Master Thesis Report

Usage intention of automated vehicles amongst elderly in the Netherlands

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Spatial and Transport Impacts of Automated Driving

Title page image taken from Google promotional video "Self-Driving Car Test: Steve Mahan" (Published 28-03-2012)

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Usage intention of automated vehicles amongst elderly in the Netherlands

By

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Spatial and Transport Impacts of Automated Driving

Preface

This thesis report is the final part of my graduation work for the master track Transport & Planning at the TU Delft. This thesis is also part of the STAD project (Spatial and Transport impacts of Automated Driving) which is a joint research project about the implications of the future of accessibility and spatial development of mobility with respect to autonomous driving technologies.

I hope that the contents of this thesis will help inspire more researchers to explore the opportunities that automatic vehicles bring to improve the mobility of vulnerable groups in the Netherlands.

I would like to thank my graduation committee for their support and guidance through this project. First and foremost I would like to thank my daily supervisor Dimitris Milakis for helping me shape the assignment and his support throughout the process. I would also like to thank Bart van Arem for introducing me to the wonderful world of automated vehicles and Eric Molin for his expert knowledge in the field of statistics and behavioral modeling.

Next I would like to thank friends and family for providing me with the opportunity to finish my master's degree at the TU Delft. And finally I would like to thank my colleagues at the T&P graduation room for their support and advice throughout this experience.

Mischa Ingeveld
Delft, April 2017

Summary

Introduction

Data from the Dutch national travel survey shows that elderly in the Netherlands travel noticeably less kilometres compared to the younger population. This decline in travelled kilometres is mainly caused by a reduction in car KM's travelled. While this reduction can be explained by a reduced need for travelling when getting older (pension) there are indicators that show that this reduced mobility is, at least partially, involuntary.

A possible solution to these mobility issues elderly experience is the introduction of automated vehicles (AV). The implementation of AV's would help elderly gain back their mobility by allowing them to overcome the restrictions to their driving capabilities. This means that the implementation of AV could potentially have a big impact on how transportation will be used in the (near) future and that the elderly group could see the biggest differences in how they travel compared to today. While there are multiple studies done on the potential impact of AV's it is still unknown if elderly actually have the intention of using AV's in the (near) future.

The aim of this thesis study is to investigate the perception of elderly of elderly on two AV technologies (owned and shared) and which aspects of AV they find most important. This will clarify if elderly have the intention of using these technologies and which aspects of AV they find attractive and which they find less appealing. In short this research can be summarized with the following research question:

To what extent will the elderly population in the Netherlands use automated vehicles in the future and what are the possible factors influencing the adoption rates of AV?

In order to provide an answers to this research question the literature review tried to find more detailed information on why elderly drive less, previous research on the acceptance of AV and the acceptance of technology by elderly.

Research design and conceptual model

The literature review revealed that elderly find that safety issues and their perception of safety are often a barrier for continuing to drive a vehicle. In addition to this deteriorating driving capabilities, age-related disorders and financial aspects are commonly found causes for driving less. Finally there are several legal issues that only elderly drivers must take into account.

The acceptance of AV in general is often influenced by system characteristics such as travel time, travel costs and environmental impact. For shared AV specific characteristics such as waiting time, fare costs and ride sharing have a significant impact on acceptance. Other factors that often determine the acceptance level are personal factors (attitude, social influence and socio-economic characteristics) and the conditions in which the system is being used. These studies done on the acceptance of AV often use acceptance models commonly found in psychological studies.

When it comes to technology acceptance by elderly they are especially influenced by their social surroundings, ease of use/learning, current social norms and their experience with technology.

On the basis of this literature study the research design was formulated. First the acceptance model that was best suited for the research goals of this thesis had to be determined. After a comparison of different models the Unified Theory of Acceptance and use of Technology (UTAUT) model was chosen because it has the ability to explain all of the impacts of AV and has been successfully used in multiple comparable studies. Since the UTAUT model was developed to test the acceptance of IT system it had to be adapted for researching the usage intention of AV. After several adjustments made to the UTAUT model based on information found in the literature and deductive reasoning the theoretical model found in figure I was formulated.

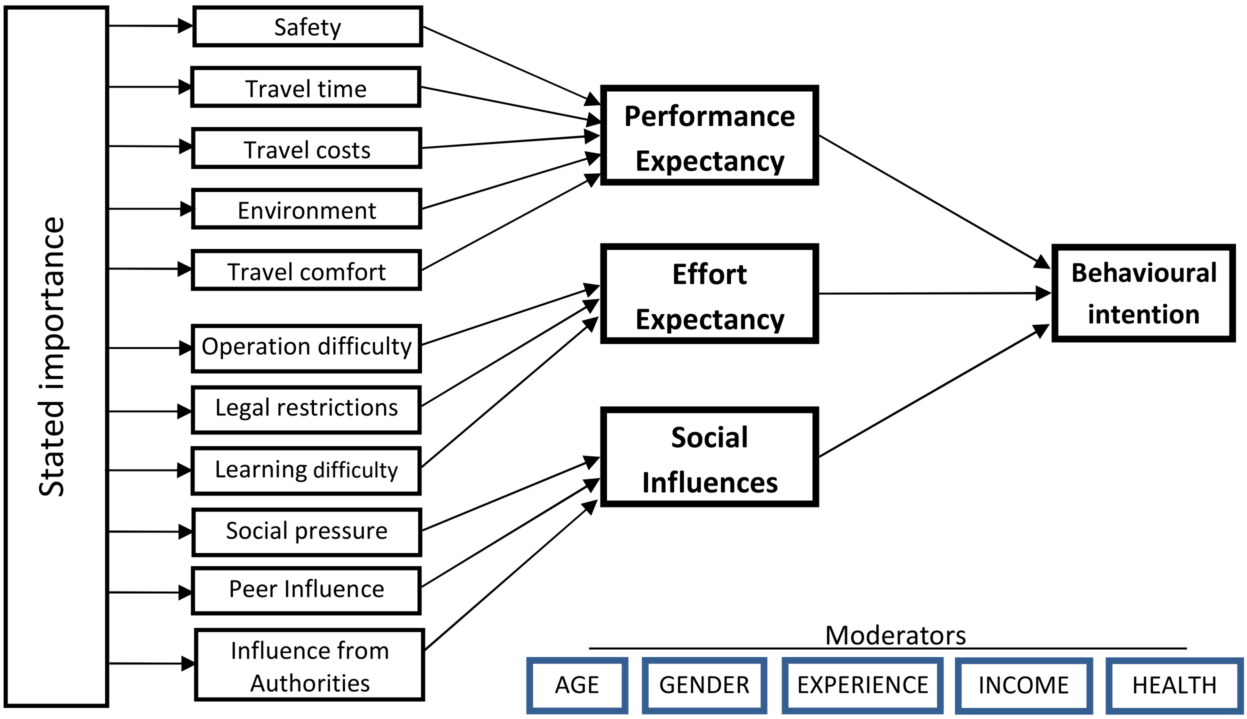

Figure I: Theoretical model

The theoretical model consists of 3 unobserved latent constructs (performance expectancy (PE), Effort Expectancy (EE) and Social influences (SI)) that are all based on their respective indicators (Safety, Legal, Social pressure etc.). The relations between these constructs and the behavioural intention show which characteristics have the most influence on the behavioural intention. During the analysis 5 moderators that potential influence the behavioural intention were tested, these are: age, gender, experience, income and health. As an additional research topic the model was run both with and without stated importance included in the data to see if this improved the explanatory power of the model.

Survey design and data collection
After the research design was completed the necessary data was collected through the use of an online survey. This survey consisted of 3 sections: Pre-explanation questions (stated importance), questions after explaining the two AV systems (Indicators and behavioural intention) and lastly the personal information of the respondents was gathered to define the moderator groups. After several test surveys the final survey was distributed through the websites of two Dutch elderly organisations. The final survey was successfully completed by 123 respondents it the targeted age group (55+).

Data analysis

In the first part of the data analysis descriptives statistics were used to describe the profile of the survey respondents. This data is was then used to give an overview on how they responded to the survey questions and determine the moderator groups that will be used during the second part of the data analysis. An analysis of the personal information that was gathered during the survey resulted in the following overview of moderator groups that were used during the rest of the analysis.

Table I: Overview of moderator groups

Moderator	Groups	n	% of total sample
Age	55-65	55	44,7%
	66+	68	55,3%
Gender	Male	76	61,8%
	Female	47	38,2%
Experience	Non-drivers	41	33,3%
	Drivers low experience	19	15,5%
	Drivers high experience	63	51,2%
Income	Below average	54	43,9%
	Above average	46	37,4%
	Unknown	23	18,7%
Health	No health issues	82	66,7%
	At least one health issue	41	33,3%

In the second part structural equation modelling (SEM) was used to evaluate the theoretical model and determine which aspects of the two AV systems have the most influence on the behavioural intention. Using the data on the original model (Figure I) revealed that the indicators did not have the same relations with the three latent constructs (PE, EE, and SI) as was theorized. Therefore an exploratory factor analysis was done to formulate new constructs that showed an empirically significant relation with its respective indicators.

For the owned AV system indicators originally found under PE and EE formed a new construct that was named Performance/Effort while the Social influences construct remained intact. For the shared AV system the PE and SI indicators formed a new construct named Performance/Social while the EE construct remained intact. Because there are different models for each type of AV and the fact that it is possible to optimize each model by removing one or more indicators several model fit criteria were used to compare the different models and check the model validity. The models for both types of AV were tested with and without the stated importance included in the data.

Research results

For the owned AV it was found that by including the stated importance the model fit was not improved and some of the results were found to be unreliable. For the remainder of the analysis the model for the owned AV used the data that did not include the stated importance. After removing the poor performing indicators (Legal and Plan) the best model fit was reached with the model found in Figure II.

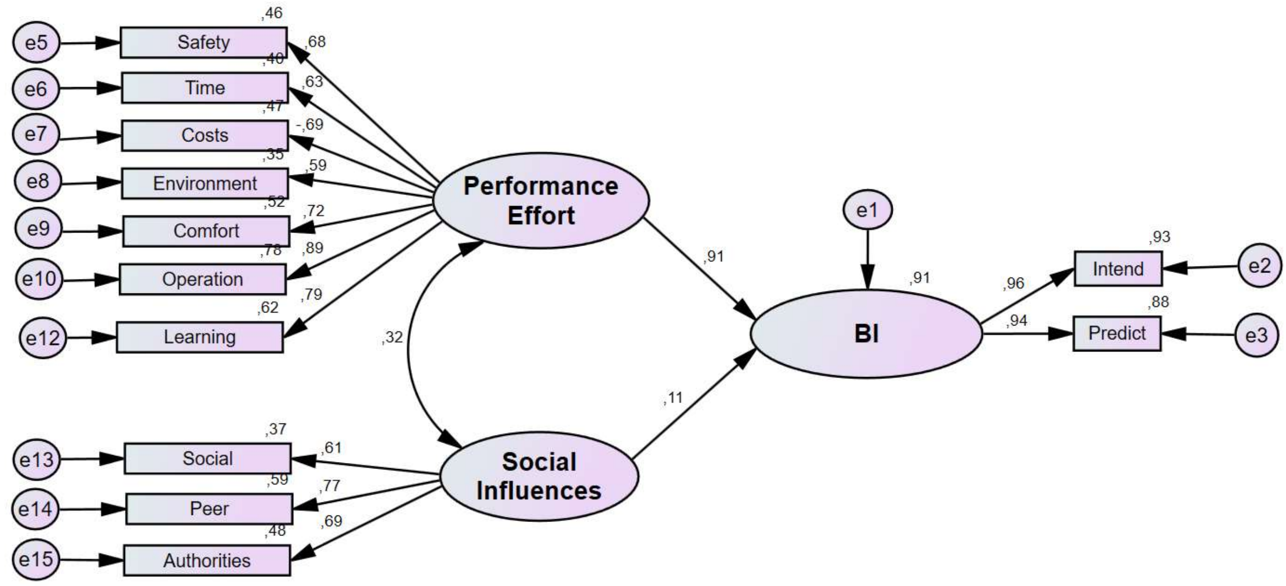

Figure II: Output model AV owned (standardized estimates)

The output model for the owned AV system shows that the new Performance/Effort construct has a strong positive relation with the behavioural intention. Especially the operation/learning difficulty indicators have a large effect on this new construct which matches with the earlier findings that these are important when determining the acceptance of technology by elderly.

While the effects of the SI construct were also found to be significant its effect on the BI is much smaller. All three indicators are important in measuring this construct but the results show that elderly are not heavily influenced by outside social pressure when deciding to use an owned AV system or not.

For the shared AV system it was found that while the inclusion of stated importance does have a positive impact the overall model fit and construct reliability values are still not ideal. For the remained or the analysis the model used the data that did include the stated importance but it has to be noted that the results for the shared AV system are less reliable than for the owned AV. The final output model for the shared AV system (including stated importance) can be found in Figure III.

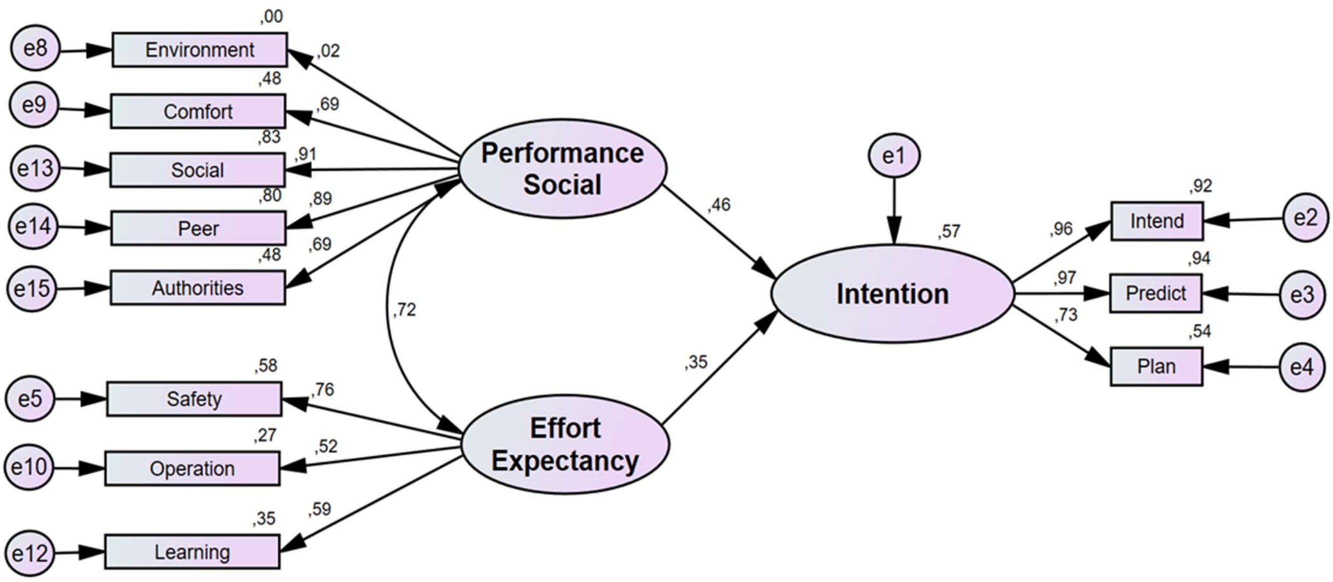

Figure III: Output model AV shared (standardized estimates)

The results for the shared AV system show that the new construct Performance/Social is largely determined by the Social/Peer pressure indicators which suggests that the outside social pressure has a large influence on the usage intention of a shared AV system. The effect of the Effort Expectancy is much higher compared to the other models which shows that the perceived amount of effort required has a significant impact on the behavioural intention for the shared AV system.

Analysis of the answers to the behavioural intention questions (Intend, Predict, and Plan) showed that the total sample group has a clear preference for the owned AV system. But when looking at the individual groups it becomes clear that Females, non-drivers, low income groups and people with health issues are more likely to use shared AV's while Males, pre-pensioners (55-65), experienced drivers and people with a higher income are more interested in owned AV's. The older age group (66+) and drivers with little experience are not very favourable towards either AV type.

A multi-group analysis was used to test if the personal characteristics (divided under the moderator groups) have an influence on the behavioural intention and show which factors might cause this difference. Table II shows the results of the multi-group analysis.

Table II: Results of multi-group analysis (Yes means that the moderation effect is significant)

Group	AV owned	AV shared
Age	No	Yes
Gender	Yes	No
Experience	Yes	Yes
Income	Yes	Yes
Health	Yes	Yes

Conclusions

With the aim of finding out if the elderly population in the Netherlands has the intention of using AV in the (near) future and what the main reasons for (not) adopting AV are a research model was formulated. A review of the available models and techniques showed that a modified UTAUT model in combination with structural equation modelling is best suited to research the acceptance of AV among elderly. After testing different models it was revealed that the proposed model works better for testing the behavioural intention of an owned AV system than for a shared AV system.

With a share of around 65% the majority of the respondents is at least somewhat positive (score of 3 or higher) towards both owned and shared AV. However the group that was (very) positive (score of 4 or higher) towards owned AV (±50%) is twice as high as for shared AV (±25%). Although the results show there is an overall preference for the owned AV system some groups within the elderly population prefer the shared AV system

The main causes for these differences in usage intention can be found in the perceived increase in travel time for SAV and the fact that respondents rate the social/peer pressure for using a shared AV very low while the analysis shows that these indicators have a big impact on the Behavioural intention. In addition all of the socio economic factors that were considered (Age, Gender, Experience, Income and Health) have a significant impact on the usage intention of either the AV system, SAV system, or both systems.

This master thesis contributes to the research done of the potential impacts of AV by formulating and testing a behavioural intention model adjusted for elderly users. The methods and results from this thesis can help researchers and policymakers to investigating the usage intention of AV for elderly and other vulnerable groups in the Netherlands. Future researchers could improve the model by testing the model on a larger and more diverse sample group, formulating a separate model for owned and Shared AV and explore the changes in perception over time with the help of longitudinal studies.

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List of Abbreviations

ARTS	Automated Road Transport Systems
AV	Automated vehicles
AVE	Average Variance Extracted
BI	Behavioural intention
CFA	Confirmative factor analysis
CFI	Comparative fit index
CR	Construct composite reliability
CTAM	Car Technology Acceptance Model
DRS	Dynamic ride sharing
EE	Effort expectancy
GFI	Goodness of fit index
GLS	Generalized least squares
ITS	Intelligent transport systems
KM	Kilometre
ML	Maximum likelihood
PE	Performance expectancy
PT	Public transport
P-value	Probability value
RMSEA	Root mean square error of approximation
SAV	Shared automated vehicles
SEM	Structural equation modelling
SI	Social influences
STAM	Senior Technology Acceptance Model
TAM	Technology Acceptance Model
TLI	Tucker-Lewis index
TPB	Theory of planned behaviour
ULS	Unweighted least squares
UTAUT	Unified theory of acceptance and use of technology
VKT	Vehicle kilometres travelled

1. Introduction

1.1. Problem definition

Elderly in the Netherlands travel significantly less compared to the younger adult population. This decline in travelled distance becomes visible when looking at the data from the Dutch national travel survey ("Onderzoek verplaatsingen in Nederland") (CBS, 2016a). Data from this survey is visualized in Figure 1 which shows the average kilometres travelled by day based on the age of respondents.

The graph shows that the average distance travelled per day starts to decline when reaching an age of around 55 with a sharp decline between the ages of 60 to 70 and with a steady decline for people aged 75 and up. It can be seen from the graph that the sharp decline in total KM's travelled is almost in its entirety caused by a decline in Car (driver) KM's travelled. This can partially be explained by the reduction in KM's travelled for people going into retirement (CBS, 2016b). However the average distance travelled by car around this age is declining much faster than other modes like train and bike while these modes are also being used to travel to and from work (Kostyniuk & Shope, 2003).

