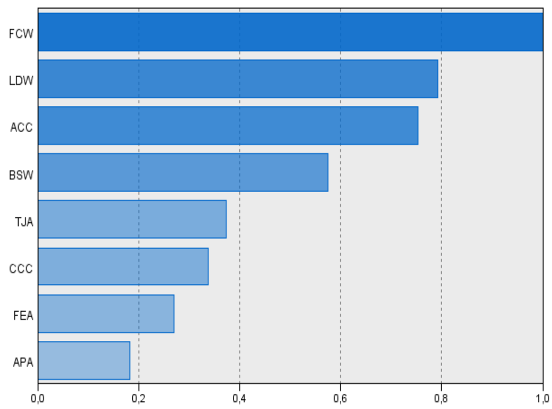

Figure 22. Predictor Importance.

The clusters with a higher percentage are those that have been named as “High” and “Middle”, being the smallest one the “Low” one. The first one (“High”) represent those users who replied for most of the systems that they know it and have used it and therefore their technology exposure is considered to be high. The second cluster includes those respondents that mainly stated to know the systems but did not use them. Finally, the last one gathers the respondents that do not know about the systems.

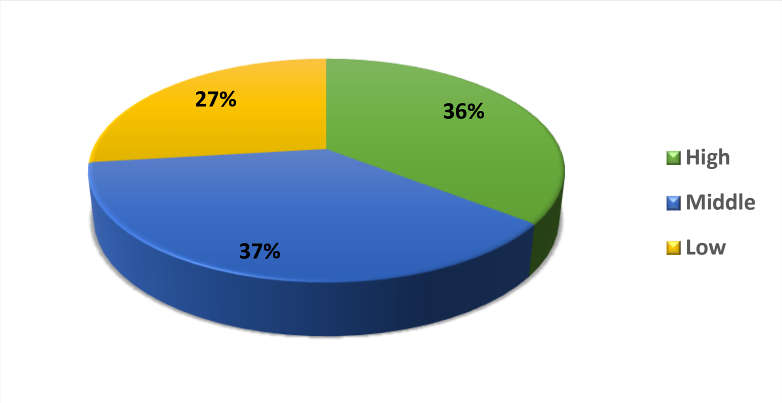

Figure 23. Cluster sizes (Percentages)

4.3. Driving style

The information obtained from the set of questions that are asked regarding Driving Style (Section 3.2.2) is used to determine the driving style of each respondent. In order to do that, and as previously stated, the research of Taubman-Ben-Ari & Skvirsky (2016) is used.

In order to determine what driving style should be assigned to each respondent, first the reaction to each of the questions asked to determine the belonging to each factor are standardised. This is done in order to be possible to compare the weight of all four factors.

The first step is to calculate the average to all the different items (Questions) by summing the answer of each respondent (ID). After the average value of each of the questions is calculated, this is used as a “loading” value to calculate the weight of each factor for each respondent. A mathematical explanation of how this is done can be seen in Figure 24, where it is explained how to calculate the loading of the first factor. The same process is followed for the other three.

ID	Item 1	Item 2	Item 3	Item 4	Factor 1
1 2 ... n	1 2 ... n	2 3 ... n	1 2 ... n	3 4 ... n	$\frac{\frac{Item\ 1\ (ID_n)}{Average\ Item1} + \frac{I2\ (ID_n)}{Average\ I\ 2} + \frac{I3\ (ID_n)}{Average\ I\ 3} + \frac{I4\ (ID_n)}{Average\ I\ 4}}{number\ of\ items}$
Sum:	1+2+...+n	2+3+...+n	1+2+...+n	3+4+...+n	
Average:	$\frac{1+2+\ldots+n}{n}$	$\frac{2+3+\ldots+n}{n}$	$\frac{1+2+\ldots+n}{n}$	$\frac{3+4+\ldots+n}{n}$	

Figure 24. Driving style calculation explanation 1

Finally, after having the weight of each factor for each respondent, it is compared which one has a higher value and assigned to each respondent the factor for which a higher value is resultant. The mathematical explanation of how is done can be seen in Figure 25.

ID	Factor 1: Anxious driving style	Factor 2: Reckless and careless driving style	Factor 3: Angry and hostile driving style	Factor 4: Patient and careful driving style	Higher	Factor
1	0.410	0.397	0.485	0.208	0.485	Factor 3: Angry and hostile driving style
2	1.071	0.397	0.631	1.098	1.098	Factor 4: Patient and careful driving style
...	...	...	...	...	...	...
n	n	n	n	n	-	-

Figure 25. Driving style calculation explanation 2

These calculations resulted in the distribution of the driving style division that can be seen in Table 6. This calculation has given a more or less evenly distributed division of the four included driving styles, which is used to analyse the differences and similarities of each factor, within themselves and with the general model, by creating four different sub-models.

Table 6. Driving style frequency table

Driving Style		Frequency	Percent	Cumulative Percent
Valid	F1. Anxious driving style	50	24.0	24.0
	F2. Reckless and careless driving style	49	23.6	47.6
	F3. Angry and hostile driving style	56	26.9	74.5
	F4. Patient and careful driving style	53	25.5	100.0
	Total	208	100.0	

4.4. Model analysis: Ordinal Regression

Before starting to analyse the model, the number of responses of each set was checked to ensure a proper distribution. Even though the survey tool makes sure that the choice-sets division is evenly spread over all of them, this has to be checked. Therefore, a frequency table is obtained, which can be shown in Table 7.

All the choice-sets are filled in with a similar amount of answers, which permits continuing with the analysis. This has resulted in a total of **1248** situations analysed by the 208 respondents.

Table 7. Frequency table of the response of each set of questions

ID Set	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Total
Frequency	68	69	69	67	67	68	73	69	70	68	72	69	73	67	73	67	71	68	**1248**
Percent	5.4	5.5	5.5	5.4	5.4	5.4	5.8	5.5	5.6	5.4	5.8	5.5	5.8	5.4	5.8	5.4	5.7	5.4	**100.0**

As previously commented (Section 3.1.23.1.3) a dummy coding is chosen in order to analyse with an Ordinal Regression method which of the alternatives produces the highest level of utility.

Table 8. Coding used

Number of levels	Design code	Dummy coding	
2	1	1	
	2	0	
3	1	1	0
	2	0	1
	3	0	0

A comparison from the Design code with the dummy coding conversion is showed in Table 9.

Table 9. Overview driving conditions with effect coding

Attributes	Design code	Dummy coding		Labels
		EC1	EC2	
Traffic intensity	1	1	0	High (Traffic jam)
	2	0	1	Medium (Interrupted flow)
	3	0	0	Low (Free flow)
Road condition	1	1		Regular (Straight road)
	2	0		Difficult (Exit lane, sharp curve…)
Visibility through weather conditions	1	1	0	High (Clear, cloudless)
	2	0	1	Medium (Rainy, snowy)
	3	0	0	Low (Foggy)
Lighting in the road	1	1	0	Daylight
	2	0	1	Night with lighting ON
	3	0	0	Night with lighting OFF
Level of fatigue	1	1	0	Low (Very fresh)
	2	0	1	Medium (A little tired)
	3	0	0	High (Very tired)
Trip distance	1	1	0	Long (> 100 Km)
	2	0	1	Medium (20 – 100 Km)
	3	0	0	Short (< 20 Km)
Travelling with:	1	1		Alone
	2	0		1 or more passenger

4.4.1. General model

With the use of SPSS 22, a complete or general model of the data obtained from the responses of all respondents at the third part of the questionnaire (Section 3.2.3 Part 3: Stated Choice Experiment) is analysed with an ordinal regression analysis. Additionally, the data from the rest of the questionnaire is combined with the experiment data in order to be able to create several sub-models and analyse specific groups on its own (e.g. Gender or Driving style models). This is done to see any possible difference between sub-models and the general model. In order to achieve a good prediction, a 95% confidence interval is used to identify the significant parameters.

Model Goodness of Fit

When analysing the model, some information is directly retrieved by the program, from which its goodness of fit can be evaluated.

Table 10. General model fitting information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	377.761			
Final	276.797	100.965	12	.000
Link function: Logit.				

Due to the fact that the R^2 value is not directly given by SPSS, the formula given in Section 0 is used to calculate it:

$$R^2 = 1 - \frac{-2LL(Final)}{-2LL(Intercept)} = 1 - \frac{276.797}{377.761} = 0.267$$

The pseudo R^2 is therefore equal to 0.267, which is considered as a good fit. Being the observed significance less than 0.05, this means that the null hypothesis that the model without predictors is as good as the model with the predictors can be rejected.

Parameters estimates

In order to determine how each attribute and level is affecting the decision of the respondents, the estimated value of each factor is calculated. This has to be put into context by first examine what are the thresholds of each answer. This is to determine if their response is not only influencing positively or negatively in comparison with the reference value but if it is closer to “Disagree” or “Agree” regarding the experiment question.

Only attribute values with a signification value that is high enough are considered. This means that the significance must have a value lower than 0.05 or otherwise would be dismissed. The results of this analysis are shown in Table 11, with a confidence level of 95%. The thresholds and the parameters are shown with the estimated value through the ordinal regression analysis. For an easier identification of each of the values, the parameters are shown with its original label instead of their numeric value, as originally given in SPSS. Additionally, for those values than “0ª” is showed, this means that this value is taken as the base or reference attribute, reason why the part-worth utility is equal to 0.

Table 11. General model Parameter estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval	
							Lower Bound	Upper Bound
Threshold	[Scale4 = 1]	-1.498	.216	48.322	1	.000	-1.921	-1.076
	[Scale4 = 2]	.035	.206	.028	1	.867	-.370	.439
	[Scale4 = 3]	2.208	.217	103.716	1	.000	1.783	2.633
Parameters	[Passengers = Alone]	.009	.112	.007	1	.932	-.210	.229
	[Passengers = 1 or more]	0[a]	.	.	0	.	.	.
	[Lighting= Daylight]	.084	.128	.428	1	.513	-.168	.336
	[Lighting= Night with lighting ON]	.024	.129	.034	1	.855	-.229	.277
	[Lighting= Night with lighting OFF]	0[a]	.	.	0	.	.	.
	[Road Condition = Regular]	.847	.114	55.546	1	.000	.625	1.070
	[Road Condition = Difficult]	0[a]	.	.	0	.	.	.
	[Traffic Intensity = High]	.035	.129	.075	1	.784	-.217	.288
	[Traffic Intensity = Medium]	.087	.129	.450	1	.502	-.166	.339
	[Traffic Intensity = Low]	0[a]	.	.	0	.	.	.
	[Trip Distance = Long]	.620	.130	22.547	1	.000	.364	.875
	[Trip Distance = Medium]	.444	.129	11.882	1	.001	.192	.697
	[Trip Distance = Low]	0[a]	.	.	0	.	.	.
	[Visibility = High]	.277	.129	4.596	1	.032	.024	.531
	[Visibility = Medium]	-.100	.129	.603	1	.437	-.352	.152
	[Visibility = Low]	0[a]	.	.	0	.	.	.
	[Level of Fatigue = Low]	-.423	.129	10.739	1	.001	-.675	-.170
	[Level of Fatigue = Medium]	-.344	.130	7.026	1	.008	-.598	-.090
	[Level of Fatigue = High]	0[a]	.	.	0	.	.	.
Link function: Logit.								
a. This parameter is set to zero because it is redundant.								

The distribution levels of the willingness to use ACC obtained from the thresholds in the previous analysis can be observed in Figure 26. SPSS provides the intermediate value between each of the four areas, which means that "Scale4 = 1" is giving the value of the border point between "Strongly disagree" and "Disagree", "Scale4 = 2" gives the border point value from "Disagree" and "Agree", and so on.

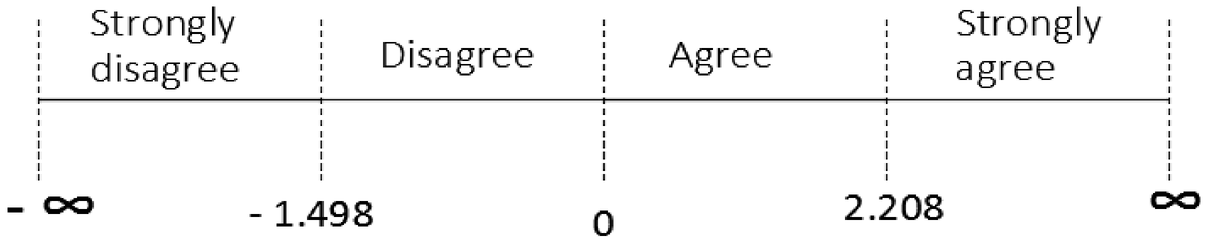

Figure 26. Thresholds of Ordinal Regression Model

Checking the attributes and their corresponding significance level, there are four out of the total seven which have a significant value, which means that they have an influence in the decision making of the respondents in order to activate ACC. These are: “Road condition”, “Trip distance”, “Visibility” and “Level of fatigue”.

On the other hand, the other three attributes (“Nº of Passengers”, “Lighting” and “Traffic intensity”) do not have an effect on the user willingness to use ACC, at least for the general model.

The first attribute (Road condition) is the one with the highest part-worth utility value, which means that this attribute is the most important one. A regular condition of the road stimulates to the drivers to choose to turn ON ACC. The conclusion of this is that the users prefer a straight road more than a curve road in order to be activating ACC, and this is, in addition, the main feature for doing so.

The second attribute (Trip distance) provides significant values for all its levels, with a higher utility for the level “Long” distance than for the level “Medium” distance. This means that the longer a trip is the higher are the probabilities to be using ACC on this trip. There are no significant differences between being a long (>100 Km) or a medium trip (20 – 100 Km). Hence, there is a barrier somewhere around 20 Km where the drivers consider that using ACC provide benefits for themselves, whereas before reaching that number it is more convenient to drive completely manually.

The third attribute (Visibility) is only significant for the “High” visibility level (clear or cloudless state), which means that the “Medium” visibility level (raining or snowing) does not influence at all the driver to use ACC. The fact that there is a clear visibility pushes the drivers to decide to use ACC, maybe considering that the system does not have any problem for dealing with this situation. On the other hand, if the visibility level is “Low” (foggy), the driver tends to be not so positive with ACC, perhaps being more confident with their own visibility than with the systems’.

The last attribute (Level of fatigue) is providing significant values at all levels. When a “Low” level of fatigue (being very fresh) is considered, this gives a negative influence on the willingness to use ACC. This means that the drivers prefer manually driving while they are fresh. On the other hand, when they are under a “High” level of fatigue (very tired) it becomes a positive attribute in order to turn ON their Adaptive Cruise Control. This could represent a trust in the system, as they might prefer to not connect it while being fresh in order to enjoy the driving and to switch it ON when they are tired in order to be safer in accident situations.

In the following figures, the effect of the four attributes previously commented (those that have significant values) is shown. The part-worth utility of each of the levels indicates if this value is giving a positive or a negative influence on the acceptance of ACC, compared to the one that is taken as the base category or reference value, which is set to 0.

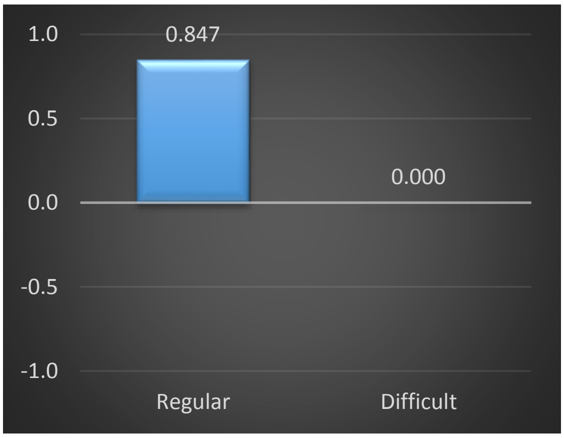

Figure 27. Road condition part-worth utility values

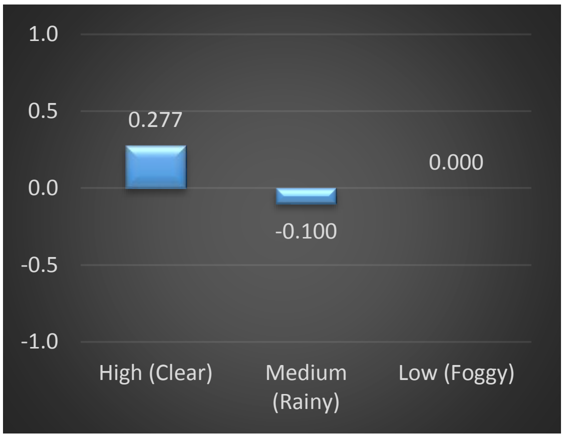

Figure 28. Visibility part-worth utility values

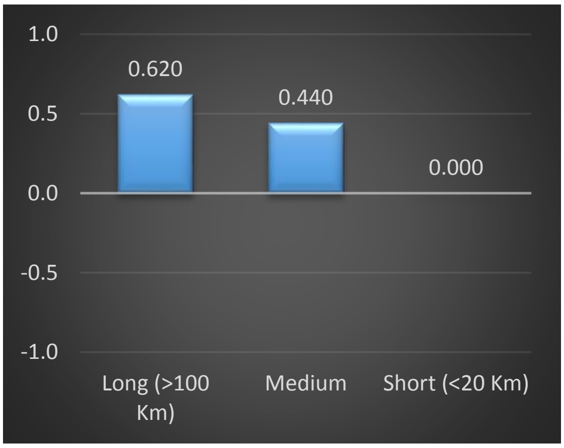

Figure 29. Trip distance part-worth utility values

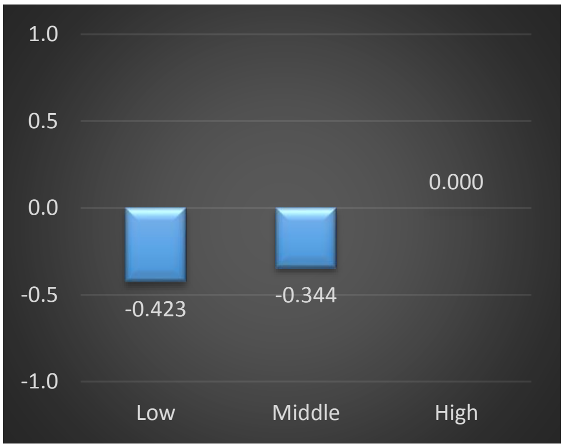

Figure 30. Level of fatigue part-worth utility values

<u>Relative importance of the significant attributes</u>

Besides calculating the part-worth utility of each of the attributes, the relative importance of each attribute is characterised (Orme, 2010). This is done by considering the differences that each attribute can make in the total utility, which is the range. Afterwards, the percentage from the relative range is calculated.

The part-worth utility of the highest and the lowest attribute levels are subtracted to calculate the attribute utility range. Then, that utility range weights are summed, after which it is possible to calculate the attributes' influence in the complete model by dividing each individual attribute utility range by the total. Taking as an example the trip distance attribute, the range of this attribute is calculated by subtracting to the long trip utility (0.620) the short trip utility (0.000), after which it is possible to calculate the percentage (attribute importance) by dividing this value by the total utility range. The results from these relative importance calculations can be seen in Figure 31 and the representation in Figure 32.

In accordance with these results, the attribute with the most importance is the Road condition, being the attribute that influences the most the decision of the respondents, with a 39% of the totality. The second one is the trip distance, which represents almost 29% of the total. The third one, representing almost 20% of the total is the level of fatigue. Finally, the attribute with the least influence is the visibility, with a bit less than 13%.

Attribute	Level	Parth-Worth Utility	Attribute Utility Range	Attribute Importance
Road Condition	Regular	0.847	0.847-0.000 = 0.847	(0.847/2.167)·100% = 39.1%
	Difficult	0.000		
Trip Distance	Long	0.620	0.620-0.000 = 0.620	(0.620/2.167)·100% = 28.6%
	Medium	0.440		
	Short	0.000		
Visibility	High	0.277	0.277-0.000 = 0.277	(0.277/2.167)·100% = 12.8%
	Medium	0.000		
	Low	0.000		
Level of Fatigue	Low	0.423	0.423-0.000 = 0.423	(0.847/2.167)·100% = 19.5%
	Middle	0.344		
	High	0		
			Utility Range TOTAL 0.847+0.620+0.277+0.423 = 2.167	

Figure 31. Relative importance of significant attributes (Calculation)

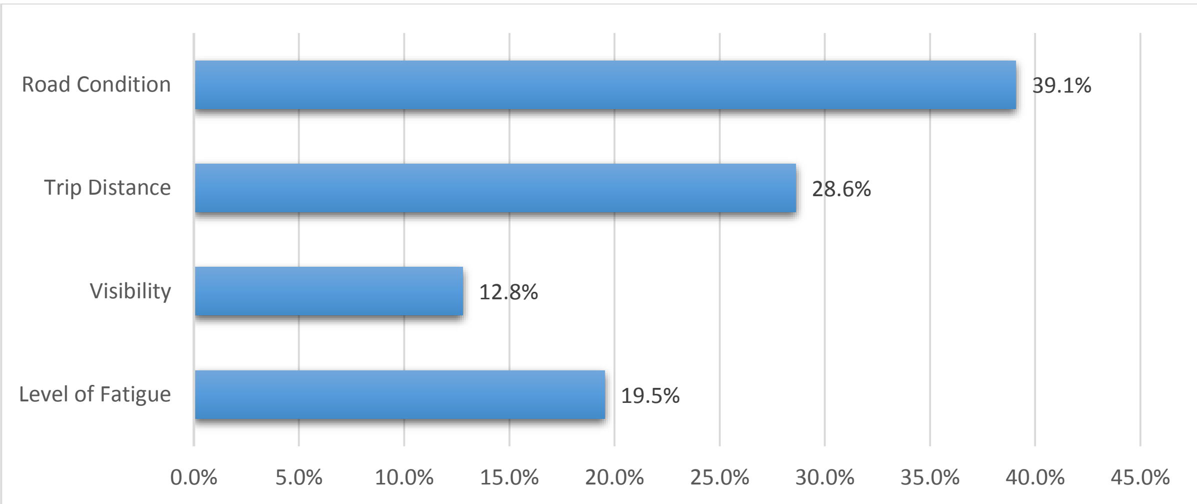

Figure 32. Relative importance of the significant attributes (Representation)

<u>Combined part-worth utility</u>

When the values of all four attributes are combined, the combination of driving conditions that are more desired by the user in order to be willing to use ACC can be determined. This combination of the part-worth utility values can be seen in Table 12.