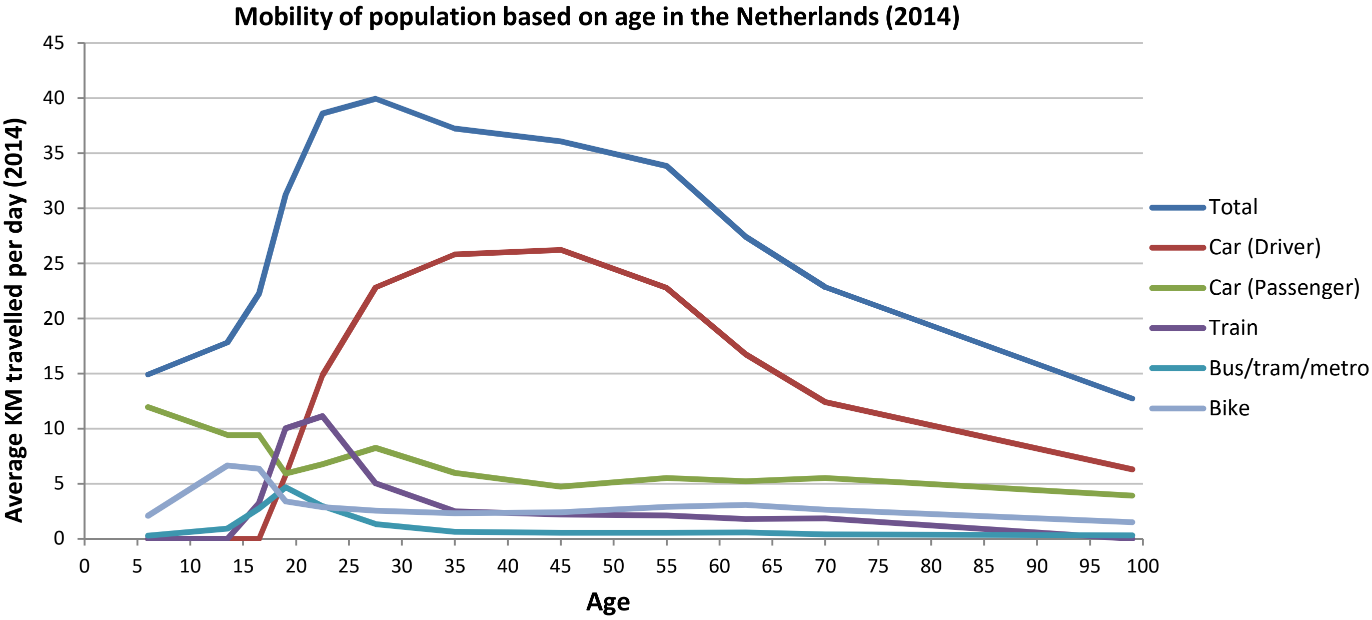


Figure 1: Average Travel distance Dutch population (Data taken from statline.cbs.nl)

Combining this data with the fact that the population in the Netherlands is rapidly aging (CBS, 2016a), which shows that there is a large group of people reaching the retirement age in the next 10 to 15 years, it becomes clear there will be large group of people who will experience this reduction in mobility as well. These changes in travel behaviour can either be voluntary due to a change in activity patterns or unwanted due to physical or mental barriers that elderly experience.

Research on the mobility of elderly shows that while the need for travelling among elderly is lower after retirement this is partially compensated by an increase in social and leisure trips (van den Berg et al., 2011). Other research reveals that the need for travelling and car ownership among elderly is increasing (Böcker et al., 2016). Even recent data reveals that people aged 65+ own more vehicles and travel more kilometres by car compared to ten years ago (CBS, 2017).

This shows that elderly in the future might not show such a sharp decline in mobility as elderly today. This increased need for travelling amongst elderly combined with the large group of people reaching the retirement age could potentially have a big impact in future travel demand. But what are the reasons for the changes in mobility among (driving and non-driving) elderly?

There are reasons to believe this reduction in KM's travelled by car have different causes in addition to a reduced need for travelling for people in this age category. In the relevant literature multiple reasons can be found for the drop in kilometres travelled by car for elderly. A more in-depth literature review on the topic of travel restrictions of elderly can be found in chapter 2.

Having these travel restrictions can have a severe effect on the mobility of elderly. Suffering from reduced travel availability can lead to social exclusion which in turn has a negative impact on the quality of life of individuals. In a comprehensive study on transport and social exclusion by (Lucas, 2012) the causes and effects of having a transport disadvantage were investigated, she concludes:

> *"What is clear from the case studies that are already available is that there is no panacea for addressing the problem of transport related exclusion. (...) If properly designed and delivered, public transport can provide a part of this solution, but it is most likely that other forms of more flexible (and often informal) transport services will be needed to complement these mainstream services".*

A solution to elderly suffering from a reduced travel availability could be the implementation of automated vehicles (AV). The implementation of AV would help elderly gain back their mobility allowing them to overcome the restrictions to their driving capability. While automated vehicles will initially be much more expensive than conventional cars it is expected that the gap in price will become relatively small over time due to mass production (Fagnant & Kockelman, 2015). The main benefit for the group of elderly that find travelling by car to expensive is the introduction of shared automated vehicles (SAV) that would operate as a taxi service.

The implementation of AV could potentially have a big impact on how transportation will be used in the (near) future and the elderly group could see the biggest differences in how they travel compared to today. The development of automated vehicles is advancing very rapidly influenced by the large amount of research that has been done in the past and is currently being undertaken. While there has been research done on the effects of AV on the mobility of the population (Harper et al., 2015) these papers often assume either a 100% adoption rate or an estimated adoption rate of AV.

While there have been a lot of studies that investigate the potential impacts of AV on the (elderly) population not much research has been done to see if elderly actually intend to use these new modes of transportation. In this research the adoption rate(s) of AV-Modes will be investigated with a special focus on elderly. The adoption rate in this case can be defined as the intention of using an automated vehicle when it becomes widely available.

The changes in mobility caused by AV could have an effect on the amount of vehicle kilometres travelled (VKT) and make it less attractive to use public transport usage of road infrastructure and many other aspects (Milakis et al., 2015) which can lead to increased congestion times (Puylaert, 2016). This means that AV could have a benefit to individual users but an overall negative impact on the mobility of the whole network. For policy makers it is important to take these changes into account estimations in future travel demand and usage of the road infrastructure network.

1.2. Research goal and Research question

This thesis project will be used to investigate the perception of elderly on AV technology and which aspects of AV they find most important. During the research a difference is made between shared AV modes and owned AV modes due to their differences in characteristics. This will clarify which AV mode will most likely be used by elderly and what the main decision makers are when determining to use AV or not. With the help of this research an indication can be given of which AV type should be made more attractive and which should be prioritized during the implementation of automated vehicles in the future. In addition the methods and results from this thesis will help researchers and policymakers in investigating the usage intention of AV by elderly and other vulnerable groups in the Netherlands.

In short, this research can be summarized with the following research question:

To what extent will the elderly population in the Netherlands use automated vehicles in the future and what are the possible factors influencing the adoption rates of AV?

The following Sub-questions will be used to help formulate an answer to the main research question:

- **Which methods are best suited to investigate the acceptance of AV among elderly?**
- **Which personal characteristics influence the decision to use AV or not?**
- **What type of automated vehicles is preferred by the elderly population?**

1.3. Outline of report and reading guide

This reading guide will detail the structure of the report and show readers were to find each main topic. A structured overview of the contents of this report and in which chapter they can be found is shown in Figure 2.

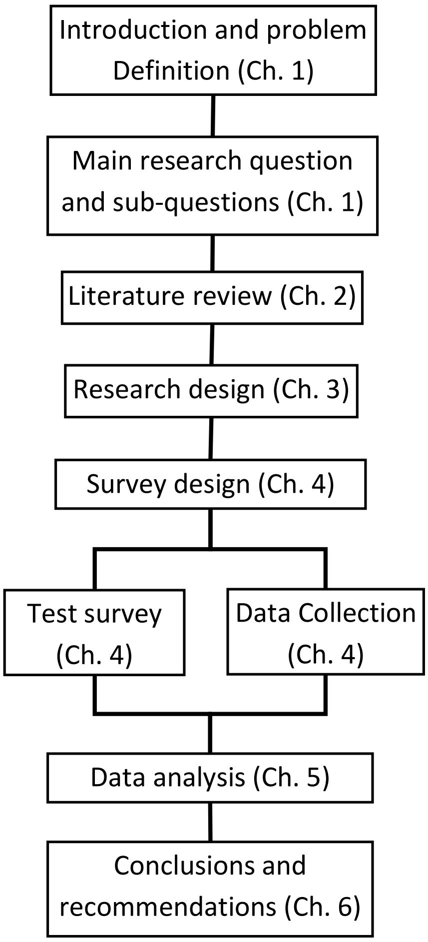


Figure 2: Research outline

The remainder of this report starts with a literature review which covers multiple topics. These topics include the main reasons elderly drive less, research on the acceptance of AV, and elderly and technology acceptance. The main findings of this literature study are then used for the research design which covers the choice for which theoretical model and research methods to use. At the end of the research design the final research model is presented.

The chapter after this contains the survey design in which the main findings of the literature study and research design are used to design an outline for the survey and the formulation of the survey questions. This chapter also includes the main findings from the test surveys and information about the data collection. In chapter 5 the results from the survey are processed so that a description of the sample can be presented and the research model can be tested with the help of structural equation modelling. The final chapter is used to formulate an answer to the research question(s), report the main findings and give recommendations for future research.

2. Literature Review

The goal of this literature review is to find a scientific basis for answering the research question and to find out how this thesis project can add to the existing research. The literature review in this report covers multiple topics such as elderly and driving, technology acceptance and automated vehicles.

Since there is no known research projects that specifically focuses on the acceptability of AV by elderly this chapter will contain research that either focuses on the acceptance of AV in general or the acceptance of technology specifically by elderly. The last part of this chapter contains a summary with the main findings from the literature study which will be used to determine the research methods and research design.

2.1. Why do elderly drive less?

In order to find out how automated vehicles would affect the mobility of elderly we first need to find the main reasons why elderly travel less by car when they get older. In the past several researchers conducted research on elderly and their motivation to (not) travel by car. Most of these researches have generally consistent results which can help to learn which indicators/measurements to consider when testing the usage intention of AV.

In a survey among Finnish elderly drivers who choose not renew their drivers licence at the age of 70 (required by law) by (Hakamies-Blomqvist & Wahlström, 1998) respondents were asked for their motivation for not doing so. Among men the most frequently indicated reason for stopping with driving was a deteriorated health. For the majority of respondents the decision to stop driving was made by themselves and not professional advice. Both men and women reported a higher feeling of traffic-related stress when getting older but women reported this more frequently than men. In addition a reduction in the need for travelling makes travelling by car to expensive and 'not worth it'.

By doing research on older drivers with a visual and cognitive impairment (Ball et al., 1998) examined how this impacted their driving behaviour. It was found that these types of drivers self-regulate their driving and tend to avoid challenging driving situations such as high speed highways, rush hour and driving at night.

(Adler & Rottunda, 2006) used focus groups with elderly who recently stopped driving to find out what influenced the participants' decision to stop driving. The majority of participants decided to stop driving on their own with a lot of them have given suggestions to stop driving by their environment. A small group of "resistors" refused to stop driving until they were forced to do so. Nearly all participants mentioned that health-related reasons caused them to stop driving (vision, reduced reflexes, and fatigue). Other reasons to stop driving included a lack of finances, responsibility to other road users and negative experiences while driving such as (near) accidents.

Quantitative research on accident rates shows that elderly drivers are more likely to be involved in a traffic accident and suffer from greater injuries when involved in an accident (SWOV, 2015). Table 1 shows that the fatality rate among elderly drivers is significantly higher than for younger drivers.

Age (years)	Walking	Cycling	Driving	All Modes
30-49	7	5	1	2
60-74	11	22	1	4
≥ 75	90	146	10	33

Table 1: Mortality rate according to age and travel mod, number of traffic deaths Per billion travelled KM's. Adapted from SWOV Factsheet "Ouderen in het verkeer"

In their paper on the mobility of elderly (Alsnih & Hensher, 2003) found that a perception of reduced safety causes elderly to drive less than they would if it was safer to drive. This resulted in a decline in car and driver's licence ownership among elderly in the study.

(Siren & Haustein, 2013) compared elderly who renewed their drivers licence at the age of 70 with elderly who choose not to renew their licence. Their results partly matched with the results of earlier studies but it was found that the percentage of older drivers that intended to keep their licence was much higher. This corresponds with the findings of (Böcker et al., 2016) that elderly are having an increased need for driving and are more healthy in general.

With the use of an open ended survey (Donorfio et al., 2009) found that psychological processes such as independence, self-worth, social connections and society also have a big impact on the decision to keep driving or not. The extent to which this influences the decision to keep driving was strongly related to gender and household composition.

(Haustein, 2012) investigated the mobility of elderly. Respondents were divided under four segments of the elderly (Captive Car Users, Affluent Mobiles, Self-Determined Mobiles, and Captive Public Transport Users). The most important mobility indicators found in this research were attitude (towards cycling, car and PT), income, car availability, availability of alternative transport, social network, weather resistance and perceived mobility necessities.

In a study done in three European countries on the reduction of driving among elderly it was investigated if elderly travel less by car and what were the reasons for travelling less (Raitanen et al., 2003). A large part of the sample reported that there was indeed a reduction in car use (number of trips and Km travelled). In addition to the common found causes (financial and health related issues) also the availability of alternative travel modes, difficulties in finding parking spaces and the (hectic) traffic conditions were considered to be of influence.

2.2. Research on acceptance of AV

In a recent study on the acceptance of Automated Road Transport Systems (ARTS) by (Madigan et al., 2016) a technology acceptance model (UTAUT) was used to see if it could work in finding the behavioural intention of using an AV system. In this study only 3 constructs where tested (Performance expectancy, Effort expectancy and Social influences). The effects of facilitating conditions on the use behaviour was not tested since earlier research showed this it does not have an effect on the behavioural intention. The results showed that the three constructs all have an impact on the behavioural intentions (with performance expectancy being the most important) but the model was not capturing all of the factors which influence an individuals' behavioural intentions towards ARTS. It is possible that adding variables such as on-board comfort and distance travelled may increase power of model. The study did not find a relation between the predictor variables (age, gender, and experience) and the behavioural intention but other studies have.

Adding to this (Nordhoff et al., 2016) developed a conceptual model to study the user acceptance of driverless vehicles (SAE level 4). This model links two technology acceptance models (UTAUT and PAD) with additional external variables (such as social-demographics and vehicle characteristics) and psychological variables (such as trust). This model is currently being validated in a pilot study involving the WEpod project in which respondents will experience the use of a driverless 'pod' like vehicle.

In trying to define a concept for the acceptability of intelligent transport systems (ITS) (Vlassenroot et al., 2010) identified 14 potential indicators. These indicators were divided under 2 categories, general indicators (personal values and attitude) and device-specific indicators (perceived performance of system). A test survey showed that the formulated questions were relevant for each indicator and that there was some correlation between some of the indicators.

This study was later used to find out which factors could predict the acceptability of Intelligent Speed assistance (Vlassenroot et al., 2011). They concluded that the amount of variables should be limited to prevent the model from becoming too complex but high enough so that the underlying reasons for acceptability become clear. The most important variables found in their research were effectiveness, equity (and personal/social views. In contrast to (Madigan et al., 2016) the predictor variables were found to have a relation with behavioural intention.

The adoption of shared automated vehicles (SAV) and dynamic ride sharing (DRS) was investigated by (Krueger et al., 2016) with the use of a stated choice analysis. In the stated choice experiment participants were given the opportunity to make the choice between 3 alternatives: SAV, SAV with DRS and Public transport only. The variables used for each mode were travel costs, travel time (including waiting time) and waiting time. While it was hypothesized SAV could be an attractive mobility option for elderly travellers elderly respondents (65-84) were not relatively more likely to select any of the SAV options compared to younger respondents. It was theorized that elderly people of today are unlikely to make use of SAV however future elderly generations are more likely to be more favourable of these systems. It was found that all three variables (travel time, waiting time and fares) had a critical influence in the acceptability of SAV and DRS. In addition the respondent's trip purpose and their current primary travel mode were of significant influence in choosing a SAV mode.

In a two party study by (Zmud et al., 2016) the consumer acceptance and the possible effects on travel behaviour of AV was investigated with the help of an online survey and a face-to-face interview. The online survey was conducted by first having a short explanation of AV followed by a video on how an AV system would potentially function in the future. Their analysis of the results showed that almost 70% of the respondents are somewhat hesitant in their intention of using AV. The usage intention was mainly influenced by ownership of a vehicle with automated features, perceived safety. The only demographic variable that was significant in determining the usage intention was whether someone suffered from a physical condition that prevented them from operating a vehicle or not. People who were likely to use AV stated that their main reasons for doing so were safety, reduced stress, being more productive and increased mobility for elderly.

(Nees, 2016) presented respondents with two different descriptions of an AV system, one description presented a realistic scenario in which AV could be used and one description showed an idealistic version of an AV system. While the influence of the different descriptions was significant it only accounted for less than 2% of the variance in acceptance of AV.

2.3. Elderly and technology acceptance

Since the research in this report is specifically focusses on elderly it is important how tech acceptance among elderly is measured in general. For this reason several studies on elderly and technology acceptance were reviewed below.

(Mostaghel, 2016) reviewed the literature of other studies done on the technology adoption by elderly in which several important facts were identified. Firstly the review showed that most studies are built on observations such as focus groups and personal interviews. Secondly the attitude towards technology is often measured through interviews and single-item variables (i.e. One question per indicator). Third, the adoption of technology is a multidisciplinary process which depends on technological innovation, marketing, social influences and process innovation. Finally, there are different definitions of elderly found in literature which vary in age, behaviour, and needs.

In an attempt to investigate the adoption of mobile phones by elderly (Renaud & Biljon, 2008) proposed and tested a Senior Technology Acceptance Model (STAM) which uses the most important indicators that influence the technology acceptance among elderly. In addition to the factors used in the regular TAM they added user context (social/personal factors), ease of learning & use, confirmed usefulness and an experimentation and exploration phase.

(Morris & Venkatesh, 2000) investigated the influence of age on the acceptance of technology and found that the age of the person has a significant impact on the willingness to use new technologies. The main causes for this difference were a different attitude towards new technology and the fact that older respondents were more motivated by subjective (social) norm and perceived behavioural control.

With the aim to find out how the adoption of technology can be improved (Czaja et al., 2006) researched witch factors and personal characteristics influenced the use of technology. They found that earlier experience with (similar) technology has a significant impact on the adoption of modern technologies. Older people were found to have less self-efficacy when it comes to using modern technology which results in a higher anxiety when using them. Sociodemographic factors such as sex, age, race, and income level have an independent effect on adoption.

2.4. Summary of literature study

To give a more structured overview of the main findings from the literature review a short summary of all three subjects is given below.

2.4.1. Why elderly drive less

Safety is often mentioned as a reason to stop driving a vehicle or to limit their travel by car to (short) familiar trips. Safety of elderly car users can be explained both as the higher actual exposure to an accidents as well as the perception of safety while travelling on the road (own safety and safety of other road users).

People start to suffer from **deteriorating driving capabilities when getting older** such as a trouble identifying the speed of other road users, not seeing other road users when turning on an intersection, not seeing traffic signs and an increase in reaction times. There is a relationship between the feeling of safety of elderly drivers and their reduction in driving capability.

Age-related disorders: Almost all of the mentioned research papers found that deteriorating health conditions is the most important reason for driving less. These disorders such as eye disorders, dementia, Parkinson's disease and diabetes are more common among elderly (Davidse, 2007). These disorders can completely prevent people from being able to operate a vehicle or requiring modifications to the vehicle.

Legal restrictions on driving by elderly: In the Netherlands elderly drivers are required to undergo a medical exam when they reach the age of 75. If a person fails this medical exam a practical driving test must be done to see if the person is fit to drive a vehicle. If these tests are passed they have to be retaken every 5 years. These legal restrictions are often not explicitly mentioned as a reason for quitting driving but the renewal requirement is often used as an evaluation point to see if a person should continue to drive a vehicle. There is a relation with the legal restrictions and the financial aspect since some people find that the extra costs involved are not worth it.

Financial: Financial reasons are often mentioned as a reason for elderly to stop driving. This is either caused by a reduced income after retirement making it too costly to own and drive a vehicle or the reduced need for travelling making people feel that it is not worth it to own a vehicle.

2.4.2. Acceptance of AV

The various research on the acceptance of AV and intelligent transport systems (ITS) shows that there are a number of factors that can be identified to see if such a system will be accepted or not. The biggest influence of the acceptance of AV are the properties of the system. Specific factors found in the literature were **travel time**, **travel costs**, **travel comfort** and the **environmental impact**. For SAV additional performance properties such as **waiting times**, **fare costs**, **and ride sharing** are relevant.

There are also several personal characterises which were found to influence the acceptance of AV. The person's **attitude towards technology** indicates how willingly they are to use new technologies in their travel options. This attitude is often measured by asking how much the person is using current state-of-the-art technologies. An important part of the personal characteristics are the **social-demographics** such as age, gender and income. How much a person is affected by **social influences** also determines the acceptance of AV. These social influences can come from people close to the person and the existing social norms.

The **conditions** in which the system was used such as the distance travelled, amount of trips that were made and the availability of other transport modes were often of influence on the acceptance. Using an alternative **description** for a select part of the sample during the survey does not have a large influence on the research results. Finally **the ease of use** and the **ease of learning** a new system is often a determent of using a new system or not.

2.4.3. Elderly and technology acceptance

The literature review showed that that sociodemographic factors (gender, age, income level) cause differences in acceptance between groups of people. The factors influencing technology acceptance among elderly are mostly the same as the acceptance of AV but the degree of influence per factor varies. Specifically for elderly the **ease of use** and **ease of learning** are important since they have more problems with these aspects compared to younger users.