Considering these results, all the combinations present a driving situation in which the respondent would “Agree” (0 – 2.208) in turning ON ACC. In addition, the most favourable one consists of a combination of a regular road condition in a long trip with high visibility and high level of fatigue, which provides a total utility value of 1.744.

Table 12. Combined part-worth utility with general model

Attribute 1	Utility	Attribute 2	Utility	Attribute 3	Utility	Attribute 4	Utility	Total Utility
Road condition (1)	.847	Trip distance (1)	.620	Visibility (1)	.277	Level of fatigue (1)	-.423	**1.321**
						Level of fatigue (2)	-.344	**1.400**
						Level of fatigue (3)	0	**<u>1.744</u>**
		Trip distance (2)	.444			Level of fatigue (1)	-.423	**1.145**
						Level of fatigue (2)	-.344	**1.224**
						Level of fatigue (3)	0	**1.568**

4.4.2. Additional models for separate groups

Additionally to the main model, the sub-models of six groups are estimated and each of them is individually analysed. With this information is expected to be discovered if different driving conditions affect to different groups of people in a different way. For example, driving conditions that are relevant for the general model might not be significant at all for specific groups of people. In contrast, some of the attributes which are not significant for the general model, can be now significant for a specific sub-model.

The reasons to analyse these groups are that have an acceptable good distribution of respondents for all the levels and therefore a similar amount of available data for its analysis. In addition, analysing the differences from the general model could provide valuable information to stimulate the use of ACC in a particular group. The following groups have been analysed:

- Gender
- Age
- Nationality
- Household
- System knowledge
- Driving styles

The following tables only contain information regarding the attributes that are significant. Even if an attribute is only significant for one of the groups, the other/s groups is/are also included in the table to show the difference between them. In addition, to reduce the information included in the tables, the level of each attribute is shown only with the level number that identifies them, instead of the label; e.g. Trip distance = "1" instead of "Long tip (> 100 km)". As a reminder, this identification can be found in Table 1. Finally, the value of the R-square is calculated and presented at the end of each table, whereas the tables regarding the goodness of fit of each of the models are located in the Appendices.

Gender

This paragraph compares the differences between genders. First of all, it has to be reminded that males are highly represented in the sample. This might be the reason behind that the "Male" model has a good fit whereas the "Female" one has a much lower value for its R-square. In addition, for all the values the "Male" model gives higher values, which means that they would be more willing to use ACC than the female group.

Even though the significant values are the same as for the general model, there are some significant differences between them. The main thing to be highlighted is how "Visibility" affects each group. For the males, the fact of driving with a "High" visibility (clear sky) is preferred in comparison with doing it with "Low" visibility (foggy), similarly than for the general group. However, the "Medium" visibility (rainy or snowy) is not significant for the males. In contrast, for the women, a "High" visibility does not have any influence, either positive or negative, whereas a "Low" visibility (foggy) has higher chances for switching ON ACC in comparison with a "Medium" visibility (rainy or snowy). This could mean that the female group prefer to release some control of the car and trust the system when there is low visibility, disconnecting ACC when there is a better visibility.

Table 13. Part-worth utility from the significant attributes (Sub-model: Gender)

Attribute	Level	Male		Female	
		Utility	Significance	Utility	Significance
Threshold	Scale4: 1	-1.432	.000	-1.961	.000
	Scale4: 2	0	*Not Sig.*	0	*Not Sig.*
	Scale4: 3	2.256	.000	1.954	.000
Road Condition	1	.968	.000	.614	.002
	2	0ª	-	0ª	-
Distance	1	.634	.000	.499	.031
	2	.449	.004	.428	.061
	3	0ª	-	0ª	-
Visibility	1	.462	.004	*Not significant*	
	2	*Not significant*		-.505	.030
	3	0ª	-	0ª	-
Fatigue	1	-.341	.030	-.651	.004
	2	-.400	.011	*Not significant*	
	3	0ª	-	0ª	-
R-square	-	0.2660		0.1253	

The information regarding the goodness of fit of the previous table models can be found in Table 32 and Table 33 (Appendix V).

Age

This paragraph analyses the differences from the several age groups. This set was originally formed by four groups, from which the last one (65 years or more) has 0 respondents. In addition, from those groups with answers, two of them have been put together. This is the case of the groups of “30 to 49 years” and “50 to 64 years”, which now make a unique new group: “30 to 64 years”. With the new distribution, there is a 50% of answers in each of the groups, with 104 respondents in both of them.

Comparing the R-square values of both groups, the younger group represents a decent model, being its value 0.17, whereas the oldest group have a better fit (0.23). Therefore, the obtained models are adequate for being analysed.

When these models are compared with the base model there are three attributes which are significant in all three models. These are: road condition, trip distance and level of fatigue. In addition, the utility values are more or less similar.

The first main difference is observed in the younger group (18-29), for which the “Traffic” intensity attributes give “significant” values. A clarification needs to be made due to the fact that for level “1” a value of 0.104 is obtained, which is slightly out of the significant area. However, this can in any case be interpreted as a positive influence for the young group (18-29) in order to use ACC when there is a “High” (traffic jam) or “Medium” (interrupted flow) traffic intensity rather than being “Low” (free flow). In contrast with what happens in the base model, “Visibility” does not have an influence on this group.

The second group (30-64) is not influenced by the “Traffic” intensity as the young group. Instead, the “Visibility” does have an influence for the “High” (clear, cloudless) level, which produces a slightly willingness of the user to turn ON ACC in comparison with the “Low” (foggy) visibility. This suggests a lack of trust in the system as it is preferred to activate ACC when there are no difficulties in the road, and take the control themselves when the visibility is lower and it is not possible to see the road as well.

Table 14. Part-worth utility from the significant attributes (Sub-model: Age)

Attribute	Level	18-29		30-64	
		Utility	Significance	Utility	Significance
Threshold	Scale4: 1	-1.360	.000	-1.705	.000
	Scale4: 2	0	*Not Sig.*	0	*Not Sig.*
	Scale4: 3	2.267	.000	2.218	.000
Road Condition	1	.760	.000	.993	.000
	2	0ª	-	0ª	-
Traffic	1	.293	.104	*Not significant*	
	2	.317	.084	*Not significant*	
	3	0ª	-	0ª	-
Distance	1	.544	.003	.744	.000
	2	.409	.025	.510	.006
	3	0ª	-	0ª	-

Visibility	1	*Not significant*		.373	.043
	2	*Not significant*		*Not significant*	
	3	0ª	-	0ª	-
Fatigue	1	-.416	.020	-.451	.016
	2	-.332	.071	-.396	.032
	3	0ª	-	0ª	-
R-square	-	0.1736		0.2397	

The information regarding the goodness of fit of the previous table models can be found in Table 34 and Table 35 (Appendix V).

Nationality

Even though the main focus of the research is put in the Netherlands, due to the multicultural country and international network of the researcher, the 43% of the respondents in this survey are from nationalities other than the Dutch. The final distribution of 57% "Dutch" nationality and 43% "Other" nationalities is considered as an unexpected way to analyse differences between them.

The R-square of the "Other" model has a low level of fit, maybe due to the fact that this group is formed by people from multiple nationalities, whereas the "Dutch" model has a good fit. For this reason the results from the "Other" model might not be as accurate as for the "Dutch" group.

The significant attributes are exactly the same as for the general model, even though for the "Other" mode the visibility is not significant. The interpretation is therefore similar than for the general model. There is a higher preference to switch ON ACC with a "Regular" road condition, "Long" trip distances, "High" (clear) visibility and "High" level of fatigue, compared with the other attribute levels.

Table 15. Part-worth utility from the significant attributes (Sub-model: Nationality)

Attribute	**Level**	**Dutch**		**Other**	
		Utility	Significance	Utility	Significance
Threshold	Scale4: 1	-1.374	.000	-1.698	.000
	Scale4: 2	0	*Not Sig.*	0	*Not Sig.*
	Scale4: 3	2.482	.000	1.969	.000
Road Condition	1	1.074	.000	.578	.001
	2	0ª	-	0ª	-
Distance	1	.800	.000	.403	.043
	2	.544	.002	.343	.079
	3	0ª	-	0ª	-
Visibility	1	.420	.014	*Not significant*	
	2	*Not significant*		*Not significant*	
	3	0ª	-	0ª	-

Fatigue	1	-.492	.004	-.352	.073
	2	-.311	.071	-.380	.056
	3	0ª	-	0ª	-
R-square	-	0.2869		0.1145	

The information regarding the goodness of fit of the previous table models can be found in Table 36 and Table 37 (Appendix V).

Household

The household type of the respondents is divided in three groups. The first one consist in people living on their own, the second one are multiple people without children, and the last one are multiple people with children. Each of the groups holds approximately one third of the total respondents. The first one ("One-person") has the lowest quality of the three models with a value of 0.12 (decent model), whereas the other two have both of them a good fit.

The first ("One-person") and second ("Multiple people without children") sub-models does not present important differences between these models and the general one, having therefore a similar interpretation. This means that those groups are well represented by the general model.

The most important element to be emphasised is found in the third model ("Multiple people with children"). In this sub-model, the "Passengers" attribute is found significant for the first and only time in any of the other groups. The number of people that are in the car is relevant for this group, which might be indeed expected considering that is the group with a higher sensitivity for passengers, as they are used to have children in their care. For this group is preferred to use ACC while driving alone than with passengers. This behaviour is opposed from what could be expected. One might think that drivers with ongoing distractions due to the fact of having more passengers in the car could be willing to use ACC as a system to take part of their actions. Therefore, this suggests a higher confidence in their own capabilities rather than in ACC. Finally, this group is only sensitive to the "Road condition" and the "Distance" trip besides the "Passengers" attribute, not being significant neither the "Visibility" nor the "Level of fatigue", as it happens in the general model.

Table 16. Part-worth utility from the significant attributes (Sub-model: Household)

Attribute	Level	One person		Multiple people without children		Multiple people with children	
		Utility	Sig.	Utility	Sig.	Utility	Sig.
Threshold	Scale4: 1	-1.831	.000	-1.322	.001	-1.402	.000
	Scale4: 2	0	*Not Sig.*	0	*Not Sig.*	0	*Not Sig.*
	Scale4: 3	1.840	.000	2.476	.000	2.530	.000
Passengers	1	*Not significant*		*Not significant*		.383	.056
	2	0ª	-	0ª	-	0ª	-
Road Condition	1	.628	.002	.757	.000	1.139	.000
	2	0ª	-	0ª	-	0ª	-

Distance	1	.566	.012	.717	.002	.646	.005
	2	*Not significant*		.506	.028	.636	.005
	3	0ª	-	0ª	-	0ª	-
Visibility	1	*Not significant*		.888	.000	*Not significant*	
	2	*Not significant*		*Not significant*		*Not significant*	
	3	0ª	-	0ª	-	0ª	-
Fatigue	1	-.593	.009	*Not significant*		*Not significant*	
	2	*Not significant*		-.609	.009	*Not significant*	
	3	0ª	-	0ª	-	0ª	-
R-square	-	0.1256		0.2522		0.2190	

The information regarding the goodness of fit of the previous table models can be found in Table 38, Table 39 and Table 40 (Appendix V).

<u>Respondents' systems knowledge</u>

This group is divided in three levels as previously commented in the literature, which are "High", "Middle" and "Low" systems' knowledge.

The first thing to be highlighted is that even though the number of participants from each group is similar (36% – 37% – 27%) there is a big difference in the quality of each of the models. The first one ("High") has a great fit with a value of 0.27 in its R^2. The "Middle" one has also a good fit with a lower value of almost 0.19. Finally, the last one ("Low") represents a model from which could be said that is "decent" (Almost 0.1 in its R^2 value). This means that the people who have a higher knowledge have an opinion that is more similar between them, whereas a lower level of knowledge produces significant differences between them, deriving in an unstable model.

The "High" knowledge group provides significant values for the same attributes than the general model. The main difference is that the part-utility values are considerably higher than for the aforementioned group. There is, however, a significant difference. The "Traffic" intensity attribute is significant for the "Medium" traffic (interrupted flow). The negative value of this attribute level means that this group of people is more willing to use ACC with a "Low" intensity (free flow) than doing it with the "Medium" intensity traffic. Unfortunately nothing can be said about the "High" traffic level (traffic jam).

For the group with a "Middle" system knowledge, two attributes are significant besides those that are common for the general group. The first additional significant attribute is "Traffic" intensity, which has an opposed influence than the previous group. In this group is preferred a "Middle" traffic (interrupted flow) than a "Low" one (free flow) in order to switch ON ACC. The second additional significant attribute is "Lighting". The users of this group are more willing to use ACC in a situation with "Daylight" rather than with no lighting during the night.

The last group ("Low"), besides having a low quality model, does not have almost any significant attributes (only "Road condition" and trip "Distance"), which have similar values than those in the general model.

Table 17. Part-worth utility from the significant attributes (Sub-model: Respondents systems knowledge)

Attribute	Level	High		Middle		Low	
		Utility	Sig.	Utility	Sig.	Utility	Sig.
Threshold	Scale4: 1	-1.650	.000	-1.567	.000	-1.382	.001
	Scale4: 2	0	*Not Sig.*	0	*Not Sig.*	0	*Not Sig.*
	Scale4: 3	2.038	.000	2.611	.000	2.158	.000
Lighting	1	*Not significant*		.515	.017	*Not significant*	
	2	*Not significant*		*Not significant*		*Not significant*	
	3	0ª	-	0ª	-	0ª	-
Road Condition	1	1.198	.000	.892	.000	.448	.037
	2	0ª	-	0ª	-	0ª	-
Traffic	1	*Not significant*		*Not significant*		*Not significant*	
	2	-.455	.041	.393	.064	*Not significant*	
	3	0ª	-	0ª	-	0ª	-
Distance	1	.674	.002	.616	.005	.603	.015
	2	.632	.004	*Not significant*		.626	.011
	3	0ª	-	0ª	-	0ª	-
Visibility	1	.536	.017	*Not significant*		*Not significant*	
	2	*Not significant*		*Not significant*		*Not significant*	
	3	0ª	-	0ª	-	0ª	-
Fatigue	1	-.593	.012	-.352	.095	*Not significant*	
	2	-.564	.011	*-.362*	*.095*	*Not significant*	
	3	0ª	-	0ª	-	0ª	-
R-square	-	0.2683		0.1882		0.0978	

The information regarding the goodness of fit of the previous table models can be found in Table 41, Table 42 and Table 43 (Appendix V).

<u>Driving styles</u>

The last sub-model to be analysed is “Driving Styles”. Due to the small sample and the fact that this group is divided in between four groups, there are only around 50 respondents on each group. The consequence of the low amount of respondents is that there are two sub-models (“F1” and “F3”) that have a poor fit and most of its attributes are not significant, which is the reason why are not commented.

The second group (“F2. Reckless and careless driving style”), provides a model of a good quality fit (R-square=0.33). For this group the willigness of using ACC is higher for the moments in which there is “Night with lighting ON” (Level 2) than when there is night but with the lights switch off (Level 3). Additionaly, has significant values for the attributes “Road condition”, “Distance” and “Level of fatigue”, such as in the general model. Regarding the trip distance, is highly desired to use ACC for distances longer than 100 km, being a bit less desired to use ACC if the trip is between 20 and 100 km. Finally, has to be highlighted the “Traffic” intenisty attribute. This group would gladly use ACC when there is a “High” level (traffic jam) in comparison with a "Low" level (free flow). This makes sense taking into consideration that they are considered to be a group that enjoys from driving at high speeds, and with the use of ACC limiting the speed this would not be possible.

The "Patient and careful driving style (F4)" has a preference for longer trips over the really short ones, which might be due to the fact that this group likes to prepare their trips in advance and being longer distances would allow to prepare the trip and use the system with fewer reservations. They also prefer to switch on ACC when there is a "High" (cloudless) or "Medium" (rainy/snowy) visibility rather than a "Low" (foggy) one.

Table 18. Part-worth utility from the significant attributes (Sub-model: Driving styles)

Attribute	Level	F1		F2		F3		F4	
		Utility	Sig.	Utility	Sig.	Utility	Sig.	Utility	Sig.
Threshold	Scale4: 1	-1.998	.000	-.909	.049	-2.995	.000	-1.146	.007
	Scale4: 2	0	*Not Sig.*	0	*Not Sig.*	0	*Not Sig.*	0	*Not Sig.*
	Scale4: 3	1.649	.000	3.062	.000	1.569	.000	2.928	.000
Lighting	1	*Not significant*		*Not significant*		*Not significant*		*Not significant*	
	2	*Not significant*		.518	.063	*Not significant*		*Not significant*	
	3	0ª	-	0ª	-	0ª	-	0ª	-
Road Condition	1	.777	.001	.982	.000	.458	.032	1.254	.000
	2	0	-	0	-	0	-	0	-
Traffic	1	*Not significant*		*.928*	*.001*	*Not significant*		*Not significant*	
	2	*Not significant*		.659	.016	*Not significant*		*Not significant*	
	3	0ª	-	0ª	-	0ª	-	0ª	-
Distance	1	*Not significant*		1.654	.000	*Not significant*		*.512*	*.051*
	2	*Not significant*		1.116	.000	*Not significant*		*.517*	*.044*
	3	0ª	-	0ª	-	0ª	-	0ª	-
Visibility	1	*Not significant*		*Not significant*		*Not significant*		*.778*	*.003*
	2	*Not significant*		*Not significant*		*Not significant*		*.494*	*.065*
	3	0ª	-	0ª	-	0ª	-	0ª	-
Fatigue	1	-.787	.003	-.649	.023	*Not significant*		*Not significant*	
	2	-.569	.033	-.770	.006	*Not significant*		*Not significant*	
	3	0ª	-	0ª	-	0ª	-	0ª	-
R-square	-	0.1311		0.3335		0.0521		0.2090	

The information regarding the goodness of fit of the previous table models can be found in Table 44, Table 45, Table 46 and Table 47 (Appendix V).

4.5. Factors underlying ACC choice decision

In this last section, the results regarding the willingness of the people for switching ON ACC and the importance of factors underlying this choice are given.

First of all, a frequency table from the responses regarding the users' willingness to switch ON ACC is provided (Table 19), for which the mean and standard deviation table can be found in Appendix III (Table 24).

Only the 32.9% "Strongly Disagree" or "Disagree" with the fact of using ACC. This gives a **67.1%** of responses with a positive people **willing to use ACC** ("Agree" or "Strongly Agree"), which duplicates the negative ones.

Table 19. Frequency table from "Scale4" factor (Willingness to switch ON ACC)

	Frequency	Percent	Valid Percent	Cumulative Percent
Strongly Disagree	127	10.2	10.2	10.2
Disagree	283	22.7	22.7	32.9
Agree	576	46.2	46.2	79.0
Strongly Agree	262	21.0	21.0	100.0
Total	1248	100.0	100.0	

In addition, besides asking the people to respond regarding their willingness to activate ACC, the factors that were influencing their decision were also asked. The questionnaire allowed selecting any or as many factors as they want from a list of three items:

- Increase / Decrease Safety
- Increase / Decrease Comfort
- Improve / Reduce Fuel efficiency

The result of the number of times that these factors were selected can be seen in Figure 33. Additionally, the mean and standard deviation from these three values can be found in Appendix III (Table 23), as well as the frequency tables of each of the values at Table 26, Table 27 and Table 28.

The most important factor for the respondents is "Safety", which is selected 2 out of 3 times (66.7%). However, this counts for both positive (reducing the risk of head-tail collisions) and negative influence, as for those users who decide to not use ACC for safety reasons it is assumed that they believe that without ACC their driving tasks become safer. Followed by safety, the second factor with a higher influence is "Comfort", for which 54% of the respondents are influenced. Comfort is, indeed, the primary purpose of ACC according to the manufacturers, reason why it makes sense a high influence in the decision of the users. Finally, the factor with the lowest influence underlying the ACC choice decision is "Fuel efficiency", which only a 16.8% has chosen.

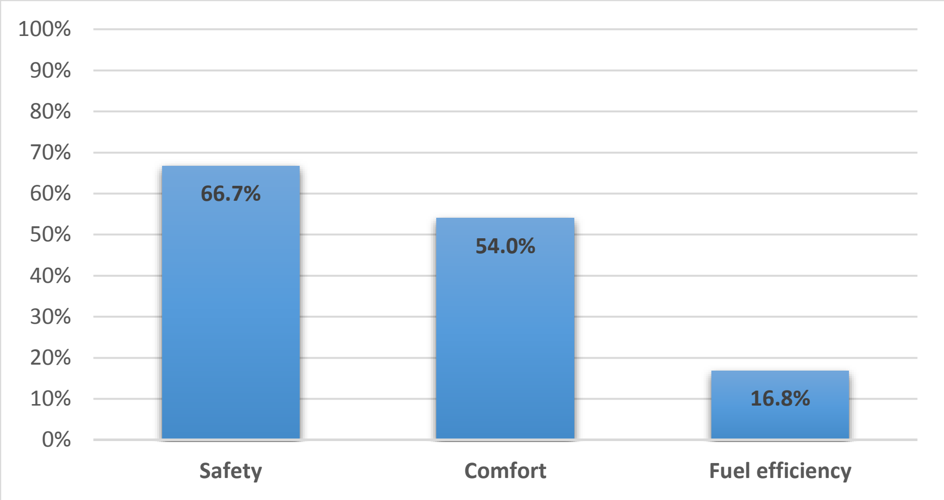

Figure 33. Factors underlying ACC choice decision

Comparing the percentage of people who chose these factors as an influence on their decision with their choice regarding the use of ACC in a 4-scale level, a crosstable is obtained (Figure 34). From this comparison is possible to discern in what way are the factors influencing the decision choice.

The main conclusion is that, in general, the three factors are perceived as positive influences for the use of ACC. About 3 out of every 4 respondents who selected any of the factors also chose to "Agree" or "Strongly agree" regarding the question of switching ON ACC. This is the case especially for the two last attributes ("Comfort" and "Fuel efficiency"), which are mainly seen as a positive influence. In contrast, "Safety" is not only seen as a positive feature, but also as some kind of concern. This is concluded by the fact that there are a 35% of people who selected safety as the reason to "Strongly disagree" or "Disagree" with their choice regarding the willingness to use ACC. This can be interpreted as that they consider that their safety is reduced by using ACC.