Research also shows that elderly are more influenced by their **social surroundings** and **social norms** compared to younger people. In addition to the (expected) properties of the system they find it important that the usefulness of the system is confirmed. Their previous **experience with technology** has a big impact if they are willing to accept new technologies or not. When using a new technology their **perceived behavioural control** (self-efficacy) often determines if they will continue using it.

3. Research Design

With the help of the literature review the research design will be formulated in this chapter. The research design is used to find a structured way to provide an answer to the research question. Firstly, the possible theoretical acceptance models found in the relevant literature are compared with each other to see which the best fit for this research is. After this the necessary modifications are discussed which are required to formulate the final research model. Finally the methods which are best suited to test this model are determined.

3.1. Existing Theoretical models

In nearly all of the reviewed literature a technology adoption model is used to investigate the usage intention of new technologies. For this study a technology acceptance model will also be used to find out the acceptance rate of the different AV-modes among elderly. In general, these models combine the (stated) intention of using a technology system with the person's perceived views on several key aspects of the system to investigate the acceptance rate of a new technology and to find out the reasons for (not) accepting this technology.

In the relevant literature many different acceptance models can be found (Bradley, 2009) but since the implementation of AV is a technological innovation and the fact there is a lot of overlap between models only 4 commonly used models will be considered: TAM, TAM2, UTAUT, and (Decomposed) TPB.

Each model has its own ideas on which indicators people take into account when deciding to use a technology. Below each model is briefly explained along with its positive and negative aspects. Afterwards the 4 models are compared to see which model is best suited for this research.

3.1.1. TAM model

The TAM (Technology acceptance model) developed by (Davis, 1986) models how users will accept and use a (new) technology and serves as an basis of most other acceptance models. This model takes as persons' thoughts on how useful a system will be (perceived usefulness) and how easy it would be to use the system (perceived ease of use) and combines this with their attitude towards a new technology to determine the acceptance rates.

- Perceived usefulness: "the degree to which a person believes that using a particular system would enhance his or her job performance"
- Perceived ease of use: "the degree to which a person believes that using a particular system would be free from effort"

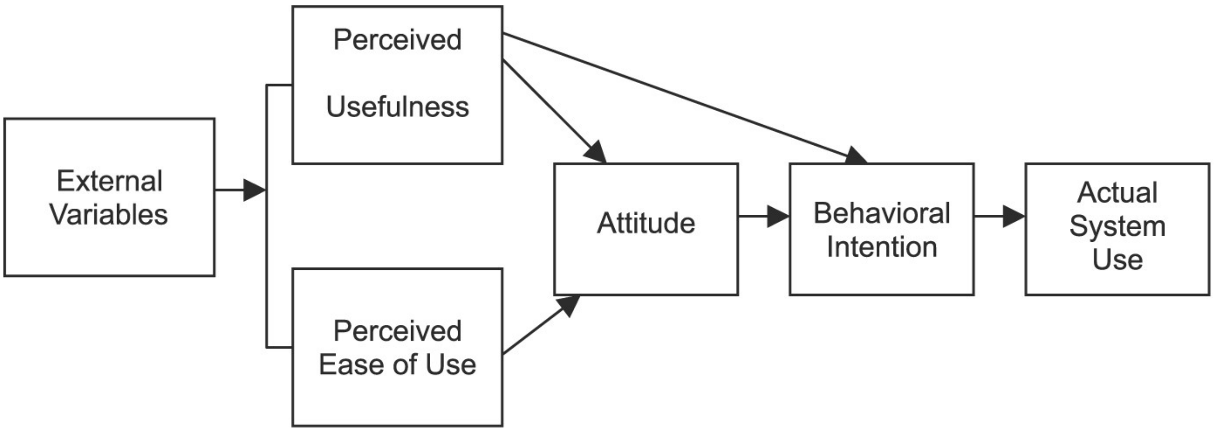


Figure 3: Technology acceptance model by (Davis, 1986)

Pros:

- Used successfully in many other researches and proven to be statistically valid
- Uses the attitude towards use of a system which is important when describing acceptance rates
- Limited number of variables prevent the model from becoming too complex

Cons:

- Limited number of indicators (social influences) which leads to a low explanatory power of the model
- Attitude towards technology does not solely depend on perceived usefulness and ease of use
- Relies on self-reported usage

3.1.2. TAM2 Model

TAM2 (Technology acceptance model 2) developed and validated by (Venkatesh & Davis, 2000) serves as an extension to the original TAM and adds seven additional variables (subjective norm, Image, Job relevance, Output quality, result demonstrability, experience and voluntariness) which affect the perceived usefulness and/or behavioural intention.

Pros:

- Higher explanatory value due to added variables
- Uses the attitude towards use of a system which is important to describe acceptance rates

Cons:

- Not all added variables are relevant to the acceptance rate of AV
- A persons' general attitude towards technology is not considered
- Variables as age and gender are not considered
- Increased complexity due to added variables

3.1.3. UTAUT Model

UTAUT (Unified theory of acceptance and use of technology) is a model that was combined from multiple other (existing) technology acceptance models and was developed by (Venkatesh et al., 2003). The UTAUT model explains the intentions for users to use an information system and the usage behaviour when doing so. The model consists of 4 main constructs that describe the intentions of using a particular system:

- **Performance expectancy** (intention): "the degree to which an individual perceives that using the system could help improve their performance"
- **Effort expectancy** (intention): "The extent to which an individual perceives that the system will be easy to use"
- **Social influence** (intention): "The degree to which an individual perceives that important others believe he or she should use the new system"
- **Facilitating conditions** (use behaviour): "the degree to which an individual perceives that organizational assistance is there to facilitate use of the system"

Gender, Age, Experience and voluntariness of use (is a person 'forced' to use technology?) are used as external variables to moderate the impact of each key component.

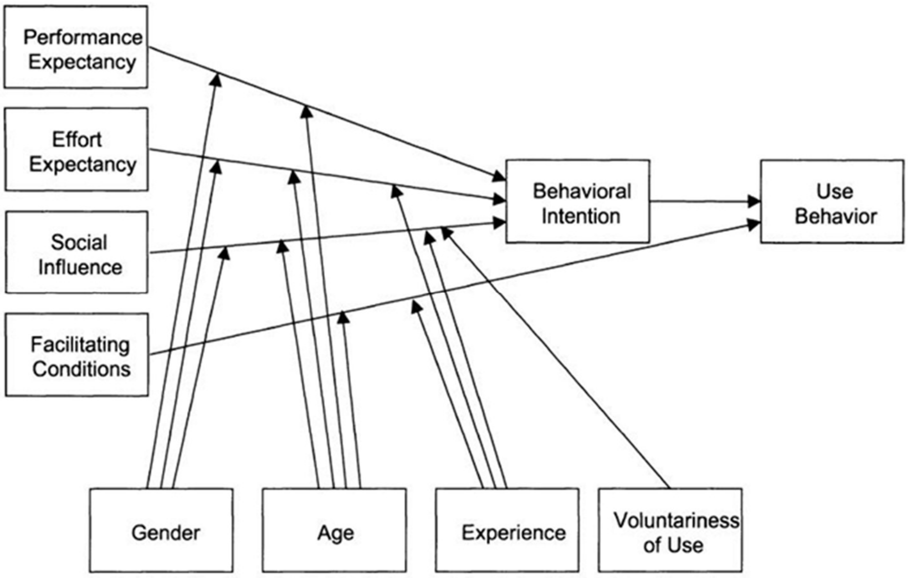


Figure 4: UTAUT model by Venkatesh, Morris, Davis, & Davis (2003)

Pros:

- Aimed at the acceptance of technology which corresponds with the implementation of AV
- A UTUAT model has been used in multiple studies to investigate the acceptance and behavioural intention of AV systems (Madigan et al., 2016), (Nordhoff et al., 2016)
- The 4 constructs used in this model can describe the effects of AV
- Higher explanatory power than TAM and TAM2

Cons:

- Relatively new and 'unproven' compared to other acceptance models
- Increased complexity compared to TAM caused by higher number of variables
- Mainly used for information systems

3.1.4. (Decomposed) TPB model

The TPB (Theory of planned behaviour) model by (Ajzen, 1985) is mainly used to model effects of social behaviour and psychological elements of system use. It models a person's behaviour and intentions based on their attitude towards behaviour, subjective norms and perceived behavioural control. The decomposed TPB model deconstructs the 3 main variables into 8 variables (Perceived usefulness, ease of use, compatibility, peer influence, superior's influence, self-efficacy, resource facilitating conditions and technology facilitating conditions).

- Attitude toward behaviour: Overall evaluation of the behaviour based on the extent to which an individual believes that the behaviour will lead to various noticeable positive or negative outcomes
- Subjective norms: "The perceived social pressure to engage or not engage in a particular behaviour"
- Perceived behavioural control: "Individual's readiness to perform a given behaviour"

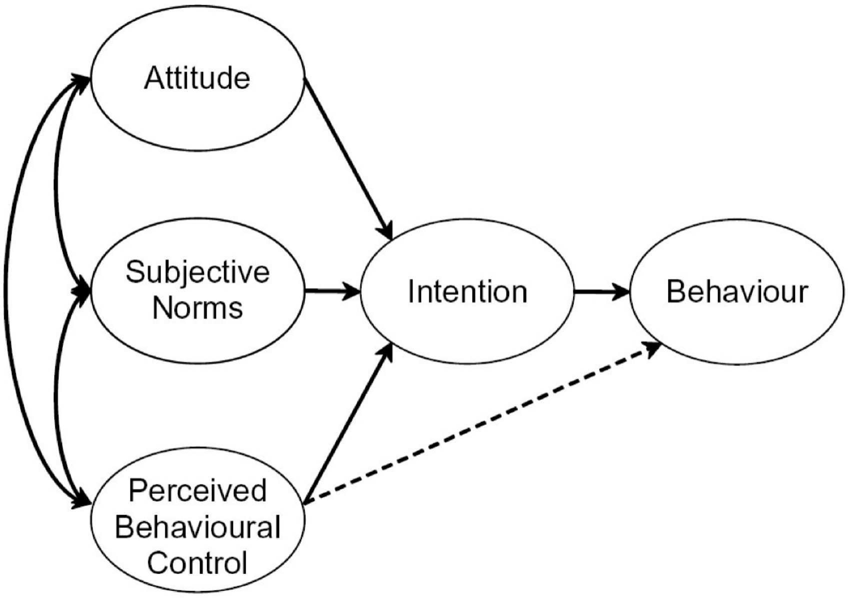


Figure 5: TPB model by Ajzen (1985)

Pros:

- Considers attitude towards system as a variable for behavioural intention
- Adds Perceived behavioural control as a variable which explains the difference between the intended behaviour and actual behaviour
- Higher explanatory power then TAM

Cons:

- Needs a high number of extra variables for a small increase in explanatory power
- Not necessarily intended to use for the acceptance of technology

3.2. Comparison of models

When choosing the model it is important that the final results are consistent and they show a relation between the dependant variables (acceptance rates) and the independent variables. This is done by comparing the suitability (can it be applied for the research? workload for respondents?), completeness (does it capture all the factors of AV?), validation (used in other research, proven to be statistically valid) and complexity.

Because of the fact there is a lot of overlap between models and they are all based on the same underlying ideas it is not likely that choosing a ‘wrong’ model completely invalidates the outcomes of the research. In addition the model that is chosen has to be adapted for the research goal and the target group. However choosing the right model helps strengthen the validity of the research and it is important to take all (expected) impacts of acceptability of AV into account while making sure that the final model isn’t too complex (which also requires large sample size).

Table 2: Comparison of acceptance models

Model	Suitability	Completeness	Validation	Complexity
TAM	++	++	++++	- -
TAM2	+++	++++	+++	- - - -
UTAUT	++++	+++++	+++	- - - -
TPB	+++	+++	++++	- - - - (- - - - -)*

* Decomposed TPB

Taking the characteristics of all models shown in Table 2 into account the UTAUT model seems to be the best fit for this study. It has the ability to explain all of the impacts of AV while still having relatively few indicators which keeps it from becoming too complex. The UTAUT model also has been used in other studies to investigate the acceptability of AV/ITS which allows for the results to be compared to this research.

3.3. Modifying the chosen model to fit study

Since the UTAUT models was mainly developed to test the acceptance of IT systems it should be adapted for researching the usage intention of AV. In order to find the indicators that are relevant for this study the literature review from chapter 2 will be used. With the help of this literature review the questions in the survey can be formulated, each indicator requires at least one question in the survey. The literature review will be used to identify the most important impacts of AV and which variables of the UTAUT model have had the biggest impact on acceptability in previous research. This information will then be used to determine the theoretical model

General conclusions

- The three constructs Performance Expectancy, Effort Expectancy and Social Influence have been proven to all have an influence of the acceptability of AV
- Performance expectancy is the most important indicator in all of the papers. It is important that the influences of AV on the performance are explained appropriately
- (Venkatesh et al., 2003) found that that the facilitating conditions only influence the use behaviour and not the behavioural intention
- External factors that are often used to test technology acceptability are: age, gender, level of income, experience, trip purpose, and health conditions
- The external factor ‘experience’ will be used to see if people with more experience respond differently to AV. The experience moderator contains two elements: The experience with driving a conventional vehicle and the experience with existing driver support technologies, both will be questioned during the survey. This information will also be used to separate the drivers from the ‘non-drivers’
- The external factor ‘health conditions’ will be used to see if respondents who suffer from a (health) condition that limits or even prevents them from driving a vehicle respond differently to AV compared to people who do not suffer from these conditions
- Research shows that the person’s attitude towards technology and social factors (equity) are both important in the acceptance of new technologies
- The conditions/situation (distance travelled) and environmental factors (such as the availability of other transport modes) in which the AV-mode is used are important factors in testing AV acceptance. This is not applicable for this research since the AV systems are not physically demonstrated/tested. Participants are to picture themselves as using the system in their own familiar environment
- The number of variables should be limited in order to reach a convergence in an acceptance model. If possible the model should consist of only single-item variables by asking only one question per indicator

Performance expectancy

- Safety is an important reason for why elderly stop driving. Safety involves the perception of safety as well as the exposure to actual risks
- For shared AV the influence of travel time, waiting time and travel costs are significant in determining acceptance
- Respondents should take into account all of the travel times savings that an AV and SAV system offers such as not having to find parking spaces at home or at their destination, this should be made clear in the description of the system
- The on-board comfort when driving with an AV should be an indicator under Performance Expectancy. On-board comfort includes the possibility of doing other tasks while driving and the need for sharing the vehicle with other passengers
- Cost of travelling is an important indicator for elderly in deciding to keep travelling by car or not. However willingness to pay does not does not explain the influence of costs very well. Different indicators must be used to explain the influence of costs on the acceptance rate.
- The impacts of environmental effects of driving with an AV compared to a traditional car on usage intention have not yet been investigated. It is however expected that widespread usage of automated vehicles will result in significant fuel savings (Milakis et al., 2015). Therefore the environmental effects could have an impact on the usage intention
- There is a distinct difference between the acceptability of shared automated vehicles with or without dynamic ride sharing (DRS)

Effort expectations

- The ease of use of a modern technology is mentioned as a crucial factor in tech acceptance by elderly. This is also important to this research since automated vehicles could be a solution to deteriorating driving capabilities which people suffer from when getting older
- Both (Renaud & Biljon, 2008) and (Czaja et al., 2006) found that older respondents are heavily influenced by the ease of learning of a new technology
- The effects of the legal consequences and the impact of AV on the environment are not yet thoroughly investigated yet

Social influences

- Research on technology acceptance among elderly shows that elderly are highly motivated by subjective/social norms in deciding to use a new technology

3.3.1. Implementing stated importance into the model

In their original UTAUT model (Venkatesh et al., 2003) theorized that 'attitude towards technology' is not a direct determinant of technology since this effect is captured by both performance and effort expectancy. While there is some personal bias when stating the performance expectancy and effort expectancy of a modern technology like AV's this it has not been proven to show how important these constructs are to the individual. As a result the original model does not fully capture the relation between the performance/effort expectancy and the actual behavioural intention since this is also influenced by how important these constructs are to the respondent.

Since the original UTAUT model was created for the acceptance of IT systems adjustments need to be made to use it for testing the behavioural intention of using AV systems. There have been several studies which have tried to incorporate a type of attitude towards the systems characteristics in the UTAUT model.

(Adell, 2009) used a pilot test to see if UTAUT can model the acceptance of driver support systems. While it was not included in the pilot-test the conclusion of this research suggests to weigh each of the constructs with the perceived importance of each respondent since it was found there are different types of drivers. Some drivers, for example, find safety more important while others might find the (potential) reduction in driving restrictions of greater value.

(Welmers, 2005) inserted the general 'attitude towards product' between the performance/effort expectancy and the behavioural intention because it was reasoned that this influence is not completely captured with performance and effort expectancy. It was found that the attitude towards the product has positive, direct relationship with behavioural intention.

(Osswald et al., 2012) proposes a technology acceptance model specifically for car technology (CTAM). This model incorporates context related determinants that are derived from literature and content analysis. The originally deemed insignificant determinants ‘self-efficacy’ and ‘attitude towards technology’ were reintroduced to the UTAUT model and ‘Anxiety’ and ‘Perceived safety’ were added as new constructs. Anxiety was found only to be sufficiently consistent when dropping a certain item from the questionnaire while the other constructs all had a good internal consistency.

These papers show that adding some form of ‘importance’ as a weighing factor towards the technology can have a positive impact on the explanatory value of the model. Therefore, the stated importance will be used to weigh the answers to the individual indicators found under the performance/effort expectancy. In addition, the social assertiveness (to what extent people let their social surroundings influence their behaviour) will also be included to weigh the indicators found under the Social Influences construct. The respondents’ stated importance will be measured with specific questions for each individual indicator.

3.3.2. Theoretical model

With the help of the conclusions from this chapter a theoretical model is made. The theoretical model shows the concept(s) on which this research is based and is used to give an overview of the theoretical reasoning's made earlier. The model shows how the respondent’s answers to the indicators influences the 3 main constructs (performance expectancy, effort expectancy and social influences). The model will also reveal if the stated importance of each indicator will have an impact on the behavioural intention. Along with the external variables (age, gender, experience, income and health) measured during the survey the relation between the constructs and the behavioural intention can then be determined. The complete theoretical model can be found in Figure 6.

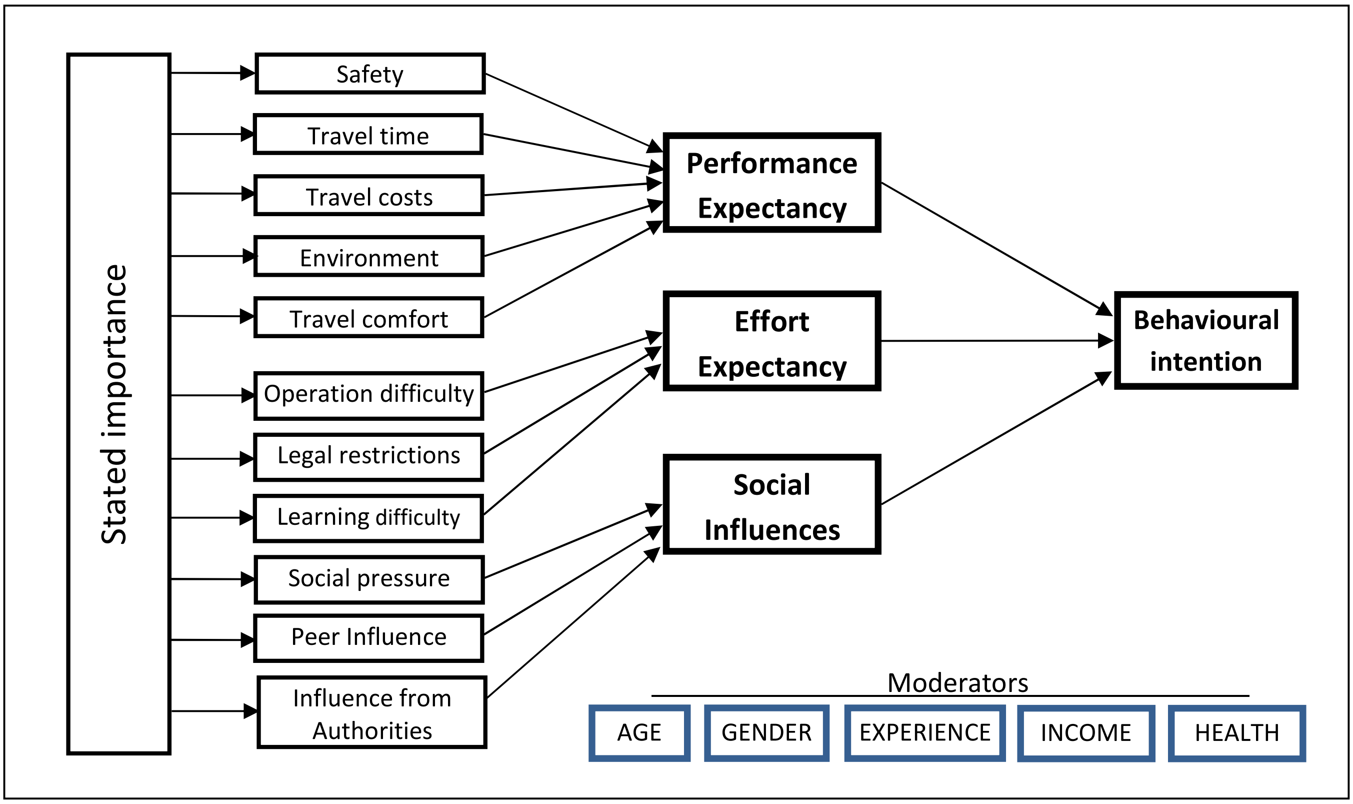


Figure 6: Theoretical model (adopted from UTAUT model)

3.4. Analysis methodology

The data gathered from the survey will be used to analyse the relations between constructs, indicators and moderators found in the theoretical model. The model will be analysed with the help of Structural equation modelling (SEM). SEM is useful in this case because it is suitable to answer more complicated questions with regard to the relations between individual constructs and the behavioural intention (BI). SEM is a path analysis method that can deal with the multiple relationships (between indicator variables) that are found in the model simultaneously. It can also account for the unreliability of measurement. In addition latent variables/constructs can be included in the model. The latent variables in this model (PE, EE, SI and BI) are variables that are not directly observed but rather deduced from the variables that are actually observed (in this case the indicators Safety, travel time, etc.). With the help of SEM the internal reliabilities of each construct (CR, AVE) can be used to see if the items accurately measure each of them. SEM is a method that can be used in research on travel behaviour and has been used successfully in previous studies (Golob, 2003).