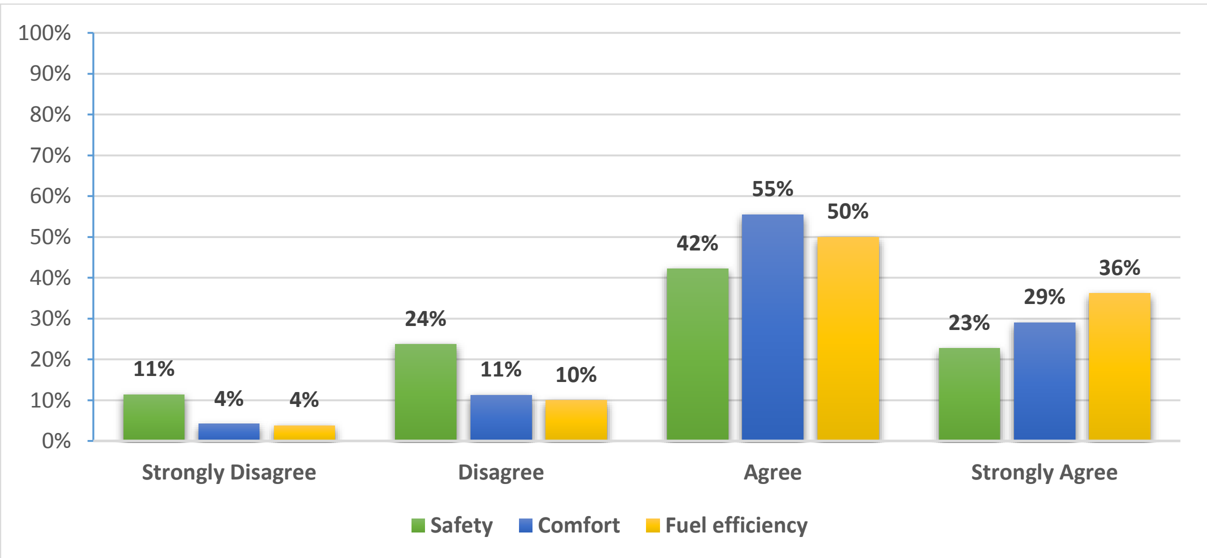

*Figure 34. Crosstable (ACC agreement * Factors)*

4.6. Willingness to possess ACC

The last question in the questionnaire concerned the extent to which respondents would be interested in having Adaptive Cruise Control in their next car. The willingness to have ACC in the next car is measured on a 5-points scale. The frequencies of the responses are given in Table 20, for which the mean and standard deviation table can be found in Appendix III (Table 25).

The results of this question show that only a few groups of people would not like to have an ACC system in their future car (16.3% considering those who are "Not at all interested" or "Slightly interested"). In contrast, considering the enthusiastic groups, there is a 61.5% of people who are "Very interested" or "Extremely interested". This percentage is similar to the one obtained from the positive answers regarding the "Willingness to switch ON ACC" at Table 19, where the 67.1% are giving a positive opinion with the different driving situations.

Table 20. Frequency table from "ACC purchasing" (Willingness to have ACC in the next car)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all interested	8	3.8	3.8	3.8
	Slightly interested	26	12.5	12.5	16.3
	Moderately interested	46	22.1	22.1	38.5
	Very interested	77	37.0	37.0	75.5
	Extremely interested	51	24.5	24.5	100.0
	Total	208	100.0	100.0	

4.7. Conclusions

The results of this survey which contain data of 208 respondents (1248 situations) are focused in determining the willingness of the users regarding the active use of Adaptive Cruise Control. The influence of seven driving conditions (attributes) in the drivers' willingness to use ACC is analysed.

First of all the collected data is analysed with a descriptive analysis. The sample is predominantly formed by male respondents and is highly educated. Additionally, several clusters are created with part of the obtained data (systems' knowledge and driving style). From this analysis is observed that the "High" and "Medium" levels of ADAS knowledge are the most represented ones, which shows a sample with previous experience in ADAS.

The Ordinal Regression analysis from the general model four attributes appears to have an influence in the decision making of the respondents, , which are "Road condition", "Trip distance", "Visibility" and "Level of fatigue". Therefore, the other three attributes ("Passengers", "Lighting" and "Traffic intensity") are not significant for the general model, even though all three are relevant at some of the analysed sub-models. There are, in addition, six additional groups for which sub-models are created to analyse the similarities and differences between these separate groups.

The attributes with a bigger influence on the choice of the users are "Road condition" and "Trip distance", which together achieve 67.7% of the importance. Additionally, the most favourable combination, which provides the highest utility value, is obtained when the attributes with higher utility value are considered together. These are formed by a regular road condition, on a long trip, with high visibility and high level of fatigue.

According to the information obtained from the general model, the respondents are more willing to switch ON ACC with a "Regular" than a "Difficult" road. In addition, the longer the trip is, the better for decide to use ACC. Furthermore, "High" visibility is preferred for turning ON ACC compared with "Low" visibility. Finally, the respondents are more willing to use ACC when they have a "High" level of fatigue (very tired) than when they are very fresh, moment in which is more likely to not connect ACC.

The six groups that are analysed show that the pattern observed in the general model are obtained as well, even though with some differences, for the sub-models. Additionally to the four attributes that are relevant for the general model, also the "Lighting" and "Traffic intensity" attributes are significant in several groups. However, there is one attribute ("Passengers"), which is only significant for the "Household" group and sub-model "Multiple people with children". Therefore, it can be concluded that this attribute does not have almost any influence in the willingness of the users for using ACC.

Furthermore, besides analysing the willingness of the people for switching ON ACC, also the importance of factors underlying this choice is analysed. Regarding the first part, it can be concluded that for the **most of the situations (2 out of 3) the users are willing to use ACC**.

In addition, considering the factors underlying ACC choice these show that, overall, "Safety", "Comfort" and "Fuel efficiency" are seen as positive elements to actively use Adaptive Cruise Control. However, the "Safety" factor is also seen by a large group of people (35%) as something negative, due to the fact that are considering that the use of ACC reduces their safety in this specific driving situation.

Finally, the results from the last question of the survey show that most of the respondents are "Very" or "Extremely" interested in having an ACC system in their future car. This is a similar percentage to the responses that, regarding the opinion to use ACC within the multiple hypothetical driving situations, are willing to use ACC.

5. Conclusions and Recommendations

This chapter includes the conclusions of this research, answering the main and additional research questions. In addition to that, the scientific and societal relevance of the project is evaluated. Afterwards, the limitations faced by this research and recommendations, not only for further research but also for other stakeholders, are presented.

5.1. General conclusions

Aiming to achieve a better transport through Smart Mobility, the willingness of the users to use Adaptive Cruise Control is evaluated, as this technology can reduce the number of accidents by increasing drivers' safety, increase traffic efficiency, and especially improve drivers' comfort. Additionally, this is a step towards a complete car automation with self-driving cars as the final goal.

Through the use of a Stated Choice experiment has been seen that the most of the respondents are willing to use ACC in most of the suggested driving conditions. However, even if the results provide reasons to believe that there should be more ACC users, this is not the case and therefore a possibility to improve this can be taken.

To analyse the user concerns regarding this willingness of the drivers towards ACC, four research sub-questions are answered, which are contributing to finally answer the main question. In the following paragraphs the answers to the research questions are given.

1. *What are the characteristics of ADAS, and specifically of ACC?*

Advanced Driver Assistance Systems (ADAS) are electronic systems supporting the driver by intervening in their driving tasks and performing certain parts of the driver's tasks. Adaptive Cruise Control (ACC) is a system designed to automatically adjust the vehicle' speed adaptively to a forward vehicle. This means that the vehicle speed is controlled by the system while being continuously adapted to a forward vehicle' speed by keeping a pre-defined time gap. In the case that the road is free, a pre-selected speed is maintained.

2. *What are the expected benefits of ACC for users, society, companies and governments?*

The existent literature show that from all the stakeholders the users are those who can take the biggest advantage from ACC. This is due to the fact that they are benefiting from all the areas in which ACC can be useful, which are driving comfort, traffic efficiency, traffic safety and fuel consumption. Society and governments might benefit from a higher efficiency in the roads and especially by increasing the traffic safety and reducing the number of accidents.

3. *What are the most relevant driving conditions?*

After studying the previous literature a list with the most relevant driving conditions affecting driver behaviour are determined. Even though, as the main focus of ACC is predominantly a comfort feature focused at freeways, some of the features that were important are not considered for not being relevant in the specific situation. This is why only one type of road is considered, leaving all the others out of the research. In addition, the most representative reason to drive on a highway is commuting and therefore the other types were cast aside. Finally, besides these general conditions that are fixed for all situations, there are other driving conditions considered. In total seven driving conditions are considered as the most relevant for this study, which are divided between external ("Traffic intensity", "Road condition", "Visibility through weather condition" and "Lighting") and internal ("Level of Fatigue", "Trip Distance" and "Number of Passengers").

After the research is conducted, some driving conditions haver outstand over the others. Some of them have a bigger influence in the user willingness to use ACC, whereas some have a minor or null influence in this decision. Therefore, after the analysis of the data is done, the most relevant driving conditions can be suggested to be "Road condition", "Trip distance", "Level of fatigue" and "Visibility".

4. *What is the current exposure to these technologies?*

After analysing the current exposure at the results of the survey it is observed that around one of every four respondents do not know almost any of the surveyed systems. Even though, there are some exceptions. The cases of APA and CCC show that almost all the respondents are familiar with these systems. In contrast, there is one system for which almost the half of the respondents are not aware of its existence, which is the case of TJA. The information obtained regarding the users' system knowledge is used to create three clusters consisting of people with a low, average and high systems' knowledge. This indicates that the most of the respondents are moderate to highly aware of the most of the surveyed ADAS technologies.

Finally, the main research question can be answered: "*How are the different driving conditions influencing users' acceptance of Adaptive Cruise Control?*".

An ordinal regression analysis of the general model has shown that there are four attributes that influence the user willingness to use ACC, which are, (1) Road condition, (2) Trip distance, (3) Visibility and (4) Level of fatigue. Even though the other three attributes are not significant for the general model, this is not the case of the rest of the several sub-models. Therefore all attributes have an influence in the users' willingness to use ACC even if this is the case for only one sub-model as in the case of "Number of passengers" attribute.

The attribute with the highest relative importance, "Road condition", influences strongly the users' willingness to use ACC in a positive way when they are asked about a "Regular road (straight)" condition in comparison with a "Difficult" one. The second one with a higher importance is the "Trip distance". This attribute makes the users willing to switch ON ACC for longer trips, being less desired to do so when the trip is shorter than 20 Km. Following with the order of relevance, the "Level of fatigue" is also modifying users' willingness to use ACC. In that case, activate the adaptive cruise control once they start to become fatigue is preferred, whereas the manual driving is chosen while they are fresh. The last attribute that is significant for the general model is the "Visibility", which slightly benefits the use of ACC when there is "High (cloudless)" visibility.

5.2. Scientific relevance

From a scientific perspective, the results based on the research questions are directly contributing to an extension of knowledge about the interaction between the several environmental and internal driving conditions and the level of users' acceptance. In addition, the results have achieved the main objective of this research, as the driving conditions that influence the users' willingness to use ACC have been exposed, as well as what driving circumstances does not have an influence in the users. Ideally, the knowledge obtained from this research might also be applied in the field of self-driving cars. Due to the fact that ACC is a step towards vehicle' automation, this information can be used for future implementation strategies of Autonomous Vehicles, as if the elements that are relevant for users' willingness to use ACC might be considered relevant as well for AV.

Finally, considering the expected results based on existent literature, the expectations from SWOV (2010) that calm traffic condition would be better to accept ACC, are not proved. This attribute is non-significant for most of the models, including the general one. In addition, for the sub-models in which "Traffic intensity" is significant, the attribute-level considering a "Low" traffic condition gives positive values at some of them, but at others is preferred a "High" or "Medium" traffic condition for using ACC. Regarding the expectation supported by Megens (2014), that younger drivers might be keener to release control and use these kind of technologies, this could not be proved. There is not a significant difference for the age groups models, both of them are equally willing to use the system.

5.3. Societal relevance

The society can profit from this research as a guidance to policymakers in order to increase the users' usage of this technology can be provided. A better understanding of the driver behaviour regarding the use of adaptive cruise control in a highway has been obtained. The focus of the study was put in finding out what driving circumstances are influencing the ACC usage, which could be further used.

The estimated model shows that some attributes have an influence in the users' choice, whereas there are others that does not have almost any influence. A more accurate information provide additional help to governments and other stakeholders to improve their decision-making. This can be done by investing their efforts in the aspects that influence the most to an increase of usage, instead of doing it in those which will not have a big impact. Furthermore, car manufacture companies can improve the system to become more desired by focusing their developments in the areas that are preferred by the users. Finally, individuals and society are undirectly benefiting from these aspects as final users for which the system is designed. Considering the factors influencing ACC choice, an increase in safety and driving comfort are the factors more appreciated by the respondents.

5.4. Limitations

In this paragraph, the limitations that are faced in this research are point out. The first and most important was the low number of respondents to analyse sub-models. Even though the number of answers was big enough for the analysis from the general model, the division into sub-models led to a low number in these groups. This triggered to models with a low goodness of fit, which might have been more accurate in the case of having a bigger amount of respondents. With a bigger sample, even after dividing the groups into smaller samples, the group might be still big enough and more representative, providing with higher amount of significant attributes.

Secondly, the sample distribution might not be the most appropriate one as does not constitute a perfect representation of the society. To begin with, the distribution is not diverse enough, in terms of age and gender. Additionally, the diversity regarding the level of education is almost inexistent, as the majority of the people of the sample have a high level of education, a factor which might to an extent affect the results.

Furthermore, due to the fact that while creating a stated choice experiment the number of attributes has to be limited, only seven attributes are analysed, which does not allow to draw conclusions about those attributes that were not finally considered. Regarding the experiment design, even though SC is a good and convenient method for the purpose of the research might not be the best one. Due to the fact that the information given to the respondents is limited to a written and video explanation, this cannot be reaching the broader perspective that other methods can provide.

5.5. Recommendations

In this section several recommendations are given. The first two paragraphs describe recommendations to the stakeholders, whereas the last one describes some suggestions for future research.

Policymakers

To government organisations, applying policies that increase the awareness and use of technologies such as Adaptive Cruise Control or other ADAS is suggested. This should be done to get advantage of the benefits that this technology provide, such as the increase in safety, which might hopefully be followed by a decrease in the number of accidents and deaths on the road. Considering the results, implement policies to increase users' usage might have a bigger percentage of success if it done starting in long straight sections of a highway, as this is the area in which the willingness of the respondents to use ACC has the highest value.

Car manufacturers

To car manufacturers, the willingness of most of the people to use ACC should be pointed out. However, the high percentage of people who are interested does not match the low penetration rate of ACC, which is something to take into consideration. A possible reason for this circumstance might be the high prices that are applied for those systems. If the event that this is the case, car manufacturers could try to encourage governmental parties to promote the use of ACC by subsidising part of the cost to stimulate a higher usage, similarly to what has been done with photovoltaic panels for a period of time.

Further research

Finally, regarding recommendations for further research, the importance of a bigger sample size must be highlighted, in order to obtain more accurate results, especially in terms of group division. Therefore, extending the time to collect the data, as well as the methods of doing so might be valuable. As an example, using person to person distribution instead of only online distribution could provide a better response. In that sense, another possibility to reduce the size sample problem might be to use interaction effects in order to keep the same number of responses at any of the sub-groups.

Even though Stated Choice Experiment has been proved in existent research to be useful, a careful consideration has to be taken in what attributes and attributes levels are included. In that sense, considering that certain attributes are not relevant for this research, if a similar research is conducted in the future, might be interesting to remove these non-relevant attributes in order to include different ones without increasing the mental burden to the respondents considerably.

A different possibility to confirm these results might be to carry on with a field operational test. This means to undertake an experiment to evaluate the suggested attributes under normal operating conditions in a more realistic environment. Additionally, other options include the use of a driving simulator or virtual reality technique, where the reaction of users in a real scenario experiment can be studied. The downside of these kind of experiments are the higher costs involved. In contrast, in there, some of the driving conditions could be tested in order to see if, indeed, the reactions that are stated in the SC experiment are the same or change. Finally, a next step in the research could be in the direction of testing whether the opinion regarding user willingness to use ACC changes or not after the users learn what are the benefits and limitations of the system by using it during some time. Besides that, the type of ACC features that are more desired by each type of driver might be studied, depending on their driving style, in order to be able to customise ACC as much as possible to fit the desire of each individual.

6. Discussion

In this last chapter, the results are discussed, as well as several aspects that could have been improved after detecting them as limitations of the research.

During the thesis process, a thorough literature review was carried out in order to discover what driving conditions are influencing people's behaviour. A careful consideration was taken in order to decide which attributes are the most relevant. One additional concern was making sure that the presented situations at the stated choice experiment were representing with fidelity real life situations. The initial broader list was narrowed down to only seven attributes. However, even when the expectations were that all the attributes would influence the driver behaviour, not all of them resulted in having an influence. Keeping in mind that this lack of influence might be due to some of the aforementioned limitations, an uncertainty regarding the accuracy in the decision making of which attributes were chosen appears. After reflecting on this, the results show that in the end a good decision was made, due to the fact that all seven driving conditions have resulted to be significant for at least some of the groups.

This study has purely analysed which situation is considered most favourable for the drivers to use ACC. However, there are other elements equally relevant, which has not been analysed, such as the cost of ACC, the liability in the case of an accident while using ACC or the 'quality' of the product, which could be understood as the selectable time-gap and brake capacity of each ACC model. Therefore, future research could pay attention as well to the effect of these elements in the users' willingness to use Adaptive Cruise Control.

Through the results of this research has been exposed that overall and despite there are some differences between the groups, there is a general tendency to be willing to use ACC. Hence, the suggested recommendations could be followed to provoke an increase in the number of users of ACC in order to get an upgraded assistance on the road.

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Appendices

Appendix I	Questionnaire
Appendix II	Cluster comparison
Appendix III	Mean, Std. Deviation and frequency tables
Appendix IV	Chi-square tests
Appendix V	Goodness of fit tables from Sub-models
Appendix VI	Driving style factor-scale questionnaire

Appendix I. Questionnaire

TU/e Technische Universiteit Eindhoven University of Technology

Welcome

Page: Welcome

Dear Sir/Madam,

I invite you to participate in this survey, which is part of my master research at the Eindhoven University of Technology.

I am researching the user acceptance of Adaptive Cruise Control (ACC), a Driver Assistance System that keeps your car at a safe distance from the one in front. Therefore, several questions regarding driving experience and attitude against some car-features are asked in this survey.

Based on past experience this survey will take approximately 10 to 15 minutes to complete.

By completing this survey you will be able to participate to **WIN a 20 € Gift Card of your choice!!**

The questionnaire consists of **4 sections** with closed questions. Your answers will be treated confidentially and anonymously.

Thanking you for your cooperation,

Mario Santamaria Puga

Start

Do you have driving license?

- Yes
- No

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Section 1: Driving experience.

What is your driving experience?

- 5 years or less
- 6-15 years
- 16-29 years
- 30 years or more

What is your weekly mileage*?

- I don't know
- Less than 200 Km (≈ 10,000 Km per year)
- 200 – 400 Km (≈ 10,000 – 20,000 Km)
- 400 Km or more (≈ 20,000 Km per year)

* As a rule of thumb, double the average kilometres you travel from home to work per day. Then multiply this number for 7 days a week.

Next

Read the names and descriptions of these 8 Driver Assistance Systems and select the response that best reflects your understanding.

	I do NOT know the system	I DO know the system	I DO know the system AND I have USED it
Forward Collision Warning (FCW) Designed to alert the driver to a hazard ahead so that can brake or swerve (deviate) in time			
Lane Departure Warning (LDW) Designed to warn the driver when the vehicle begins to move out of its lane			
Fuel Efficiency Adviser Analyze fuel consumption while you drive, providing feedback to drive more efficiently			
Automated Parking Assist System Autonomous car-manoeuvering system that moves a vehicle from a traffic lane into a parking spot			
Blind Spot Warning (BSW) Designed to detect other vehicles located to the driver's side and rear (back)			
Conventional Cruise Control (CCC) Designed to maintain a steady (constant) speed as set by the driver			
Adaptive Cruise Control (ACC) Designed to automatically adjust the vehicle speed adaptively to a forward vehicle			
Traffic Jam Assistance Designed to follow the vehicle ahead and automatically operate the accelerator and brakes within slow driving in traffic jams			

Section 2: Driving style.

Read each item and rate the extent to which it fits your feelings, thoughts, and behaviour during driving.

	Never	Rarely	Sometimes	Often	Usually	Always
Misjudge the speed of an oncoming vehicle when passing						
Feel nervous while driving						
Driving makes me feel frustrated						
While driving, I try to relax myself						

Previous Next

Read each item and rate the extent to which it fits your feelings, thoughts, and behaviour during driving.

	Never	Rarely	Sometimes	Often	Usually	Always
Enjoy the excitement of dangerous driving						
Enjoy the sensation of driving on the limit						
In a traffic jam, I think about ways to get through the traffic faster						
When I am in a traffic jam and the lane next to me starts to move, I try to move into that lane as soon as possible						
Purposely tailgate (drive close behind a vehicle) other drivers						

Previous Next

Read each item and rate the extent to which it fits your feelings, thoughts, and behaviour during driving.

	Never	Rarely	Sometimes	Often	Usually	Always
Swear at other drivers						
Blow my horn or "flash" the car in front as a way of expressing frustrations						
When someone does something on the road that annoys me, I flash them with the high beams (distant illumination)						

Previous Next

Read each item and rate the extent to which it fits your feelings, thoughts, and behaviour during driving.

	Never	Rarely	Sometimes	Often	Usually	Always
At an intersection where I have to give right-of-way to oncoming traffic, I wait patiently for cross-traffic to pass						
When a traffic light turns green and the car in front of me doesn't get going, I just wait for a while until it moves						
Drive cautiously						
Always ready to react to unexpected maneuvers by other drivers						

Previous Next

Section 3: Adaptive Cruise Control (ACC) explanation.

In this section several hypothetical driving situations in which you can make use of ACC will be shown. The goal of this research is to understand under what kind of driving conditions you would use this system.

Before showing you the different situations, a short video is shown to **explain how ACC works**, in order to get you more familiar with the system.

Before playing this short explanatory video please turn on your speakers or connect your headphones:

• The driver always decides whether the ACC system is **turned ON** or **OFF**

• We are considering an ACC with an extra feature called **Stop-and-Go**. This mean that it is able to keep the distance even at 0 Km/h.