Since a theoretical model has already been constructed a priori with both the help of the literature review and argumentation the proposed model (Figure 6) will be validated with the use of confirmative factor analysis (CFA). Although the presumed underlying factors that explain the relation between the latent constructs (PE, EE and SI) and their indicators is already determined in the theoretical model it is possible that this assumption is found not to be correct when analysing the data from the survey. If this is the case an exploratory factor analysis (EFA) can be used to see if there are different latent variables that can be derived from the observed variables. The SEM analysis will be the main source of information to provide answers to the research questions stated in the introduction.

3.5. Summary of chapter 3

The most commonly used acceptance models used in behavioural studies were compared to see which model would best fit the research goal of this study. The models that were compared were the TAM, TAM2, UTAUT, and (decomposed) TPB model. These models were assessed on their Suitability for the research, completeness, validation and complexity. The UTAUT model was found to be the best fit for this study.

Using the literature review the UTAUT model was modified to provide an answer to the research questions. The final theoretical model has additional moderators (Age, gender, experience, income, health) than the original model and uses indicators which were found to be relevant to the elderly target group. In addition the stated importance, which is also gathered during the survey, is added to the model which is used as a weighing factor for each indicator. The data gathered during the survey will be analysed by using structural equation modelling which will reveal the relationships (and their strength) in the model.

4. Survey design and data collection

With the help of the research design and final research model formulated in the previous chapter the survey design will be constructed. The survey is a key-part of the research as it will be used as the main source of data. Firstly, the requirements for the survey will be listed based on the findings from the literature review as well as the research model. After this an overview of the final survey, including the relevant questions for each indicator, will be given. Before the data collection starts a description of the AV systems that will be presented during the survey will be formulated. In the last part of this chapter the data collection process is detailed.

4.1. Survey requirements

To formulate the right questions that will be asked during the survey several requirements for the survey are listed below. These requirements will help to find an answer to the research question and make sure that the survey questions align with earlier findings.

- All the elements found in the literature study must be considered (indicators found in the theoretical model)
- Since there are no clear definitions of 'elderly' which can be found in the literature the respondents of the survey should be aged 55 and up. From this age the decline in mobility can be observed (Figure 1), this will also show the difference in usage intention between people who are still working and people who are retired.
- It must contain multiple questions on the usage intention of the described AV systems
- Must contain questions for each construct on:
    - Individuals perception of system (performance of system)
    - Individuals stated importance towards performance, effort, and social influences
- Survey will be held in Dutch, In order to prevent translations errors the translation will be done with the help of the paper on translating survey's by (Zavala-Rojas, 2014)
- Each of the AV systems (owned and shared) has to be properly explained with their level of automation and how they could be used for fulfilling the need for transportation
- A 5 point Likert scale will be used to reduce complexity of questions and making it faster to fill in the survey

The survey will be divided in different sections with each section having their own purpose. Firstly in the introduction the objective of the research is explained showing why respondents are filling in the survey, in the introduction also an explanation of the different steps in the survey will be given.

Before explaining the 2 AV systems respondents will be asked questions which will be used to gather their stated importance towards performance, effort and social influences. These questions will be based on the main characteristics of AV (Safety, Travel time, costs etc.) and importance of vehicle ownership in general (in relation to SAV). After this a video will be shown which gives the respondents an idea of how this system would function. The video will be accompanied with a short description on each of the AV systems (AV and SAV) in which the properties of each system will be detailed.

After the explaining the AV modes the main constructs of the UTAUT will be tested (performance expectancy, effort expectancy, social influences) with at least 1 question covering each indicator specified in the theoretical model. After the questions of the UTAUT model are answered the respondent's (anonymous) information will be collected including age, gender, income, driving experience and experience with existing AV technologies.

During the design of the survey it should be taken into account that it will be filled in by elderly which means that completion time of the survey should be as low as possible. The number of respondents should also be high enough which would become a problem if the survey takes too long. Therefore the survey should take no longer than 20 to 25 minutes to complete.

4.2. Survey outline

In Table 3 an outline of the survey is shown containing all the items that will be present in the final survey including the questions that will be asked to measure each of the indicators. The complete survey can be found in the attachments.

Table 3: Survey outline

<table>
<tr><th>Section</th><th>Components/indicators</th></tr>
<tr><td>Introduction</td><td>• Explain objective of the study
• Explain content of survey and how to fill in the survey</td></tr>
<tr><td>Base-line information</td><td>• Personal characteristics (Gender, age, source of income, income, health conditions)
• Driving experience (drivers licence ownership, car ownership and annual km driven)
• Current experience with AV options (speed assist, lane assist etc.)</td></tr>
<tr><td colspan="2">Pre-explanation questions</td></tr>
<tr><td colspan="2">Stated importance (Performance)</td></tr>
<tr><td colspan="2">APE1: I find that safety is an important factor in choosing a transportation mode
APE2: For me the travel time is an important factor in choosing a transportation mode
APE3: I find that travel comfort is an important factor in choosing a transportation mode
APE4: For me the costs of travelling are an important factor in choosing a transportation mode
APE5: The environmental impact I make when travelling is important to me
APE6: Sharing a vehicle with other people is problematic for me
APE7: Sharing rides with other people is problematic for me</td></tr>
<tr><td colspan="2">Stated importance (Effort)</td></tr>
<tr><td colspan="2">AEE1: It is important that it is easy to use a travel mode
AEE2: I approve of the current regulatory restrictions on driving by elderly (such as a health checks and mandatory renewal of driver licence at the age of 75)
AEE3: Needing to learn how to use a new travel mode is a barrier for using it</td></tr>
<tr><td colspan="2">Stated importance (Social)</td></tr>
<tr><td colspan="2">ASI1: People who are important to me often influence my behaviour
ASI2: Seeing people around me using a new technology makes it more likely for me to use it as well
ASI3: Advice from the authorities often influences my behaviour</td></tr>
<tr><td colspan="2">Explanation of the system (VIDEO + description)</td></tr>
<tr><td colspan="2">Post- explanation expectations of AV system</td></tr>
<tr><td colspan="2">Performance expectancy</td></tr>
<tr><td colspan="2">Performance expectancy items in original UTAUT model:
• I would find the system useful in my job.
• Using the system enables me to accomplish tasks more quickly.
• Using the system increases my productivity.
• If I use the system, I will increase my chances of getting a raise.</td></tr>
<tr><td colspan="2">Performance expectancy items in this survey:
PE1: Using this system would improve my safety on the road
PE2: Using this system would reduce my travel time
PE3: Travelling with this system would be more expensive than current travel modes
PE4: Using this system will have a lower environmental impact compared to conventional travel by car
PE5: This system will allow me to perform other tasks (such as sleeping or working) while driving</td></tr>
</table>

Effort expectancy
Effort expectancy items in original UTAUT model: • My interaction with the system would be clear and understandable. • It would be easy for me to become skilful at using the system. • I would find the system easy to use. • Learning to operate the system is easy for me.
Effort expectancy items in this survey: EE1: *I would find this system easy to use* EE2: *I would expect this system to remove the driving restrictions (renewal of drivers' licence) which are in place for elderly* EE3: *It would be easy for me to learn how to operate this system*
Social influences
Social influences items in original UTAUT model: • People who influence my behaviour think that I should use the system. • People who are important to me think that I should use the system. • The senior management of this business has been helpful in the use of the system. • In general, the organization has supported the use of the system.
Social influences items in this survey: SI1: *Having people who are important to me using this system will make me more likely to use it to* SI2: *People who are important to me would think that I should use this system.* SI3: *In general, the authorities would think that I should use this system*
Behavioural intention to use the system:
Behavioural intention items used in original UTAUT model: • I intend to use the system in the next <n> months. • I predict I would use the system in the next <n> months. • I plan to use the system in the next <n> months.
Behavioural intention items used in this survey: BI1*: I intend to use this system when it becomes available* BI2: *I predict I will use this system when it becomes available* BI3: *I plan to use this system when it becomes available*
Explanation of SAV system
Post- explanation expectations of SAV system (same questions as above)

4.3. Future mode choices and system descriptions

Since most AV technology are not yet (widely) available the survey needs to include a description of the system and how it could be used in the daily lives of people. For this survey there are two distinctly different types of AV-modes that are being investigated: AV-Owned and AV-shared. The AV-Owned system will allow people to drive their own vehicle anywhere without having to physically operate the vehicle or being required to intervene at any time. The AV would be able to (autonomously) park near the persons' destination and origin resulting in little to no waiting times. Since this research aims to investigate the usage intention of people who suffer from more severe restrictions such as blindness and full disability the driver is not assumed to be capable to operate the vehicle under any conditions. Therefore, these automated vehicles should operate on either (SAE) Level 4 or 5. Which means the vehicles can operate fully automatic all the time (level 5) or under certain conditions (level 4).

The AV-shared system would work like a taxi system, people do not own the vehicles so there would be no initial costs but a higher price per KM travelled. The shared AV system would automatically travel to the passengers' origin so there would be no walking distance to the vehicle (compared with current shared vehicle systems). This system could be used for the full trip or only for access/egress to conventional public transport systems. To reduce the amount of empty vehicle KM's the SAV system could use Dynamic ride sharing (DRS) which allows multiple passengers to use the vehicle at the same time. This would however increase waiting and travel times for all users.

These systems will be explained with the help of a video which shows how the systems works and how it could be used in fulfilling the need to travel. This video should be detailed enough to help respondents to understand the systems and how it could change their travel behaviour but not so specific that it would influence the answers on the survey too much.

During the survey the following video will be presented to participants of the survey:

https://www.youtube.com/watch?v=cdgQpa1pUUE (Self-Driving Car Test: Steve Mahan)

This video by Google shows a prototype of the Google car being used for everyday trips by an elderly person with a (visual) disability. The video will be shown with Dutch subtitles. After viewing the video the participants will receive the following description of system:

> *When answering questions during this survey imagine a system similar to the one shown in the video that would be widely available from multiple manufacturers. This system would be able to operate both on freeways and in urban areas. The vehicle will be able to park close to your destination and origin on its own resulting in little to no waiting times. When driving the vehicle no physical interaction other than specifying the destination is required. During driving no intervention of the driver is needed but manually operating the vehicle is a possibility if the driver wishes to do so. When answering the questions we are interested in your opinion about such a system and how you think it would perform in everyday life.*

After answering the questions on the owned AV system the following description of the Shared AV system is given:

> *Now imagine the same system only now the vehicles are not privately owned but shared among other users. This system would operate similar to a conventional taxi system picking you up on your origin and drop you of at your destination. To improve efficiency and to reduce costs you might have to share rides with up to 2 other passengers.*

4.4. Data collection

After completion of the first survey outline a version of the survey was worked out on paper and tested in 2 test surveys to see if there could be any improvements made to the setup of the survey. After the final survey method was determined the data collection performed through an online survey website.

4.4.1. Test survey

Before the final survey was carried out 2 separate test surveys with multiple participants were used to see what the best setup for the final survey would be. Results from these test surveys showed:

- Roughly how long it took to complete them
- If all the questions where clear and interpreted correctly for all respondents
- How the video should be presented
- How different formats such as a face-to-face survey or a survey were respondent fills in the survey by themselves (or a combination of these two) impact the completion time and clarity of the survey

These test surveys showed that there were a few questions that were unclear and some questions suffered from poor translation, these issues were corrected for the final survey. The face-to-face method were the interviewer asked each of the questions to the respondent proved to take a long time to complete (45 min to 1 hour)

There was also some confusion during the interview due to the repetitive nature of some questions which worked better if the respondents read and fill in the questions themselves. A combination of face-to-face and independently filled in survey also took a long time due to the fact that there are a lot of separate sections in the survey (Explanation of survey (goal), introduction to AV with video, opinion on AV system, introduction to SAV, opinion on SAV system, gathering of personal information).

With help of the test surveys the choice was made to conduct an online survey which lets respondents to fill in the survey independently wherever they are and was shown to take the least amount of time to complete (estimation of around 20 minutes). An online survey also helps reaching a larger response group and thus acquiring a larger sample which is a requirement for using SEM.

4.4.2. Online data collection

With the help of the survey outline found in Table 3 and the Dutch translation of the complete survey (see attachment II) an online survey was set-up with the help of typeform[1]. Typeform offers a platform to host online surveys which can be modified to fit the survey requirements and allows for logic jumps so that respondents do not have to fill in unnecessary questions. The online survey can be accessed with the help of the following URL https://ingeveld.typeform.com/to/Z0eULt

After the survey was constructed respondents were recruited trough the websites of KBO and ANBO which are both Dutch interest groups for elderly with the intent of targeting elderly aged 55+ from anywhere in the Netherlands. Results from the online survey were gathered for a period of 3 months (from 17-10-2016 to 16-01-2017).

During this period the survey was accessed 169 times and successfully completed 125 times with 123 people who were aged 55+. The results of the survey are discussed in detail in the next chapter “Data analysis”.

[1] www.typeform.com

5. Data analysis

The data analysis of the survey results starts with the descriptive statistics which mainly focusses on the personal information of the respondents that was gathered during the survey. These statistics will be used to describe the profile of the survey respondents, give an overview on how they responded to the survey questions and to determine the moderator groups (age, income etc.) that will be used during the SEM analysis. In the last part of the descriptives an overview of how the individual groups responded towards the AV and SAV systems be given.

In the second part of the data analysis structural equation modelling (SEM) is used to see if the data gathered during the survey corresponds with the proposed theoretical model formulated in chapter 3. If needed, the original model will be optimized to obtain the best model fit. After the model is optimized the multi-group analysis will show if the proposed moderator groups (age, gender, experience, income and health) are invariant and differences between groups will be identified. The final part of the analysis is used to implement stated importance in the model to see if it actually improves the model fit or not.

5.1. Descriptive statistics

The descriptives statistics are used to give a profile of the survey respondents by presenting the main findings from the personal information that was gathered during the survey. This information is useful when comparing this research with other research results and seeing how the sample compares to the whole (elderly) population of the Netherlands.

This information will also be used in determining which respondents belong to which moderator group. Except for the gender and Health moderator groups the exact boundaries for the other groups haven't been determined yet. These boundaries depend on the answers given by the whole sample and key figures of the population of the Netherlands.

The last part of the descriptives is used to give a brief overview of the difference between groups in how they answered the indicator and behavioural intention questions. The individual groups are discussed in more detail during the SEM analysis.

5.1.1. Profile of survey respondents

In total the survey was started 169 times of which it was completed 125 times (73% completion rate). Of the 125 people who completed the survey 2 where younger than 55 and thus excluded from the data analysis leaving a total sample size of **123**. The survey was built in a way that every question had to be answered before the results could be submitted. This means that there is no missing data except for the questions on the respondents' source and level of income which they could choose not to answer. Below the key figures of the sample are discussed in more detail.

Gender: 38% of the respondents are female (n= 47) and 62% are male (n= 76), this means there is overrepresentation of males in the sample compared to the population of the Netherlands (50.4% female and 49.6% male).

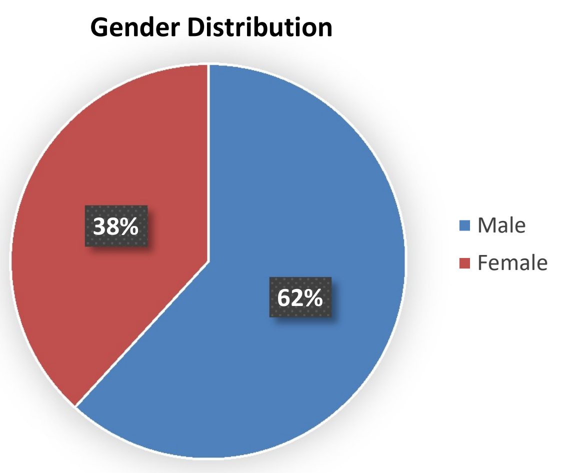


Figure 7: Gender distribution of Sample

Age: The age distribution of the total sample can be found in Figure 8. The youngest respondent (in the final sample) is 55 the oldest 82. The average age of the sample is 67.07 years and the median age is 67 years.

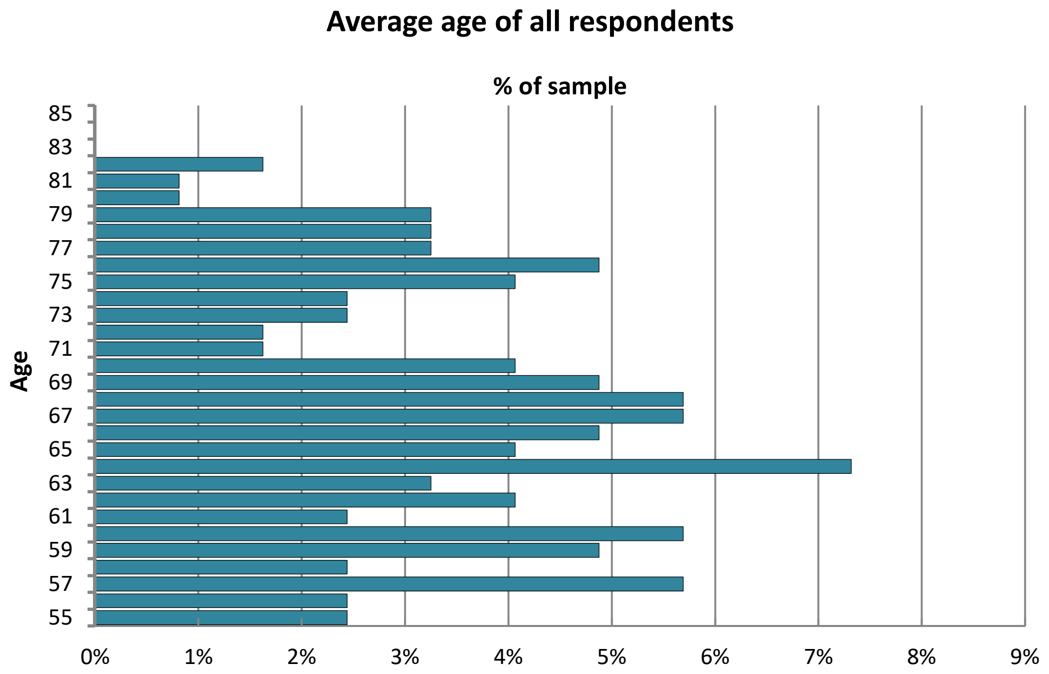


Figure 8: Age distribution of total sample (Respondents aged 55+)

Figure 8 shows a good distribution of the different ages in the sample with the group between 60 and 70 years old being slightly overrepresented. The only real negative aspect of the sample group is that there are almost no respondents who have a very old age (80+), this has to be taken into account when discussing the research results. Looking at the age distribution by gender (Figure 9) it shows that there are no big differences between the age distribution of males and females in the sample.