Additional remarks (to learn more about the system):

Click here to read the extra information

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Section 3: Explanation choice experiment

This is an **overview** of the driving conditions that will be analyzed on the next section.

The left column shows the different attributes, which are the same for all situations.

The right column shows the values of each attribute, which differ for each situation.

Attributes	Values
Traffic intensity	**[1]** High (Traffic jam)
	[2] Medium (Interrupted flow)
	[3] Low (Free flow)
Road condition	**[1]** Regular (Straight road)
	[2] Difficult (Exit lane, sharp curve...)
Visibility through weather conditions	**[1]** High (Clear, cloudless)
	[2] Medium (Rainy, snowy)
	[3] Low (Foggy)
Lighting	**[1]** Daylight
	[2] Night with lighting ON
	[3] Night with lighting OFF
Level of fatigue	**[1]** Low (Very fresh)
	[2] Medium (A little tired)
	[3] High (Very tired)
Trip distance	**[1]** Long (> 100 Km)
	[2] Medium (20 – 100 Km)
	[3] Short (< 20 Km)
Travelling with	**[1]** Alone
	[2] 1 or more passengers

Previous Next

Section 3: Example choice experiment

To respond to the next questions, imagine yourself in a hypothetical situation in which you are **commuting in a highway** with a car equipped with **ACC and Stop-and-Go**. In addition, there will be other factors (**Attributes**) to be considered, which define the details of a specific trip (**Situation**).

In the first table, read carefully the descriptions that define each of the attributes [1st table].

Consider your opinion regarding the active use of Adaptive Cruise Control (ACC) and choose the response that best fits your viewpoint [2nd table]

Attributes	Situation
Traffic intensity	**Medium (No congestion)**
Road condition	**Difficult (Exit lane, sharp curve...)**
Visibility through weather conditions	**Low (Foggy)**
Lighting	**Daylight**
Level of fatigue	**Low (Very fresh)**
Trip distance	**Short (< 20 Km)**
Travelling with	**1 or more passengers**

In the presented situation ***I would turn ON ACC***	○ **Strongly Disagree** ○ **Disagree** ○ **Agree** ○ **Strongly Agree**
Is your choice regarding the Turning ON/OFF of ACC related to (select all that apply)	☐ ***Increase/Decrease* Safety** ☐ ***Increase/Decrease* Comfort** ☐ ***Improve/Reduce* Fuel efficiency**

This was an example question. Based on this explanation, we hope that you can evaluate the **next 6 similar situations**.

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Section 4: Socio-demographic questions.

What is your gender?

- Male
- Female

What is your age?

- 18-29 years
- 30-49 years
- 50-64 years
- 65 years or more

What is your level of education?

- Low education (secondary school or lower)
- Medium (professional education)
- High education (college / university)
- I prefer not to answer this question

What is your annual household income?

- 15,000 € or less
- 15,000 – 30,000 €
- 30,000 – 60,000 €
- 60,000 € or more
- I prefer not to answer this question

What is your household situation?

- One-person
- Multiple person without children
- Multiple person with children

What is your nationality?

- Dutch
- Other (name it)

To what extent do you agree with the following sentence

	Not at all interested	Slightly interested	Moderately interested	Very interested	Extremely interested
I would be interested in having ACC in my next car	○	○	○	○	○

Thank You for Completing Our Survey!

Thank you for taking time out to participate in our survey. We truly value the information you have provided.

Do you have any **comments or suggestions** regarding this questionnaire?:

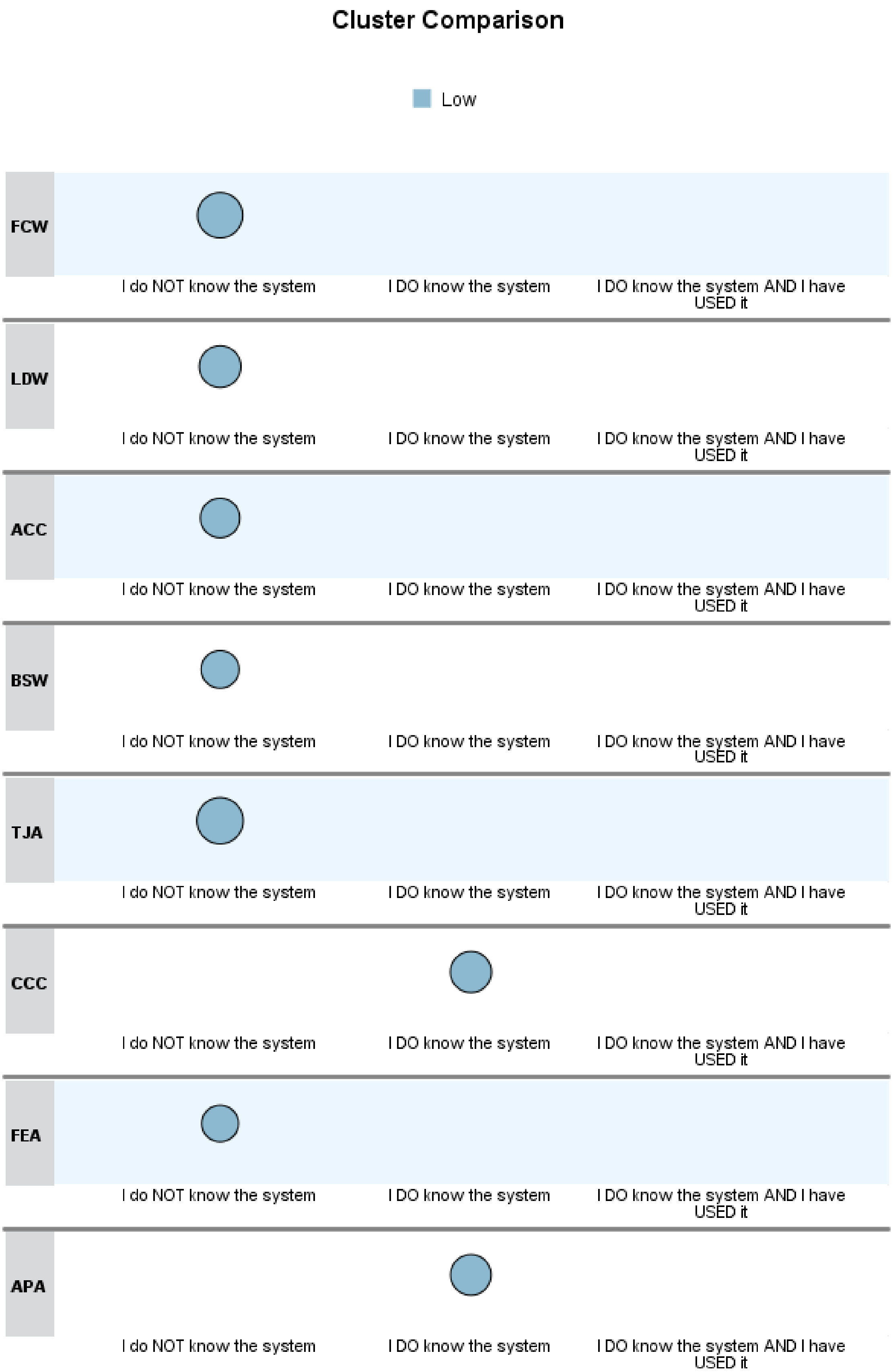
If you want to participate in the raffle of the Giftcard, write your e-mail so we can contact you back:

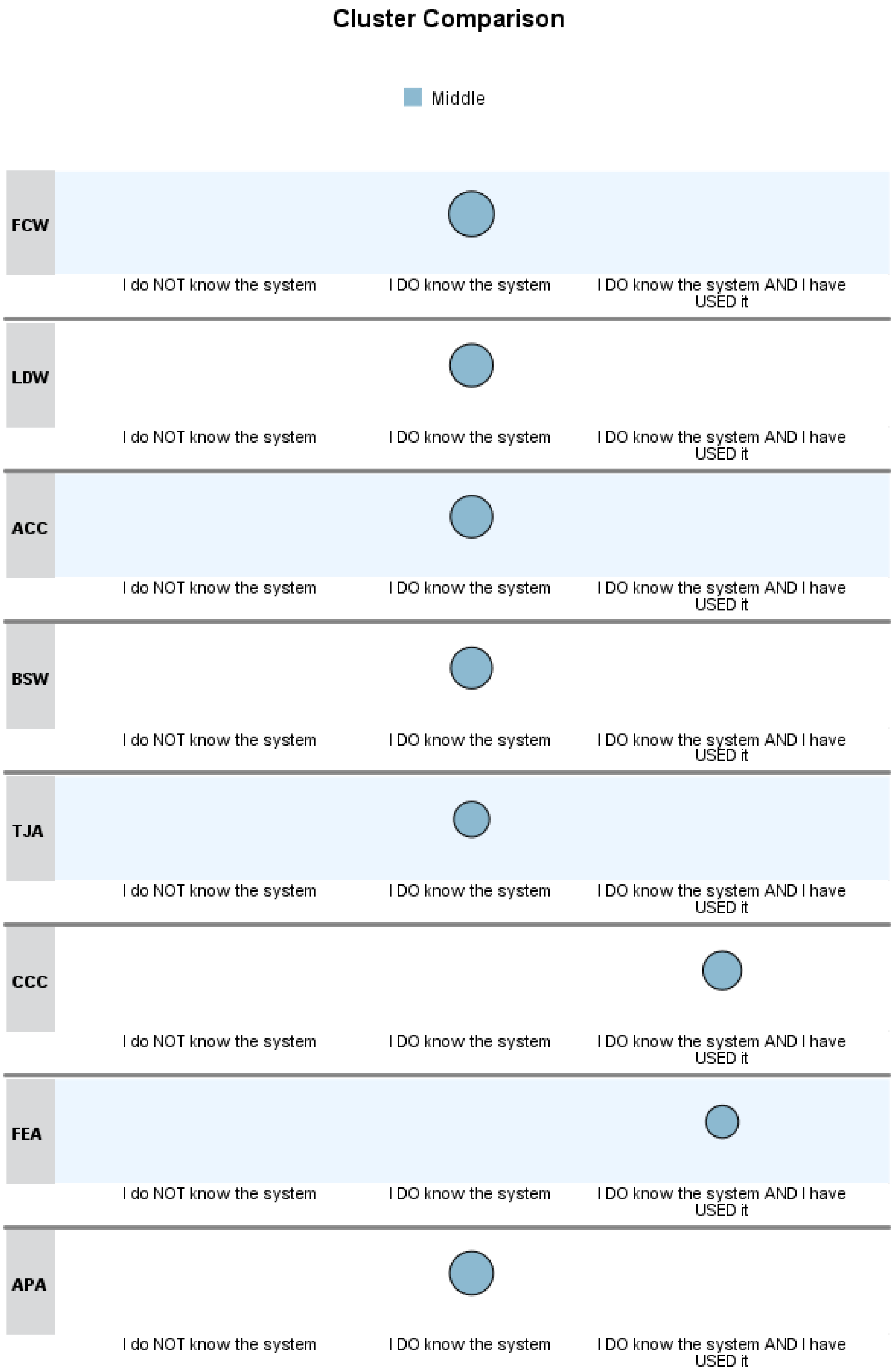
For SurveyCircle users (www.surveycircle.com): The Survey Code of this survey is: N2HP-8CZF-45HZ-X6S6
If you think somebody could be interested in this questionnaire, please share it with them, with the following link: **https://vragen9.ddss.nl/q/ACC**

This is the end of the questionnaire. Once you press **Finish** you will exit this survey.