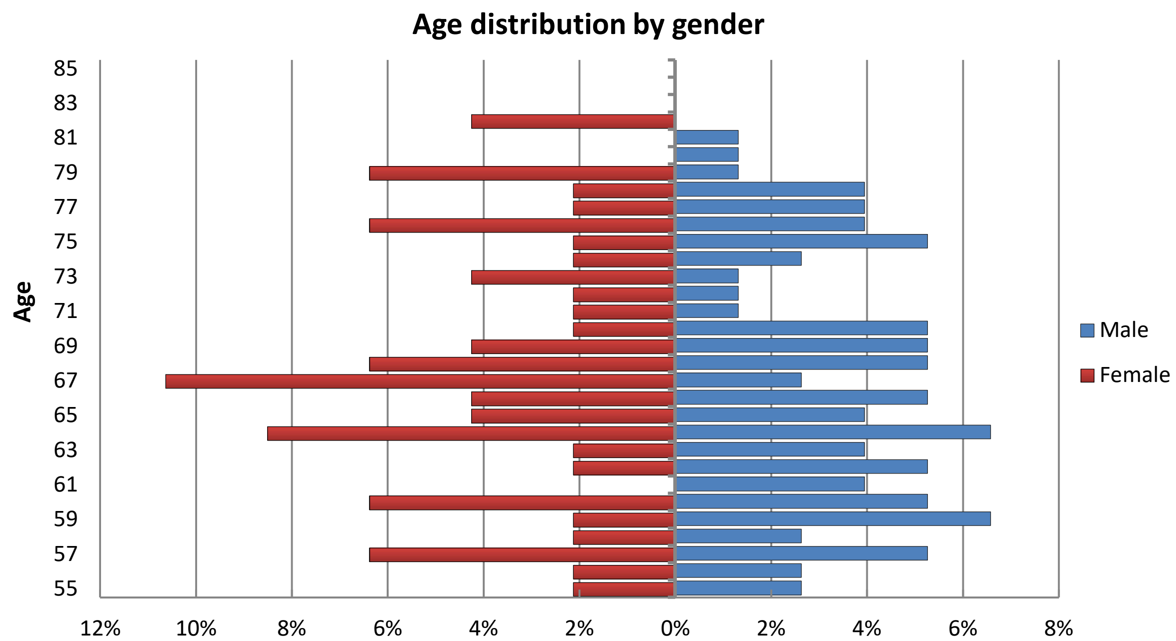


Figure 9: Age distribution of sample distinguished by gender

Experience with driving support technologies:

During the survey respondents were asked how familiar they are with 7 currently available driving support technologies. Table 4 shows the percentage of the sample that choose each answer. The results show that most commonly known driving support technologies (navigation and cruise control) have been use or are at least known by the majority of the sample. Newer technologies like adaptive cruise control, park assist, and lane departure warning systems are only used by a very small section of the sample.

Table 4: Respondents experience with 7 driver assistance technologies

	Never heard of this	*Heard of this but never used*	*Used occasionally*	*Used frequently*
In-car navigation system	0.81%	15.45%	31.71%	52.03%
Cruise control	7.32%	43.90%	30.89%	17.89%
Adaptive cruise control	62.60%	29.27%	4.07%	4.07%
Park assist/ automated parking	31.71%	52.03%	14.63%	1.63%
Blind-spot assistance	35.77%	60.98%	2.44%	0.81%
Collision warning/prevention system	42.28%	24.39%	6.50%	26.83%
Lane departure	62.60%	31.71%	4.88%	0.81%

Income and main sources of income:

During the survey respondents were asked what their main sources of income are (work, Pension, old-age pension/security or other) and what their households' average spendable income per month is (Less than €1000, between €1000 and €1500, between €1500 and €2000, between €2000 and €2500 between €2500 and €3000, between €3000 and €4000 or More than €4000). The distribution of the answers can be seen in Figure 10.

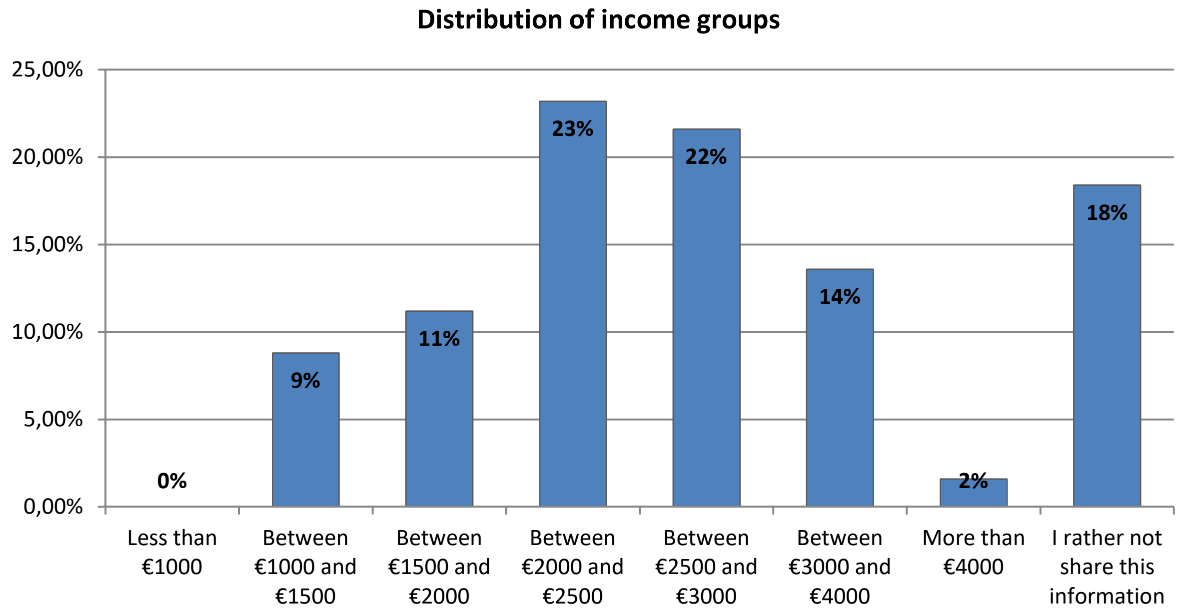


Figure 10: Distribution of income groups

The majority of the sample has an average spendable household income of between €2000 and €3000 per month. The distribution also shows that there are not many people in the lower income groups. It is possible that the lower income groups are overrepresented in the 18% of the respondents that didn't answer the question. The main sources of income of the sample group can be found in Figure 11 (note that respondents could fill in multiple sources of income).

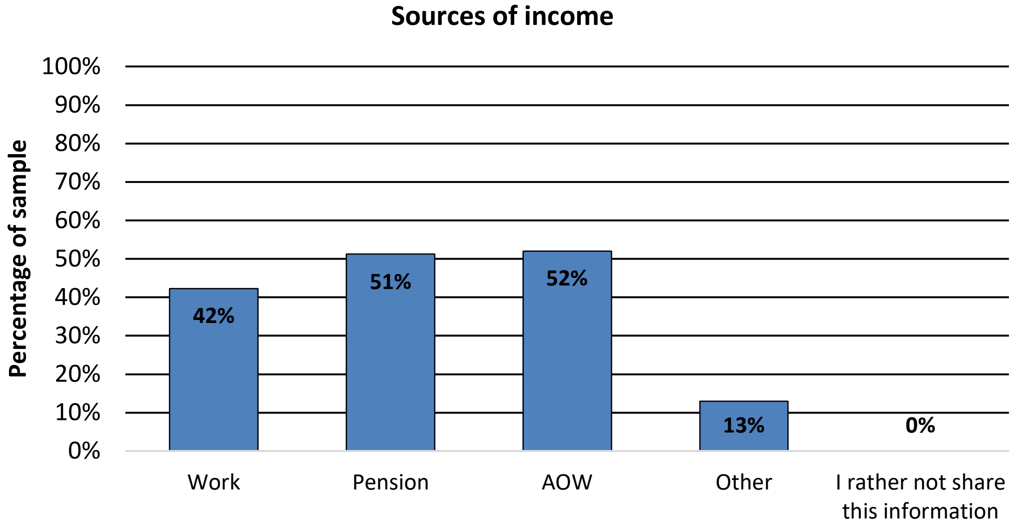


Figure 11: Main sources of income of respondents

Health:

During the survey respondents were asked if they suffered from any of the 4 following health issues:

- Reduced eyesight
- Reduced hearing
- Limited use of arms/hands
- Limited use of legs/feet

For each condition they answered yes to they could indicate how much it hindered them in their ability to travel and to operate a vehicle with a score of 1 to 5 (1 meaning not at all and 5 meaning a lot). Table 5 shows the percentage of people who answered yes to the question if they suffered from any of the health conditions and how severe these conditions were rated.

Table 5: Respondents answers to health questions

		Limited in travel			Limited in driving		
	% yes	1 or 2	3	4 or 5	1 or 2	3	4 or 5
Eyesight	59.35%	59%	1%	0%	44%	15%	0%
Hearing	13.01%	13%	0%	0%	11%	2%	1%
Arms/fingers	26.83%	18%	9%	0%	10%	8%	9%
Legs/feet	29.27%	8%	9%	12%	6%	4%	20%

Comparing these results with the data from the whole population (SCP, 2012) shows that the percentage of people who suffer from some form or reduced eyesight in the sample (59%) is much higher than in the Dutch population (19% for people aged 65+). This is countered by the fact that a large part of the sample states that their reduced eyesight does not impact their ability to travel of drive a vehicle. The discrepancy between the percentages could be explained by the way this disability is formulated in the population data in contrast to the question asked in the survey.

The results for the other types of disabilities are much closer to the population data. These are 15% (65+) for people with hearing difficulties and 51% (65+) people with a motoric disability (which includes problems with both arms as well as legs).

Drivers and non-drivers:

During the data-analysis it is important to make a distinction between drivers and non-drivers. Drivers are people who own a drivers' licence and currently still drive a vehicle, non-drivers are people who do not a valid drivers' licence or own a licence but currently do not drive at all. Figure 12 shows the percentage of respondents that own a drivers licence and the percentage that still drives a vehicle.

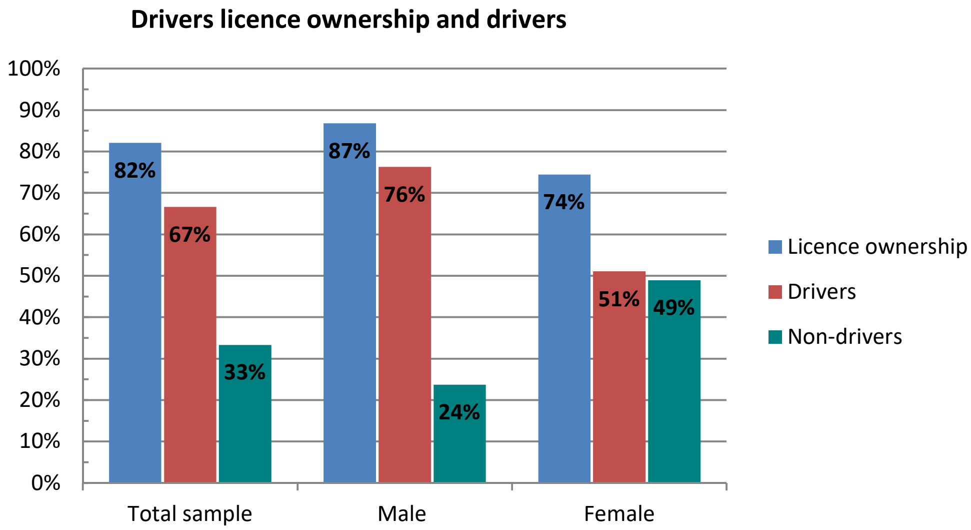


Figure 12: drivers licence ownership and percentage of drivers

82% of the sample owned a driving licence with men being more likely to own a licence than women. The data also shows that males are more likely to continue driving when they get older and that women tend to stop driving while they still own a licence.

People who did not own a licence and people who stopped driven were asked to rate how much the following indicators determined to stop driving or not getting a licence: health, costs, licence renewal and safety. Figure 13 shows that cost and health issues are the main reasons for quitting driving and that men are held back more by health issues and women by safety concerns.

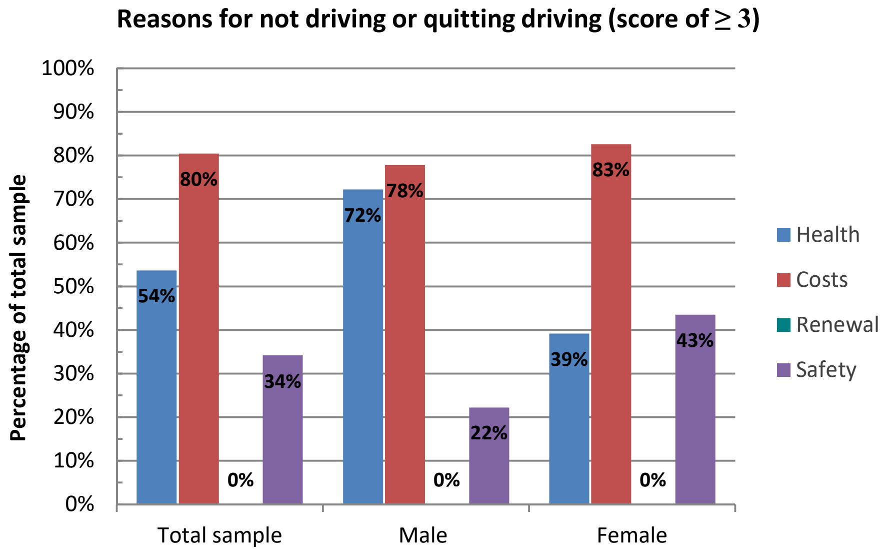


Figure 13: Reasons for not-driving or quit driving

General opinion towards AV's (owned and shared)

Figure 15 (owned) and Figure 14 (shared) show the general opinion of the sample group towards AV and SAV and what their expectations are towards the individual indicators (Performance, effort and Social). If the bar is skewed towards the right it shows that there is a more positive sentiment towards that indicator if it is more skewed towards the left there is a more negative resentment. Table 6 shows an overview of the mean, standard deviation, skewness and kurtosis of each indicator.

Table 6: Key data of individual indicators

Indicator	code	Mean	SD	Skewness	Kurtosis
AV Owned					
Intend to use	BI1	3.42	1.086	-0.282	-0.938
Predict to use	BI2	3.32	1.058	-0.242	-0.840
Plan to use	BI3	2.57	1.056	0.215	-0.613
Safety	PE1	3.90	0.962	-0.693	-0.112
Travel time	PE2	3.82	0.859	-0.661	0.781
Cost	PE3	4.02	0.962	-0.714	-0.180
Environment	PE4	3.12	0.920	-0.624	0.158
Comfort	PE5	3.62	1.004	-0.253	-0.984
Operation difficulty	EE1	3.05	1.093	0.017	-0.833
Legal restrictions	EE2	2.89	0.948	-0.252	-0.808
Learning difficulty	EE3	2.85	0.920	0.103	-0.600
Social pressure	SI1	3.12	0.764	-0.208	-0.036
Peer influence	SI2	2.87	0.868	-0.200	-0.461
Pressure from authorities	SI3	3.54	0.749	-0.212	0.415
AV shared					
Intend to use	BI1	2.80	0.983	-0.105	-0.755
Predict to use	BI2	2.73	1.009	-0.118	-0.756
Plan to use	BI3	2.04	0.927	0.354	-0.947
Safety	PE1	3.79	0.643	-1.632	5.243
Travel time	PE2	2.47	1.081	-0.005	-1.268
Cost	PE3	2.09	0.724	0.254	-0.144
Environment	PE4	4.37	0.604	-0.370	-0.651
Comfort	PE5	3.07	0.879	-0.360	-0.762
Operation difficulty	EE1	3.15	0.775	0.060	-0.682
Legal restrictions	EE2	4.07	0.561	0.025	0.203
Learning difficulty	EE3	2.93	0.686	-0.070	-0.445
Social pressure	SI1	2.95	1.047	-0.333	-0.817
Peer influence	SI2	2.62	1.177	0.230	-0.985
Pressure from authorities	SI3	4.12	0.845	-1.378	3.173

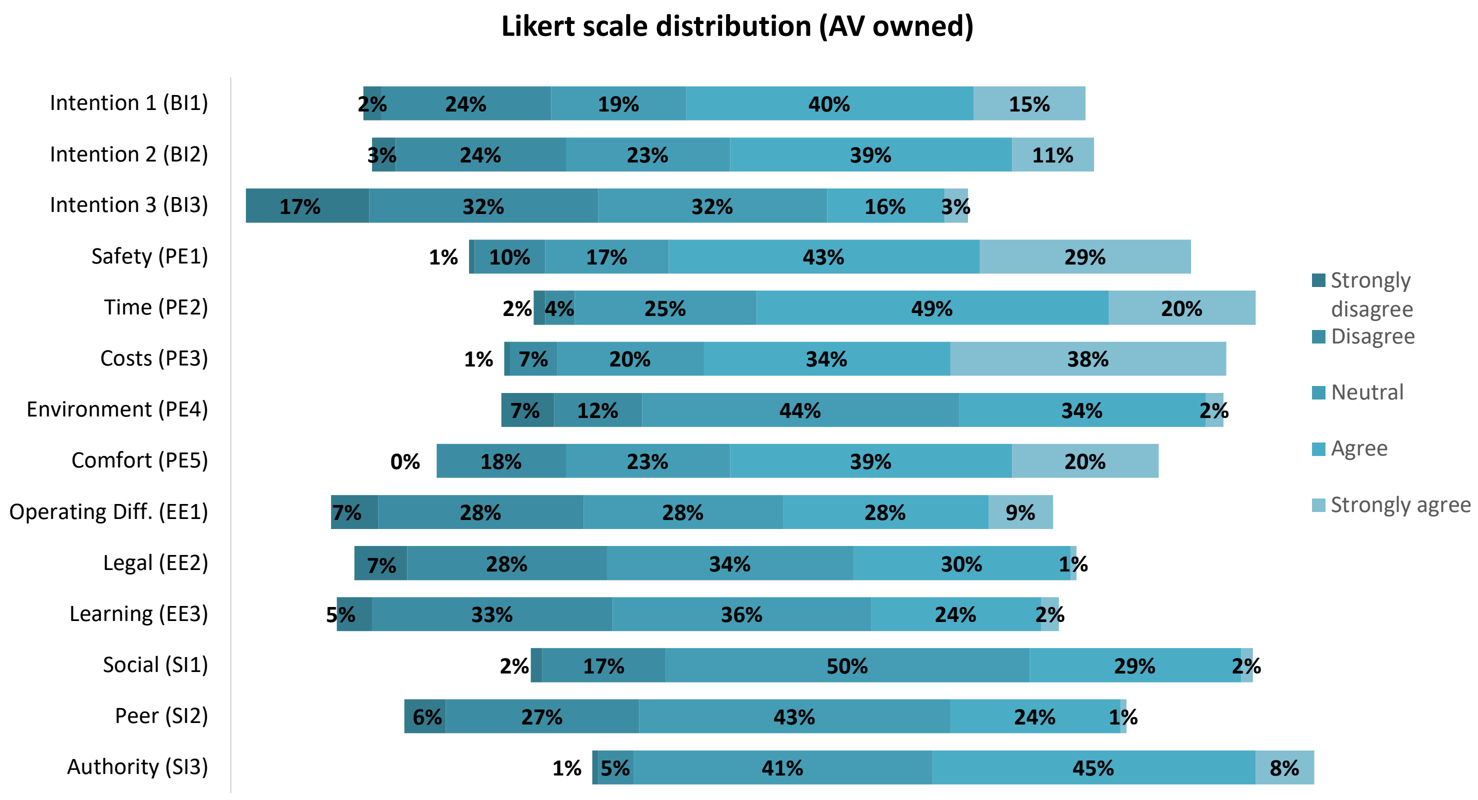


Figure 15: Likert scale distribution whole sample (AV owned)

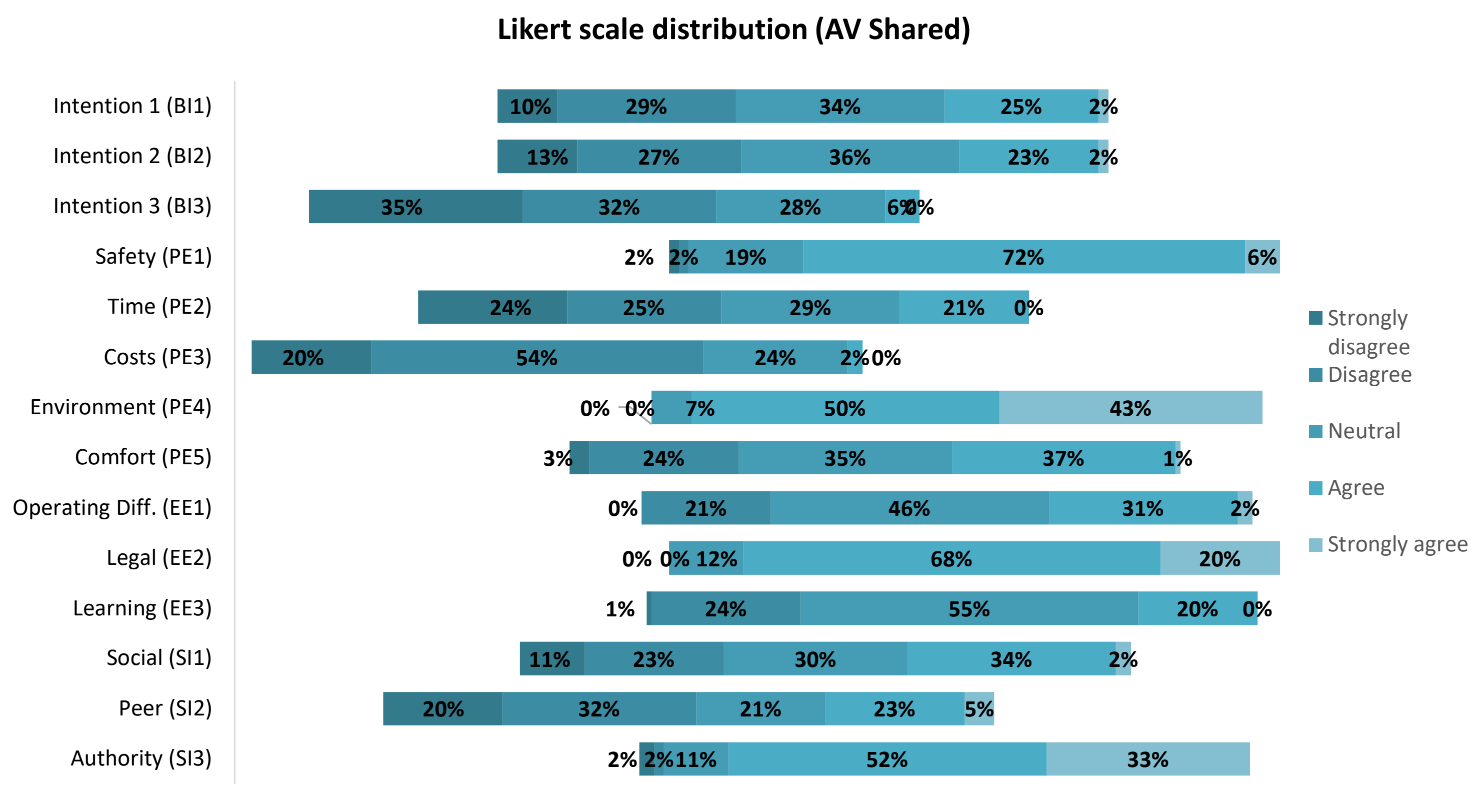


Figure 14: Likert scale distribution whole sample (AV shared)

For both the owned as the shared AV it stands out that BI3 (intention 3) scores considerably lower than BI2 and BI3. This is most likely explained by the translation/formulation of the question in the survey. The question for the indicator BI3 asked if the respondent is actively making plans for using AV in the future which is likely not something the majority of the respondents is doing currently. This causes a lower rating towards this usage intention questions which is something that should be taken into consideration during the SEM analysis.

5.1.2. Groups of respondents

During the literature study and research design the following moderators were identified as having a potential impact on the usage intention of (Shared) AV:

- Age
- Gender
- Experience
- Income
- Health

Respondents will be categorized in different groups based on these moderators, therefore for each moderator certain values/characteristics should be set which will show what impact each of the moderators has on the usage intention and predictors used in the theoretical model. While age, gender and income can be categorized based on general demographics the experience and health groups are defined from data found within the sample.

Age:
During the survey the age of the respondents was gathered in terms of full years. While it is possible to use age as a continuous variable and analyse each individual age (in years) as a different group in Amos this is not practical and will not show a significant difference between each age group. In order to capture the affect that age might have on the predictors the respondents are divided in age categories.

Due to the limited number of participants the age groups will consist of two types, respondents are categorized in the age groups 55-65 (pre-pension) and 66 or higher (Pensioners)[2] The two age groups that will show the biggest difference in their answers to the survey are pre-pensioners and pensioners due their different need for mobility (Adler & Rottunda, 2006) and a difference in expectations of a travel mode (Renaud & Biljon, 2008). Among the respondents 55 people had an age of 55 to 65 (45%) and 68 people where aged 66 or higher (55%).

Gender:
The second moderator in the theoretical model is gender. During the analysis a distinction is made between male and female respondents. There is a general consensus that there is a significant difference in how men and women value different aspects of travelling(Gordon et al., 1989). As stated before the sample contains 76 Males (62%) and 47 Females (38%)

[2] During the period the survey was conducted the retirement age was 65.5 years which might cause a small error in the data

Experience:
The moderator 'experience' in the theoretical model was defined as the experience with driving a conventional vehicle as well as the familiarity with current driver support technologies. During the survey respondents were asked how familiar they are with 7 currently available driver support technologies and how much KM they drive per year (if they drive at all). With this data respondents are divided into experience groups based on their knowledge of current (in-car) AV technologies and the amount of km they drive (if they drive at all).

The in-car technologies that were questioned consist of navigation, cruise control, adoptive cruise control, park assist, blind-spot assist, collision warning and lane departure warning (no description of the technologies was given during the survey). For each technology respondents could answer one of 4 possible answers: 'never heard of this', 'heard of this but never used', 'used occasionally' or 'used frequently'.

Based on the response of the whole sample (see Table 4) each possible answer was ranked based on how often that answer was given. Each response was then given a ranking of 1 to 4 with 1 being the most common answer and 4 being the least common answer. An overview of the ranking for each technology can be found in Table 7.

Table 7: Ranking of answers to technology experience questions

	Never heard of this	*Heard of this but never used*	*Used occasionally*	*Used frequently*
In-car navigation system	4	3	2	1
Cruise control	4	1	2	3
Adaptive cruise control	1	2	3	3
Park assist/ automated parking	2	1	3	4
Blind-spot assistance	2	1	3	4
Collision warning/prevention system	1	3	4	2
Lane departure	1	2	3	4

In order to distribute the respondents in the technology experience groups each respondents is given a technology score based on their own answers and the ranking of their answer. The technology scores are based on the base score of the 4 possible answers multiplied by the ranking of that particular answer, the base scores are:

- Never heard of this = -2
- Heard of this but never used = -1
- Used occasionally = +1
- Used frequently = +2

Example: If a person answers 'never heard of this' on the question about in-car navigation he/she gets added 4 * -2 = -8 to their technology score.

The graph in Figure 16 shows an overview of the total technology scores of the whole sample.

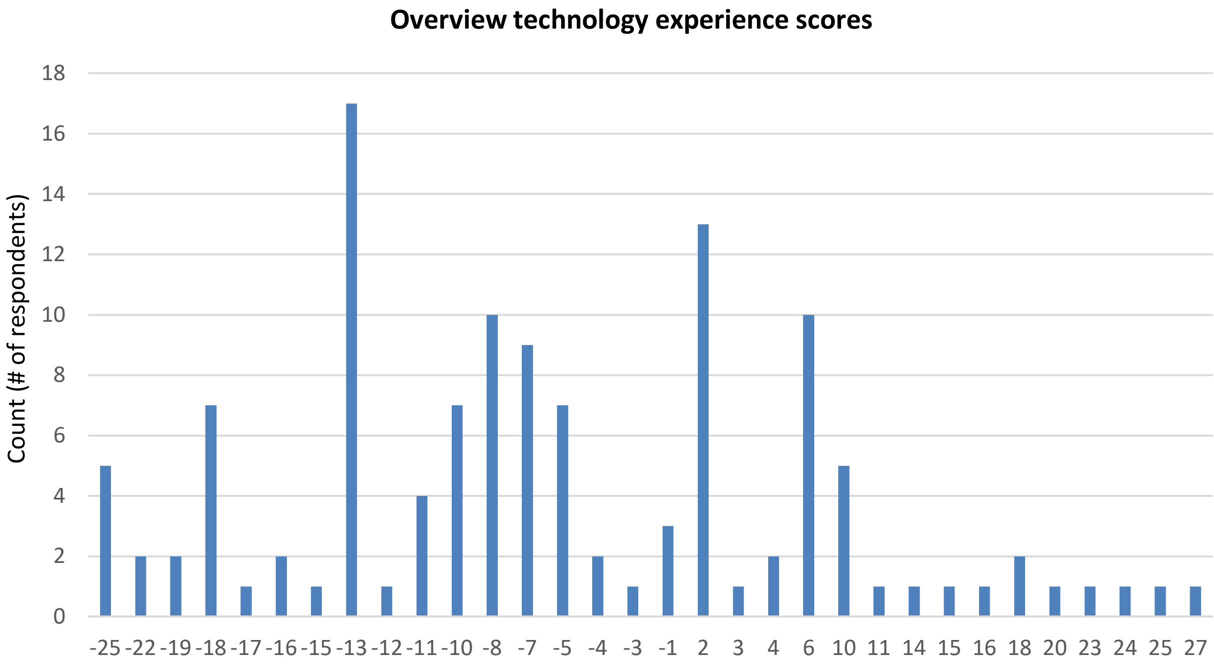


Figure 16: Overview of technology scores

With this data, it is possible to make multiple groups based on how experienced they are with AV technologies however the limited sample size means that there should be enough respondents in each group.

The median technology score is -7 therefore it is assumed that people who scored -7 or higher have at least somewhat experience with AV technologies and people with a score of -8 or lower are less experienced with AV technologies. There are 59 respondents with a technology score of -8 or lower and 64 respondents with a score of -7 or higher. Although the technology scores used in this analysis use an arbitrary scale it can be concluded that the majority of the sample

In addition to the experience with technology the respondents driving experience was also questioned. The amount of km driven by the people in the sample can be found in Figure 17. This graph shows that many of the people who currently still drive have chosen the same 4 options (2500-20,000 km). This means that a clear distinction between only 2 groups can be made, Drivers and Non-drivers while still having a large enough size for each group.

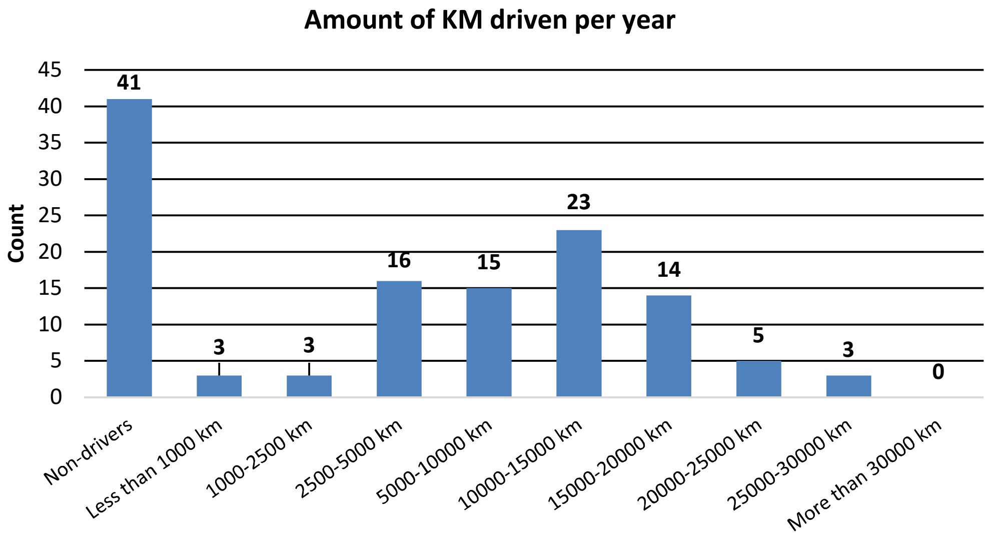


Figure 17: Count of amount of KMs driven annually

Combining the technology score with the driving experience it is possible to make 4 groups for the experience moderator: Non-drivers low experience in AV technologies, Non-drivers high AV technology experience, Drivers with low technology experience and Drivers with high AV technology experience. However, the data shows that there is only one respondent who falls under the second category 'Non-drivers with high AV technology experience' which means it is impossible to analyse this 'group'. Therefore only 3 categories will be used during the analysis under the experience moderator:

1. Non-Drivers (n=41)
2. Drivers with low AV technology experience (n= 19)
3. Drivers with high AV technology experience (n=63)

Household Income:
For the income moderator the groups are composed based on the income questions from the survey (An overview of the answers can be seen in Figure 10). The average income of the whole sample as well as the average income of households in the Netherlands will be used to determine the group definitions.

During the survey 23 people filled in 'I rather not share this information' which means their income is unknown. Of the 100 respondents who shared their income the mean as well as the median answer was "between €2000 and €2500".

According to the Dutch statistics bureau the average household income for people between the age of 45 and 65 is €3,400 per month and for people aged 65+ it is €2,400 per month (CBS, 2015). But these numbers are heavily dependent on the composition of the household such as number of people, age and the number of children.

The survey results are not detailed enough to give an in-depth analysis of how these averages would compare to the average in the sample. Because most of the answers are in 2 categories (Between €2000 and €3000) and there need to be enough respondents in each group two income groups will be formulated. If the average spendable income is set at €2500 per month and people are divided in 'above average' and 'below average' two groups which are roughly equal in size will be formed. An average spendable income of €2,500 per month is slightly lower than the average for Netherlands which should be considered when comparing the results with the rest of the population.

The two income groups are:

1. Below average (<€2500/month) (n=54)
2. Above average (>€2500/month) (n=46)

Health:
The health groups are based on the persons' health conditions and how much they affect their ability to travel and/or operate a vehicle. Table 5 showed the answers to these health questions and the severity of the health conditions.

People who suffered from a health condition where asked to score their condition 1 (no impact) to 5 (most severe) based on how much it influenced their ability to travel and to operate a car/vehicle. It is assumed that a score of 1 or 2 means that the condition doesn't have a noticeable impact on the respondents' mobility. In Table 8 the number of people who answered at least one of the questions with 3 and the number of people who answered at least one question with 4 or 5 are shown.

Table 8: Health groups

Group	#	% of sample
No serious health problems	82	66,67%
at least one 3	13	10,57%
at least one >3	28	22,76%

Table 8 Shows that the majority of the sample does not suffer from any serious health problems that would result in a big change in the behavioural intention of AV. The group who scored any health condition with a maximum score of 3 is likely to small to accurately examine during the analysis. Therefore a distinction between two health groups will be made, one group with no serious health problems and one group with at least one health issue (score of 3 or higher).

Health groups:

1. No serious health problems (n= 82)
2. At least one health issue (>3) (n=41)

Overview of groups

Table 9 shows an overview of the groups that were used in the data analysis with the number of respondents in each group and the percentage of the total sample that each group represents. In total there are 11 groups divided under 5 categories which will be considered during the rest of the analysis.

Table 9: Number of respondents in each moderator group

Moderator	Groups	n	% of total sample
Age	55-65	55	44,7%
	66+	68	55,3%
Gender	Male	76	61,8%
	Female	47	38,2%
Experience	Non-drivers	41	33,3%
	Drivers low experience	19	15,5%
	Drivers high experience	63	51,2%
Income	Below average	54	43,9%
	Above average	46	37,4%
	Unknown	23	18,7%
Health	No health issues	82	66,7%
	At least one health issue	41	33,3%

5.1.3. Comparison of groups

The usage intention (average of indicators BI1, BI2 and BI3) for each individual group can be found in Figure 18 for the owned AV system and Figure 19 for the shared AV system. The behavioural intention of the owned AV system is notably higher than for the shared AV across the sample. But among the individual groups different preferences for either system can be observed.

The younger age group (55-65), males, drivers with technology experience, people with a higher income and people who do not have health issues clearly have a preference for the owned AV system. Females, non-drivers, people with a lower income and people who suffer from at least one health issue prefer the shared AV system. The 66+ age group and the drivers with little technology experience have no clear preference.

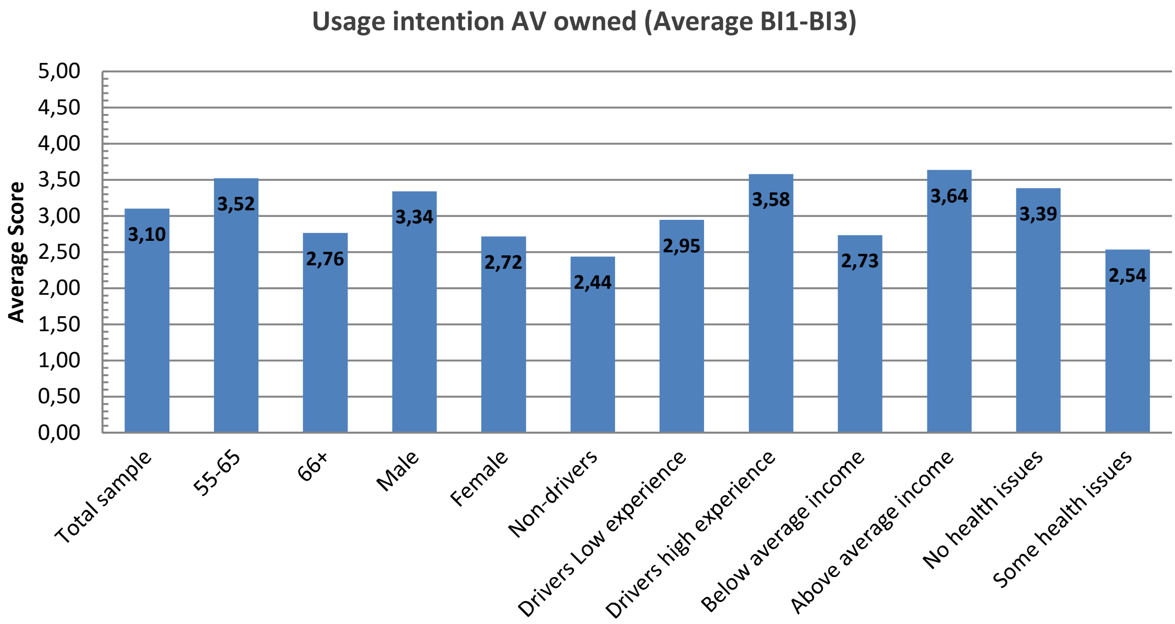


Figure 18: Usage intention per moderator group for AV owned

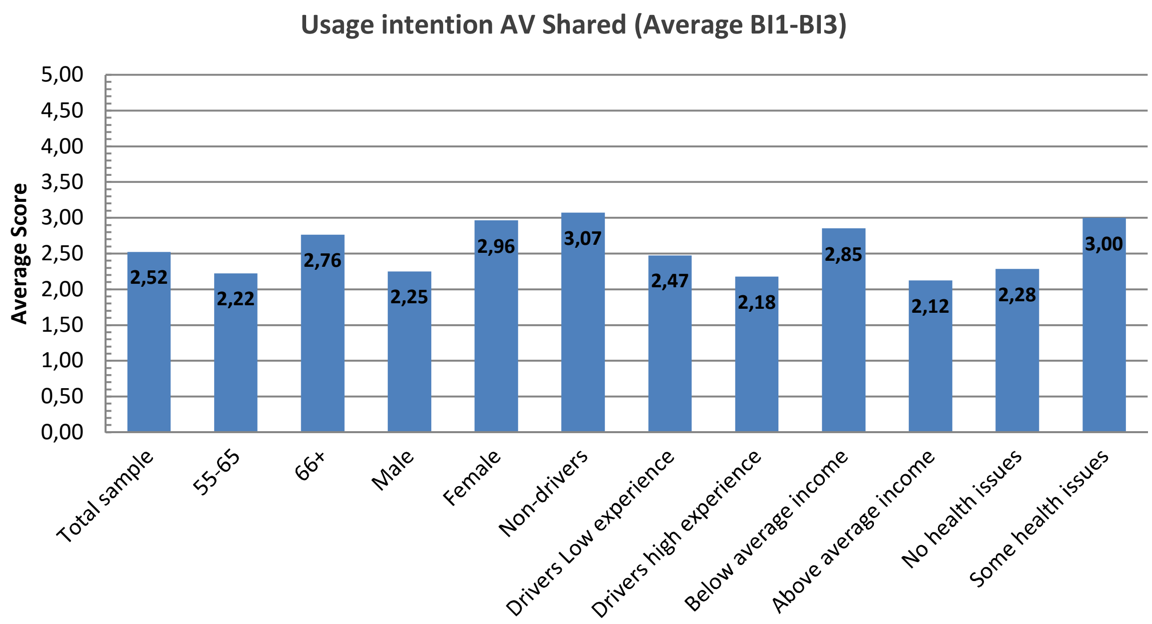
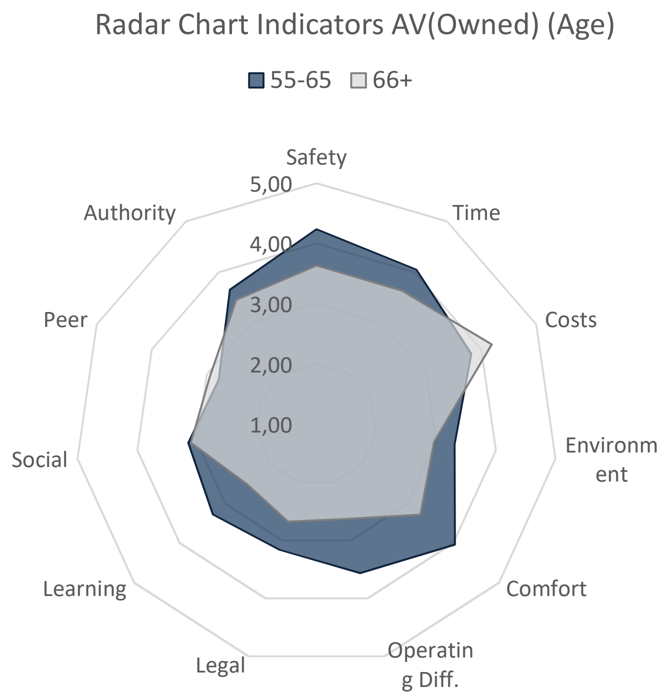


Figure 19: Usage intention per moderator group for AV shared

Average indicator scores per group:

In the radar charts below the responses of each group towards the eleven indicator questions (safety, time, legal etc.) are shown grouped per moderator (Age, gender, experience, income and health).