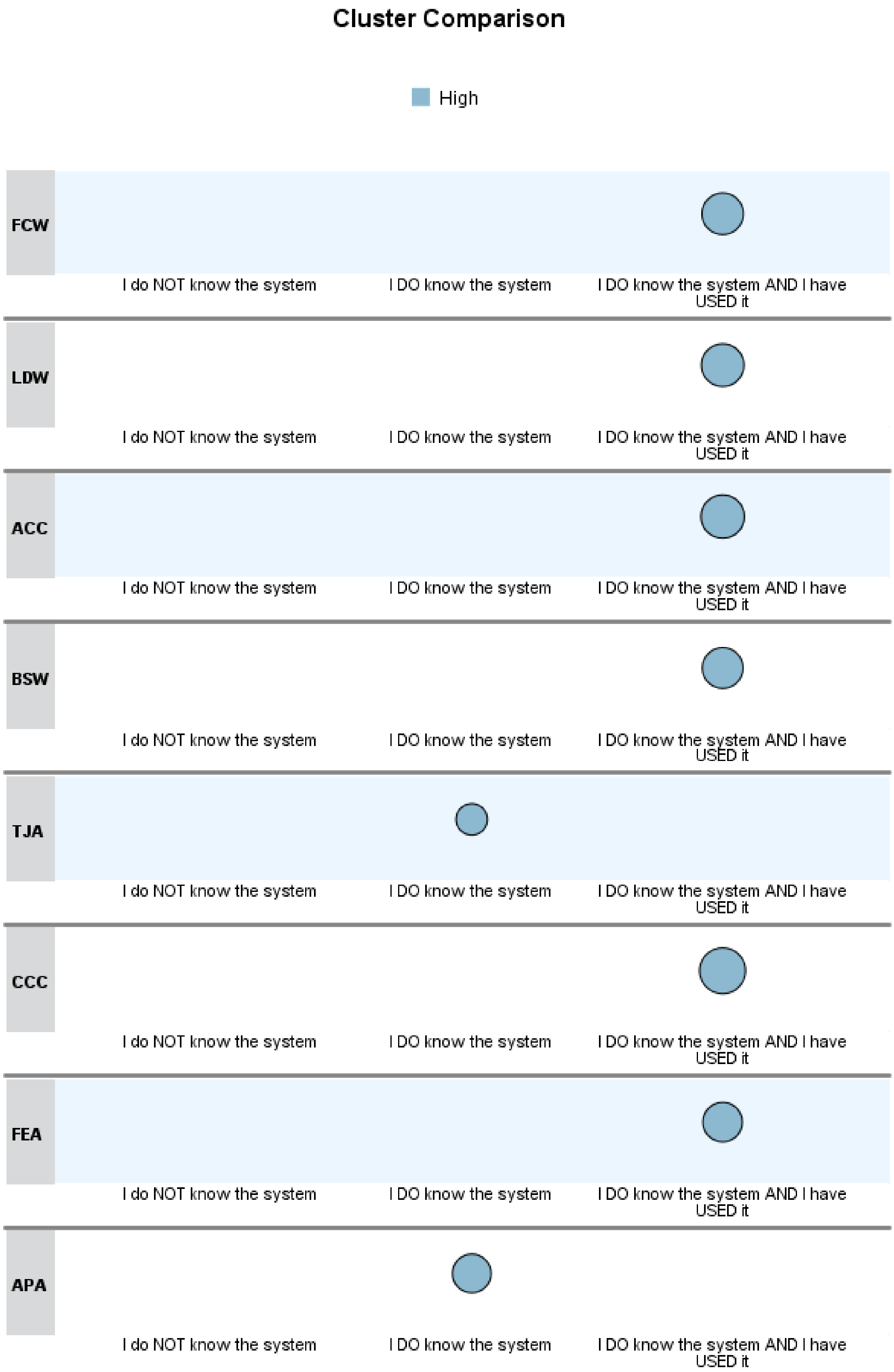
Previous Finish

Appendix II. Cluster comparison





Cluster Comparison
Middle
FCW
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
LDW
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
ACC
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
BSW
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
TJA
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
CCC
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
FEA
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
APA
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it


Cluster Comparison
High
FCW
I do NOT know the system
I DO know the system
I DO know the system AND I have USED it
LDW
ACC
BSW
TJA
CCC
FEA
APA

Appendix III. Mean, Std. Deviation and frequency tables

Table 21. Mean and Std. Deviation values (Systems knowledge cluster analysis)

		TwoStep Cluster Number
N	Valid	208
	Missing	0
Mean		1.91
Std. Deviation		.788

Table 22. Frequency table systems knowledge cluster division

		Frequency	Percent	Cumulative Percent
Valid	High	74	35.6	35.6
	Middle	78	37.5	73.1
	Low	56	26.9	100.0
	Total	208	100.0	

Table 23. Mean and standard deviation values (Factors influencing ACC choice)

		Safety	Comfort	Fuel efficiency
N	Valid	1248	1248	1248
	Missing	0	0	0
Mean		.67	.54	.17
Std. Deviation		.472	.499	.374

Table 24. Mean and standard deviation (Scale4)

Scale4		
N	Valid	1248
	Missing	0
Mean		2.78
Std. Deviation		.892

Table 25. Mean and standard deviation (ACC purchasing)

N	**Valid**	**208**
	Missing	0
Mean		3.66
Std. Deviation		1.096

Table 26. Frequency table (Increase / Decrease safety)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	416	33.3	33.3	33.3
	True	832	66.7	66.7	100.0
	Total	1248	100.0	100.0	

Table 27. Frequency table (Increase / Decrease comfort)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	574	46.0	46.0	46.0
	True	674	54.0	54.0	100.0
	Total	1248	100.0	100.0	

Table 28. Frequency table (Improve / Reduce fuel efficiency)

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	False	1038	83.2	83.2	83.2
	True	210	16.8	16.8	100.0
	Total	1248	100.0	100.0	

Appendix IV. Chi-square tests

*Table 29. Chi-Square test (Mileage * Driving experience crosstab)*

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	86.525[a]	9	.000
Likelihood Ratio	102.200	9	.000
Linear-by-Linear Association	75.004	1	.000
N of Valid Cases	208		
a. 1 cells (6.3%) have expected count less than 5. The minimum expected count is 2.88.			

*Table 30. Chi-Square test (Age * Gender crosstab)*

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	20.874[a]	2	.000
Likelihood Ratio	22.017	2	.000
Linear-by-Linear Association	19.491	1	.000
N of Valid Cases	208		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 9.20			

*Table 31. Chi-Square test (Age * Gender crosstab)*

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	74.358[a]	8	.000
Likelihood Ratio	84.529	8	.000
Linear-by-Linear Association	29.246	1	.000
N of Valid Cases	208		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 6.87.			

Appendix V. Goodness of fit tables from Sub-models

Table 32. Goodness of fit information (Sub-model Male)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	313.100			
Final	229.791	83.309	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	40.886	39	.388
Deviance	41.448	39	.364
Link function: Logit.			

Table 33. Goodness of fit information (Sub-model Female)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	242.550			
Final	212.150	30.400	12	.002
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	69.484	39	.002
Deviance	68.336	39	.003
Link function: Logit.			

Table 34. Goodness of fit information (Sub-model 18-29)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	276.899			
Final	228.812	48.087	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	52.019	39	.079
Deviance	52.940	39	.067
Link function: Logit.			

Table 35. Goodness of fit information (Sub-model 30-64)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	277.646			
Final	211.081	66.565	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	46.704	39	.185
Deviance	44.871	39	.239
Link function: Logit.			

Table 36. Goodness of fit information (Sub-model Dutch)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	316.292			
Final	225.538	90.754	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	52.329	39	.075
Deviance	52.496	39	.073
Link function: Logit.			

Table 37. Goodness of fit information (Sub-model Other)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	247.825			
Final	219.448	28.377	12	.005
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	52.508	39	.073
Deviance	53.079	39	.066
Link function: Logit.			

Table 38. Goodness of fit information (Sub-model One person)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	252.115			
Final	220.444	31.671	12	.002
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	69.500	39	.002
Deviance	75.187	39	.000
Link function: Logit.			

Table 39. Goodness of fit information (Sub-model Multiple people with children)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	233.494			
Final	174.597	58.898	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	24.484	39	.966
Deviance	25.892	39	.947
Link function: Logit.			

Table 40. Goodness of fit information (Sub-model Multiple people without children)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	231.508			
Final	180.799	50.709	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	38.352	39	.499
Deviance	37.242	39	.550
Link function: Logit.			

Table 41. Goodness of fit information (Sub-model High)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	249.012			
Final	182.181	66.832	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	32.359	39	.765
Deviance	32.308	39	.767
Link function: Logit.			

Table 42. Goodness of fit information (Sub-model Middle)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	246.106			
Final	199.768	46.338	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	48.481	39	.142
Deviance	50.944	39	.095
Link function: Logit.			

Table 43. Goodness of fit information (Sub-model Low)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	221.461			
Final	199.795	21.666	12	.041
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	58.079	39	.025
Deviance	58.277	39	.024
Link function: Logit.			

Table 44. Goodness of fit information (Sub-model F1)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	210.313			
Final	182.740	27.573	12	.006
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	49.179	39	.127
Deviance	52.949	39	.067
Link function: Logit.			

Table 45. Goodness of fit information (Sub-model F2)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	223.022			
Final	148.624	74.398	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	30.397	39	.836
Deviance	37.092	39	.557
Link function: Logit.			

Table 46. Goodness of fit information (Sub-model F3)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	207.232			
Final	196.428	10.803	12	.546
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	53.293	39	.063
Deviance	61.642	39	.012
Link function: Logit.			

Table 47. Goodness of fit information (Sub-model F4)

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	221.352			
Final	175.076	46.276	12	.000
Link function: Logit.				

Goodness-of-Fit			
	Chi-Square	df	Sig.
Pearson	45.837	39	.210
Deviance	44.814	39	.241
Link function: Logit.			

Appendix VI. Driving style factor-scale questionnaire

Complete list of questions asked in the questionnaire to analyse the four types of driving style.

Factor 1: Anxious driving style

- Misjudge the speed of an oncoming vehicle when passing
- Feel nervous while driving
- Driving makes me feel frustrated
- While driving, I try to relax myself

Factor 2: Reckless and careless driving style

- Enjoy the excitement of dangerous driving
- Enjoy the sensation of driving on the limit
- In a traffic jam, I think about ways to get through the traffic faster
- When in a traffic jam and the lane next to me starts to move, I try to move into that lane as soon as possible
- Purposely tailgate other drivers

Factor 3: Angry and hostile driving style

- Swear at other drivers
- Blow my horn or “flash” the car in front as a way of expressing frustrations
- When someone does something on the road that annoys me, I flash them with the high beam

Factor 4: Patient and careful driving style

- At an intersection where I have to give right-of-way to oncoming traffic, I wait patiently for cross-traffic to pass
- When a traffic light turns green and the car in front of me doesn’t get going, I just wait for a while until it moves
- Drive cautiously
- Always ready to react to unexpected manoeuvres by other drivers