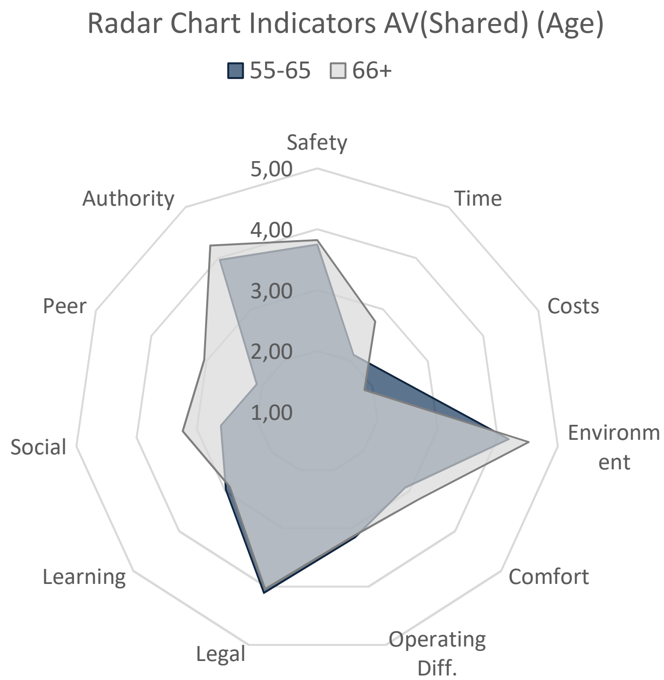


Figure 20: Radar charts Income groups (AV owned and AV shared)

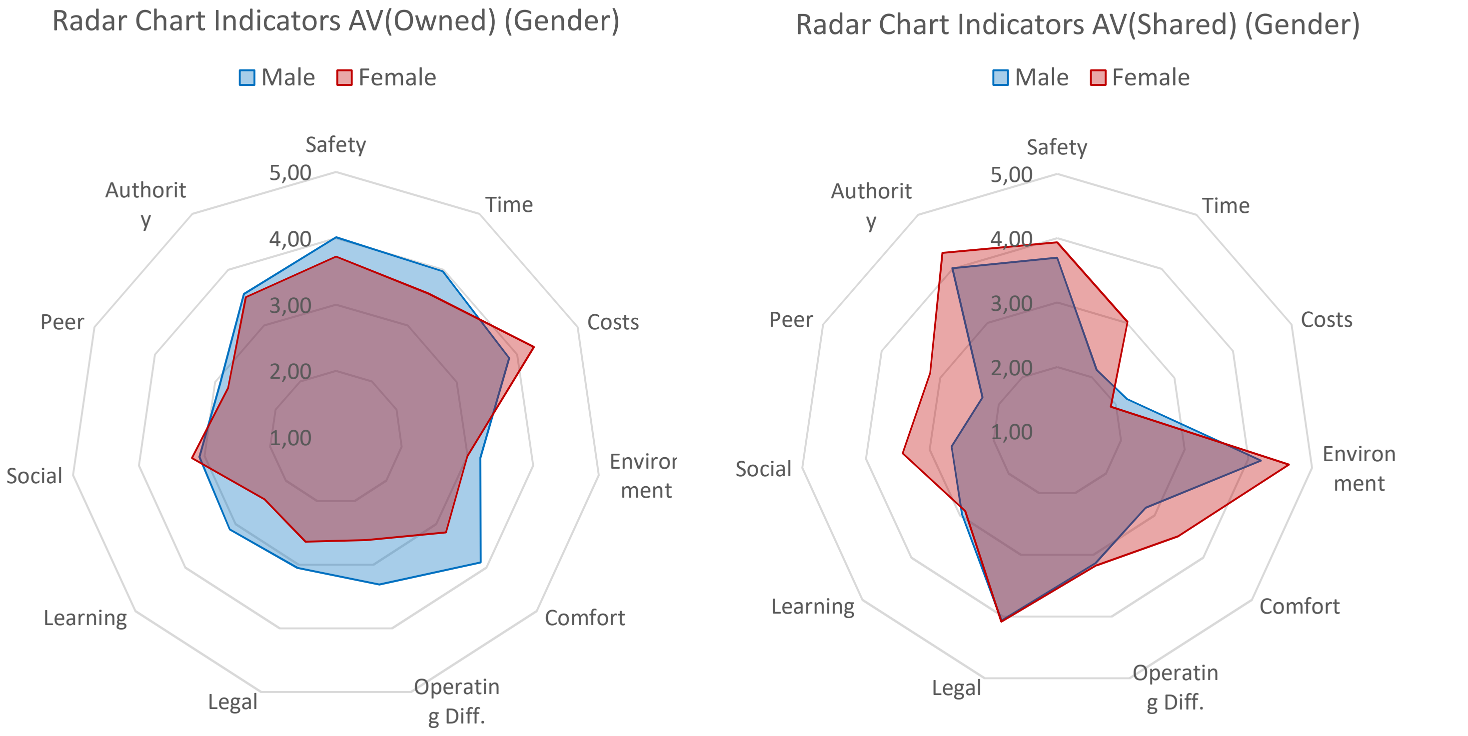


Figure 21: Radar charts Gender groups (AV owned and AV shared)

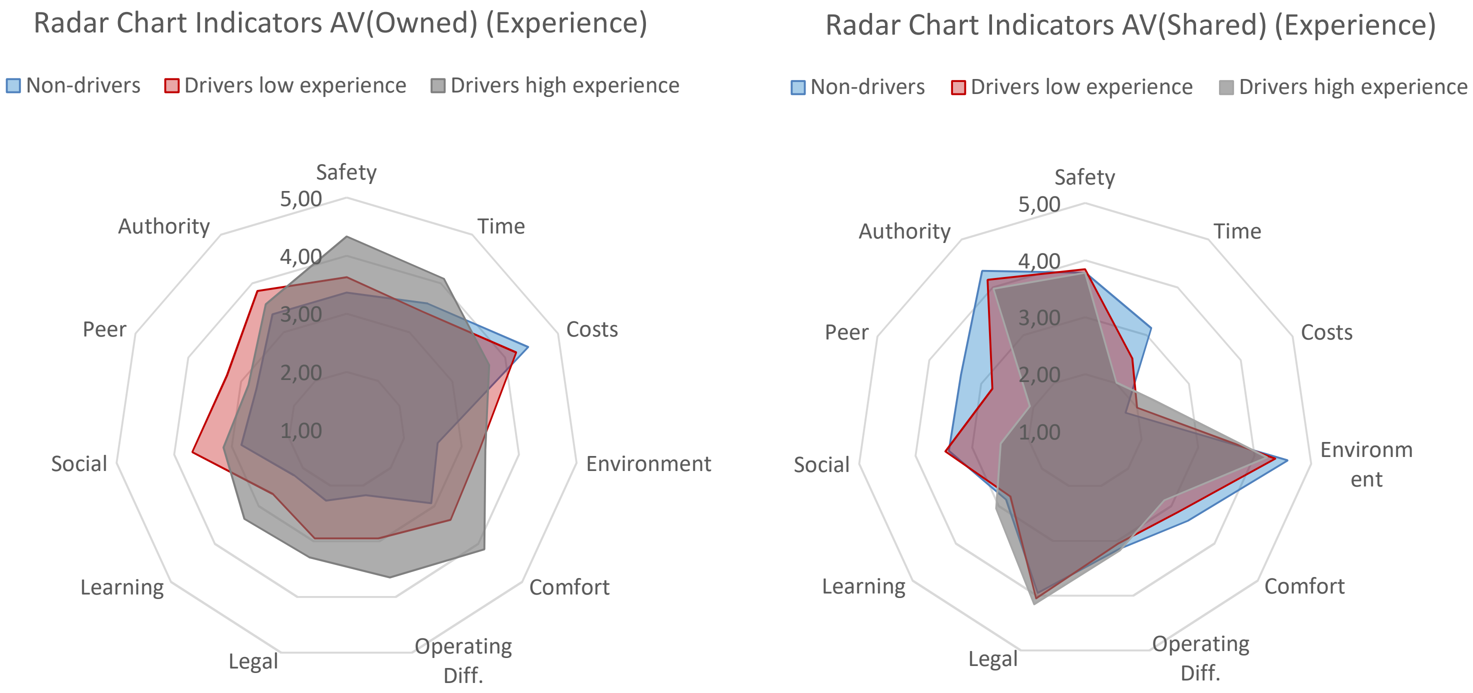


Figure 22: Radar charts Experience groups (AV owned and AV shared)

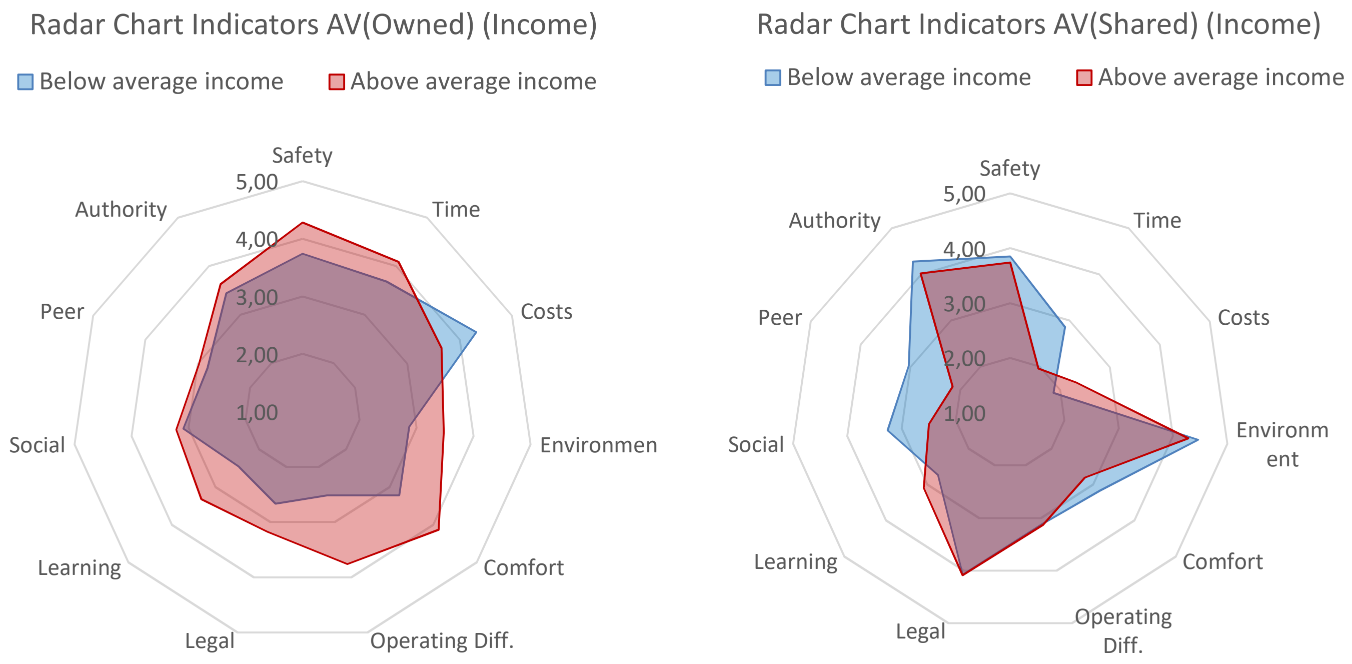


Figure 23: Radar charts Income groups (AV owned and AV shared)

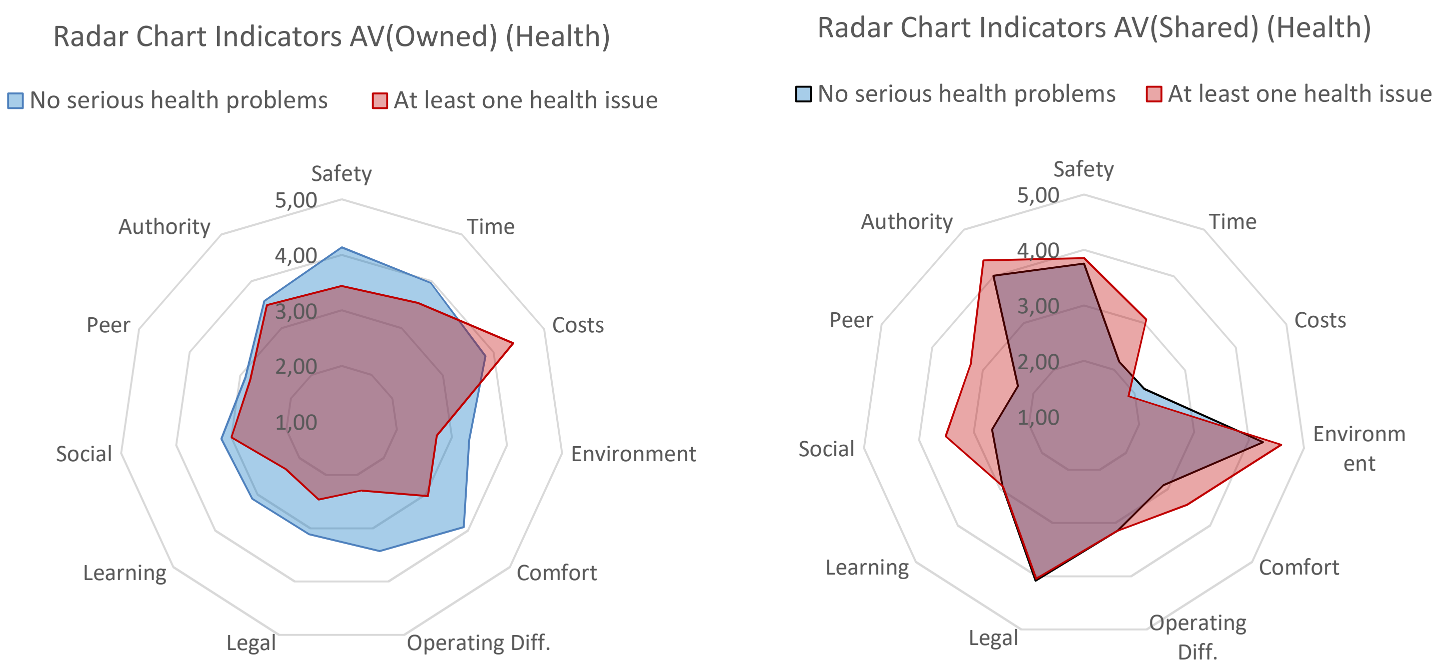


Figure 24: Radar charts Health groups (AV owned and AV shared)

5.2. Structural equation modelling

During the SEM analysis the theoretical model formulated in chapter 3 will be tested with the data gathered during the survey. Firstly the discrepancy function and model fit criteria will be determined with the help of the relevant literature. These are important when comparing the results from the AV and the SAV system as well as the results from other research.

After the model fit criteria have been determined Exploratory Factor Analysis (EFA) is used to test if the theoretical model from chapter 3 is correct or if it has to be adjusted based on the data gathered during the survey. After this the (new) model will be tested with the help of Confirmative Factor Analysis (CFA) with the program SPSS AMOS (version 22). This will show how the proposed model fits the data i.e. how well the model explains the behavioural intention of the respondents and if there have to be any adjustments made to the model to reach a good model fit.

Next, the stated importance of respondents that was also gathered during the survey will be implemented in the measurement model to see if it improves the model fit or result in a more complete model. Finally, a multi-group analysis is used to see if the effects of the suggested moderator groups are significant which proves if the individual groups are invariant or not. This will also show which constructs have the most influence on the behavioural intention of each group. All of the analyses will done with both the data from the AV system as well as the data from the SAV system.

A more in-depth discussion of the results found in analysis will be presented in the last chapter.

5.2.1. Model specifications

Discrepancy function
Before starting with the calculations in AMOS the discrepancy function that will be used is chosen. This function determines how the discrepancy between the structural model and the actual data is calculated. The most commonly used function is the Maximum likelihood (ML) which assumes that the data has a multivariate normal distribution (normal distribution in multiple dimensions) but has been proven to also provide good parameter estimations when using non-normal distributed data (Finney & DiStefano, 2006). This method has been successfully used before on variable data with an ordinal scale (Likert scale) and on data sets with a small sample size (Golob, 2003).

An alternative but similar function is the Generalized Least Squares (GLS) function. This function is simpler compared to ML which should improve the calculation speed but also assumes multivariate normal distributed data. This function has been proven to perform less well with small sample sizes (Golob, 2003).

For data that is not multivariate normal distributed the Unweighted Least Squares (ULS) method can be used. The downside is that with this method the standard errors and chi-square statistic cannot be calculated with this function (see model fit criteria).

The skewness and kurtosis values from the data collected during the survey (Table 6) indicate a normal distribution for each indicator except PE1 and SI3 (shared AV). Combining this with the fact that the sample size is relatively small (N=123) the discrepancy function best suited for this analysis is the Maximum likelihood (ML) function.

Model fit criteria

The model fit criteria are used to test out different models and compare them with each other and see which provides the best model fit. In the relevant literature there can be found many different criteria that can indicate the global fit of the model. The most commonly accepted criteria are discussed below and will be used throughout the analysis. These model fit criteria do not necessary say if a model is a 'good model' or not but can give a decent indication and will be mainly used to compare models during this analysis.

The most common model fit criteria is the Chi-square significance test which states that if the Chi-square value is significant the model should be rejected. During the SEM analysis a minimum probability value (P-value) of above 0.05 is required for a good model fit. It is possible that the Chi square test rejects a (good) model when used on data sets with a large sample size (>200) but with a sample size of 123 this should not occur.

The Chi-square value is also used in the relative or normed chi-squared test which is the chi-square statistic (called CMIN in AMOS) divided by the degrees of freedom (DF). This statistic is considered to be acceptable if it lies between 1.0 and 5.0 although a value of below 3.0 or even 2.0 is currently being considered a good fit (Bentler, 1990; Ullman & Bentler, 2003). Due to the limited sample size it is possible that the normed chi-square statistic will be rejected with the use of ML as a discrepancy function (Golob, 2003), in those cases the other model fit criteria will be leading.

Comparative fit index (CFI) provide a method to compare the proposed model with the null model (chi-square of 0). A value closer to 1 indicates a better fit a value above .90 is considered to be acceptable and a value above 0.95 to be a good fit (Bentler, 1990).

The Goodness of fit index (GFI) is an alternative to the chi-square test and shows how closely the model comes to replicating the covariance matrix (Bentler & Bonett, 1980). A value close to 1.0 indicates a good fit with 0.90 being a minimum value. This index increases when the sample size is larger.

Root mean square error of approximation (RMSEA) is a commonly used criteria which is also based on the chi-square value. Currently a value below 0.08 is considered a reasonable fit while a value below 0.05 is preferred (Bentler, 1990).

The normed fit index (NFI) varies between 0 and 1 indicating how much the proposed model improves the fit of the null model. A value above 0.90 is considered to indicate a good fit (Bentler, 1990). This fit can be overestimated if the number of parameters is increased which is corrected with the Tucker-Lewis index/Non-Normed fit index (TLI/NNFI). This index also requires a value above 0.90 or even above 0.95 (Hu & Bentler, 1999).

An overview of the proposed model fit criteria can be found in Table 10.

Table 10: Proposed model fit criteria

Fit criteria	Threshold value	Note
Chi-square test	P-value > 0.05	
CMIN/DF	≥1.0 - ≤5.0	<3.0 or <2.0 preferred
GFI	>0.90	
CFI	>0.90	>0.95 preferred
RMSEA	<0.08 (reasonable fit)	<0.05 preferred
NFI	>0.90	
TLI/NNFI	>0.90	>0.95 preferred

CR and AVE scores

The measurement model (PE, EE, SI and BI) can be validated by using the Construct composite reliability (CR) scores and the Average Variance Extracted (AVE) scores for each individual latent construct. The CR and AVE scores are used to explain the convergent validity i.e. how much the measured indicators of each construct are actually related to each other. The AVE score should be higher than 0.50 (Fornell & Larcker, 1981) and the CR score should be above 0.70 (Hair, 2010). The CR score is calculated by squaring the sum of all factor loadings and dividing it by this value plus the sum of all error variances. The AVE score is calculated by the sum of each squared factor loadings divided by the number of indicators the construct contains.

Model specification in AMOS

The model is built in AMOS from the theoretical model found in Figure 6. The model contains 14 measured indicators (PE1…BI3), 3 unobserved exogenous variables (PE, EE, SI), 1 unobserved endogenous variable (BI), 15 error variables and 3 covariances (PE-EE, PE-SI, EE-SI). The final model specifications in AMOS can be found in Figure 25.

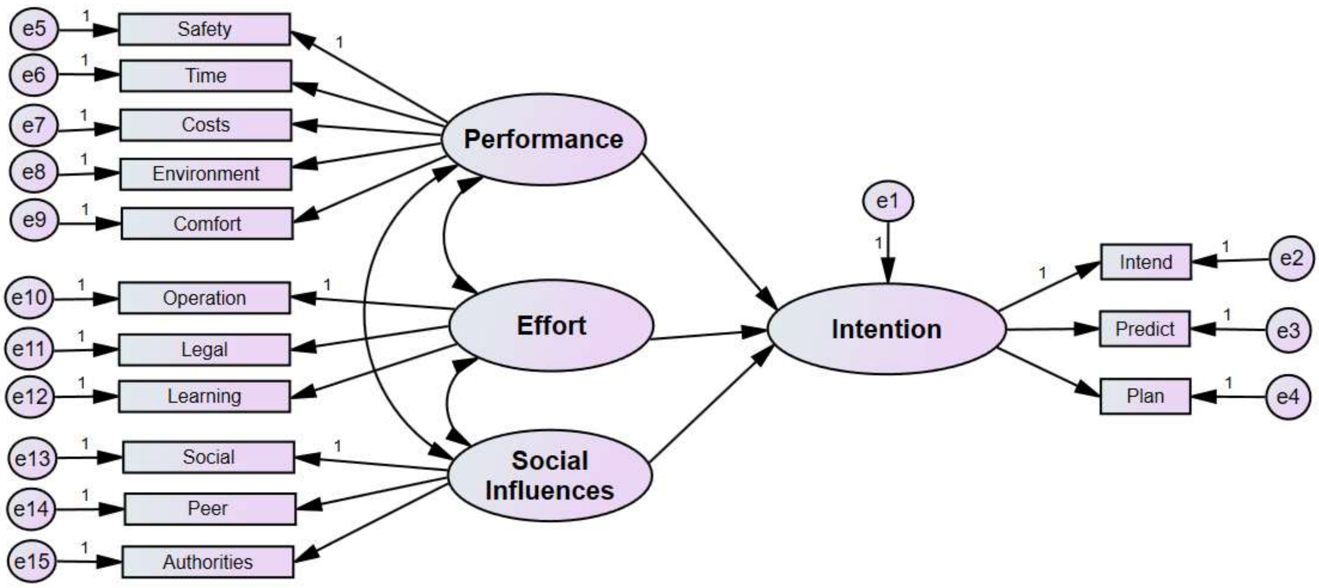


Figure 25: Model specification in AMOS

5.2.2. Factor analysis AV-owned

Running the complete model as shown in Figure 25 revealed that the correlation between the Performance and Effort constructs is very high (0.97). While a correlation higher than 0.60 or 0.70 is already worrisome a correlation of above 0.90 indicates multicollinearity (Hair, 2010). In addition there are also standardized estimates above 1.00 which indicates multicollinearity as well.

Multicollinearity occurs when the indicators used in the model are highly correlated which means that one indicator can be linearly predicted from the others (Hair, 2010). In the case of the AV owned model it is likely that the indicators which were placed under the Effort expectancy construct are highly correlated with the indicators from the Performance Expectancy construct.

The presence of multicollinearity means that any results obtained from this model cannot be accepted. To solve this issue an Exploratory Factor Analysis (EFA) is carried out in SPSS to see how the new model should look. EFA is used to explore the relationships between the indicators and formulate which new constructs should be used in the updated structural model. During this EFA Maximum Likelihood (ML) is used as a fitting procedure and direct oblimin is used as a rotation method (which allows correlation between indicators).

Table 11 shows the results of the EFA in a pattern matrix which contains the regression coefficients of each indicators on each of the proposed factors.

Table 11: Pattern matrix for AV owned (ML, Oblimin rotation)

	Factor	
Indicator	1	2
Safety (PE1)	0.621	
Time (PE2)	0.596	
Costs (PE3)	-0.696	
Environment (PE4)	0.604	
Comfort (PE5)	0.804	
Operation (EE1)	0.895	
Legal (EE2)	0.497	
Learning (EE3)	0.794	
Social (SI1)		0.638
Peer (SI2)		0.764
Authorities (SI3)		0.667

**** Values below 0.30 are omitted***

The results of the EFA show that two new factors/constructs are formed with the first construct containing the indicators originally placed under performance expectancy as well as the indicators placed under effort expectancy. The second construct is identical to the theoretical model containing the indicators originally placed under Social Influences. Which means that unlike in the original UTAUT model by (Venkatesh et al., 2003) there are no separate constructs for Effort and Performance. The PE and EE indicators are placed under the same construct because of the high correlation between these indicators which means that these indicators explain the same underlying factor.

There are multiple possible reasons why the Performance expectancy and effort expectancy for the owned AV system are highly related. Firstly the indicators used in this research notably differ from the indicators used in the original UTAUT model and although the literature suggests that indicators such as time and costs are judged independently from indicators such as operation difficulty this might not be the case when testing this theory in practice. Another reason is that the original UTAUTA model is often used to test the adoption of ICT systems while in this case it is used to examine the behavioural intention of an automated vehicle. Lastly, by using a sample group that exclusively consists of elderly the interpretation of the questions and understanding of the AV system might cause a deviation from the theoretical definitions found in the literature in contrast to when a more varied sample group is used.

The original proposed model was adjusted to contain only two latent exogenous constructs, Performance/Effort (P/E) and Social Influences (SI), and then run with the original data gathered during the survey. The full model containing all proposed indicators resulted in a model with a Chi-square statistic below 0.05 and a GFI below 0.90.

After removing the indicators Legal (EE2) and Plan (BI3) the best model fit was reached. The results for this updated model can be found in Figure 26 as well as Table 12, Table 13, and Table 14.

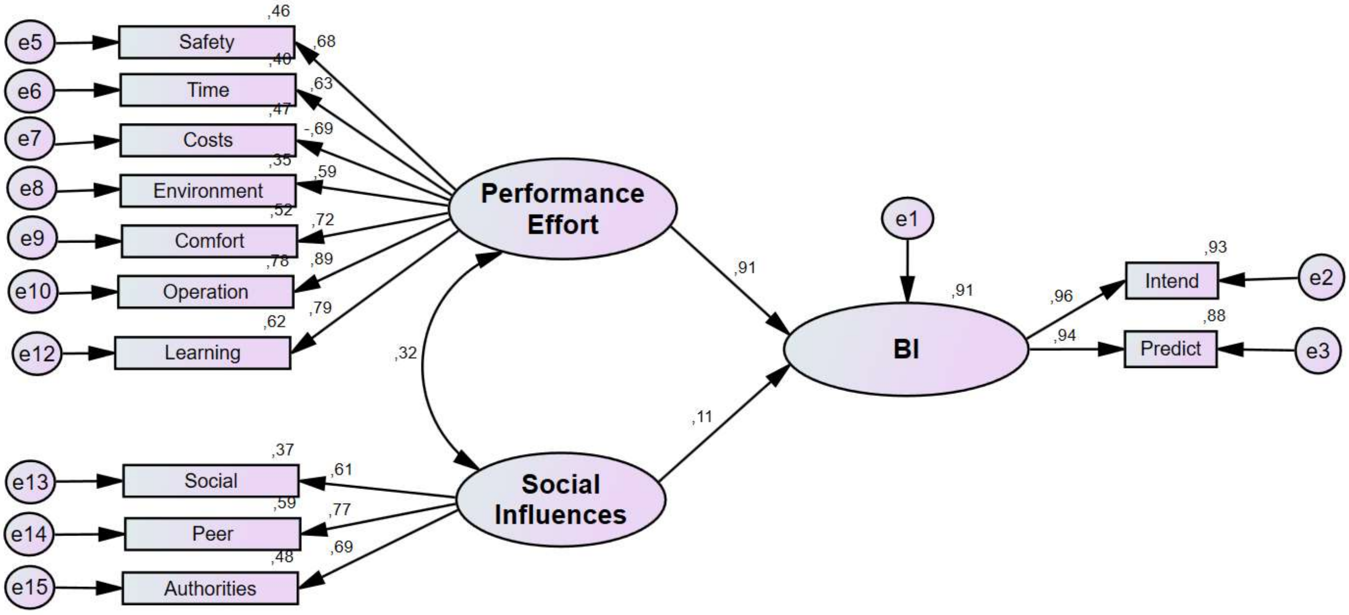


Figure 26: Output updated model, standardized estimates (AV owned)

Table 12: Model fit values (AV owned, Updated model)

Fit criteria	Threshold value	Actual value
Chi-square test	>0.05	0.230
CMIN/DF	≥1.0 - ≤5.0 (<2.0)	1.140
GFI	>0.90	0.927
CFI	>0.90 / >0.95	0.992
RMSEA	<0.08 / <0.05	0.034
NFI	>0.90	0.937
TLI/NNFI	>0.90 / >0.95	0.989

Table 13: Construct reliability scores (AV owned, Updated model)

Construct	# of indicators	Average factor loadings	AVE	CR
Performance/Effort (P/E)	7	0.710	0.516	0.880
Social influence (SI)	3	0.690	0.478	0.732
Behavioural intention (BI)	2	0.950	0.902	0.948

Table 14: Construct regression weights (AV owned, Updated model)

Relation	Estimate	Standardized estimate	Standard error (S.E.)	P-value
P/E ---> BI	1.460	0.914	0.163	***
EE ---> BI	-	-	-	-
SI ---> BI	0.252	0.112	0.127	0.047

The updated model shows very good model fit values (Table 12) and significant construct regression weights (Table 14). While the AVE score for the SI construct is slightly below 0.50 the rest of the AVE and CR scores are above the thresholds (Table 13).

Taking in consideration all this data it can be concluded that the proposed theoretical model from chapter 3 had to be adjusted by using EFA before a good model fit could be reached. The new model together with the data that was gathered during the survey resulted in an acceptable model fit. The model fit was improved by experimenting with different combinations of removing indicators the best model fit was found by removing the indicators legal (EE2) and Plan (BI3). The reason why removing BI3 from the model results in a better model fit can be found in Figure 15. The answers to this usage intention questions deviate notably from BI1 and BI2 which is likely caused by the formulation/translation of the question.

Total effect of constructs:

Table 15 shows the correlation effects between the 3 remaining constructs PE, SI and BI.

Table 15: Correlation effects improved model (AV owned)

	P/E	SI	BI
Performance/Effort (P/E)	1		
Social influence (SI)	0.32**	1	
Behavioural intention (BI)	0.91**	0.11**	1

***** P-value = below 0.05; * P-value = below 0.10***

Using this data the total effect of the Performance/Effort on the Behavioral Intention becomes:

P/E -->BI + (P/E-->SI * SI-->BI) = 0.91 + 0.32 * 0.11 = <u>0.945</u>

And the total effect of the Social Influences on the Behavioral Intention becomes:

SI-->BI + (SI-->PE * PE-->BI) = 0.11 + 0.32 * 0.91 = <u>0.401</u>

5.2.3. Effects of stated importance on AV owned model

During the survey respondents were asked to rate several aspects on how much they influenced them when choosing which transportation mode to use. These ratings (1 to 5) are used as a measure of their perceived importance towards each indicator (PE1…SI3). The objective of this chapter is to see if implementing this form of “attitude” in the model will result in an improved measurement model that increases the explanatory power of the UTAUT model.

The suggestion by (Adell, 2009) to weigh each of the constructs by their perceived importance was not further elaborated on so a practical method to implement this has to be formulated. In this report the importance is incorporated in the measurement model by combining the scores of the individual indicator with the score of their corresponding importance question. For example: the indicator travel time (PE2) “*Using this system would reduce my travel time”* is combined with the stated importance towards travel time (APE2) “*For me the travel time is an important factor in choosing a transportation mode*”. For this method both scores are weighed equally i.e. the average of the two scores is used.

The implementation of stated importance in the model will be tested with both the data from the AV-owned system as well as the AV-shared system. The results will be compared to see if this method might be better suited based on the type of system. The model fit indices together with the construct regression weights and reliability values will be compared to see if and how implementing importance in the model shows an improvement.

The first results with the new dataset show a poor model fit and a high P-value for the SI construct. Looking at the individual factor loadings it becomes apparent that this is caused by 3 indicators, namely Safety (PE1), Comfort (PE5) and Learning difficulty (EE3) which show very poor factor loadings and Squared Multiple Correlation values. The overall model fit is not significantly improved if these or any other indicators are removed.

These results would indicate that including stated importance in the model results in a poorer overall model (fit). However the fact that the three mentioned indicators had a good performance when they were not combined with their importance scores could indicate that stated importance should only be applied to certain indicators. This could be explained by either the formulation of the questions in the survey or the fact that the 'perceived' importance of these indicators does not match the respondents' actual importance on the behavioural intention. Safety, comfort (in the survey described as the ability to perform other tasks while driving) and learning difficulty are indicators which people might state as important when directly asked but do not actually influence their decision in which vehicle to buy.

To test this assumption the same model was run again but this time the data did not include stated importance for indicators PE1, PE5 and EE3 while it did for all of the other indicators. The first results already showed notably improved results and after improving the model by removing the indicator PE4 (Environment) the best model fit was reached. A comparison of the models with and without stated importance included can be found in Table 16.

Table 16: Comparison of model with and without including importance (AV owned)

Fit criteria	**Without importance**	**Including importance**		
Chi-square	0.230	0.050		
CMIN/DF	1.140	1.312		
GFI	0.927	0.905		
CFI	0.992	0.980		
RMSEA	0.034	0.051		
NFI	0.937	0.923		
TLI/NNFI	0.989	0.975		
Construct	**AVE**	**AVE (importance)**	**CR**	**CR (importance)**
P/E	0.516	0.489	0.880	0.869
SI	0.478	0.605	0.732	0.821
BI	0.902	0.805	0.948	0.925
Relation	**Standardized estimate**	**Standardized estimate (importance)**	**P-value**	**P-value (importance)**
P/E ---> BI	0.914	1.021	***	***
SI --> BI	0.112	0.157	0.047	0.004

Table 16 clearly shows that by included stated importance in the measurement model the model fit values have worsened while there is no notable effect for the CR/AVE scores or the probability values of the individual constructs. Because the middling performance of the new model might be caused by new correlations within the dated dataset EFA was again used to see if a new structural model was formed. This EFA showed the same two factors/constructs being formed as before with correlations similar to those found in Table 11.

The values found in Table 16 indicate that including stated importance does not improve the (measurement) model and even produce standard estimates above 1.0 which indicate multicollinearity. In addition several indicators are not suitable for this method which might lead to researcher bias in only including indicators that are the most beneficiary to the research. Results might improve if different questions are used in the survey or if importance is incorporated in a different way into the mode. For example, the importance questions form a separate latent construct that directly influences the behavioural intention.

5.2.4. Multi-group analysis AV owned

With the help of the multi-group analysis the effects of the moderator groups that were suggested by both (Venkatesh et al., 2003) and hypothesized in the literature study are either confirmed or refuted. The following 5 moderator groups were considered during this analysis.

- Age
- Gender
- Experience
- Income
- Health

The multi-group is performed with the updated model (Figure 26) and the data without the importance included. This is done because this model and data showed the best performance and therefore are the most reliable in predicting the actual influence of the moderator groups.

Fully unconstraint vs fully constraint

The chi-square difference test will be used to see if the calculated regression weights and covariances are significantly different between groups. The Chi-square statistic between the unconstrained models is compared with the fully constrained models. In the unconstrained model the coefficients for both groups are calculated independently (regression weights, (error) variances and co-variances) while these are equal across groups in the constrained model. For all groups the model that is used is always the same (see Figure 26).

If this test does not reveal a significant difference between the unconstrained and constrained models, then it can be concluded that factor loadings and structural paths for both groups are identical and there is no moderator effect taking place for that moderator group. The results for each group can be found below.

Age:

Table 17: Results Chi-Square difference test for Age moderator (AV owned)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	103.673	102	0.435	32.051	27	**0.230**
Fully constrained	135.724	129	0.325			

The results show that the P-value of the Chi-square difference is above 0.05/0.10 (0.230) which means that the chi-square difference between the unconstrained model and the fully constrained model is not significant. As a result the regression weights in the structural model between the two moderator groups “55-65” and “65+” do not significantly differ from each other and are invariant. This refutes that there is a moderation effect of age in the case of the owned AV system. While there is no significant difference on the model level there may still be a difference between groups in the measurement model between the latent constructs and its indicators.

Gender:

Table 18: Results Chi-Square difference test for Gender moderator (AV owned)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	104.189	102	0.421	37.763	27	**0.082**
Fully constrained	141.952	129	0.206			

The results show that while the P-value of the Chi-square difference is not below 0.05 it is below 0.10 (0.082) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant at the 0.10 level. As a result the regression weights in the structural model between the two moderator groups “Male” and “Female” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of Gender.

Experience:

Table 19: Results Chi-Square difference test for Experience moderator (AV owned)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	186.592	153	0.033	96.520	54	**0.000**
Fully constrained	282.112	207	0.000			

The results show that the P-value of the Chi-square difference is below 0.05 (0.000) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant. As a result the regression weights in the structural model between the three moderator groups “Non-drivers”, “Drivers low experience” and “Drivers high experience” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of Experience.

Income:

Table 20: Results Chi-Square difference test for Income moderator (AV owned)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	121.29	102	0.093	44.513	27	**0.018**
Fully constrained	165.803	129	0.016			

The results show that the P-value of the Chi-square difference is below 0.05 (0.018) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant. As a result the regression weights in the structural model between the two moderator groups “Below average income” and “Above average income” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of Income.

Health:

Table 21: Results Chi-Square difference test for Health moderator (AV owned)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	127.033	102	0.047	41.131	27	**0.040**
Fully constrained	168.165	129	0.012			

The results show that the P-value of the Chi-square difference is below 0.05 (0.040) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant. As a result the regression weights in the structural model between the two moderator groups "No health issues" and "At least one health issue" significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of Health.

Table 22 gives an overview of the results of the multi-group analysis and contains the (standardized) estimates of the two latent constructs (P/E and SI), their probability value, and the standard errors for each individual moderator group.

Table 22: Results of multi-group analysis, relation between constructs and BI (AV owned)

Constructs	Unstandardized estimate	Standardized estimate	P-value	S.E.
Performance/Effort (P/E)				
55-65 (age)	1.735	0.938	***	0.377
66+	1.361	0.860	***	0.213
Social influence (SI)				
55-65	0.187	0.071	0.488	0.270
66+	0.347	0.173	0.019	0.149
Performance/Effort (P/E)				
Male	1.473	0.948	***	0.200
Female	1.108	0.791	***	0.209
Social influence (SI)				
Male	0.111	0.048	0.487	0.160
Female	0.480	0.271	0.005	0.171
Performance/Effort (P/E)				
Non-drivers	1.266	0.797	***	0.308
Drivers low experience	1.376	0.939	0.001	0.433
Drivers high experience	1.827	0.945	***	0.365
Social influence (SI)				
Non-drivers	0.380	0.209	0.088	0.223
Drivers low experience	0.348	0.218	0.042	0.171
Drivers high experience	0.219	0.065	0.458	0.295
Performance/Effort (P/E))				
Below average income	1.086	0.792	***	0.195
Above average income	2.216	1.000	***	0.625
Social influence (SI)				
Below average income	0.425	0.241	0.024	0.188
Above average income	0.081	0.035	0.659	0.183
Performance/Effort (P/E)				
No health issues	1.562	0.901	***	0.256
At least one health issue	1.360	0.904	***	0.264
Social influence (SI)				
No health issues	0.930	0.159	0.051	0.200
At least one health issue	0.151	0.087	0.375	0.170

***** = below 0.001***

5.2.1. Factor analysis AV-Shared

Since the data gathered during the survey for the SAV system is independent from the data for the owned system a separate factor analysis is done. Firstly, a Confirmative Factor Analysis (CFA) is done with the same model from Figure 25 which was also used to analyse the data from the owned SAV system. The same discrepancy function and model fit criteria were used for the shared AV model. After running the original model a very high correlation is found again between two constructs which indicates multicollinearity. In the case of the AV shared model the correlation between the Performance expectancy and the Social influences was found to be very high (0.89).

Similar to the AV owned model an Exploratory Factor Analysis (EFA) was performed on the data gathered for the Shared AV system. This EFA was also done with Maximum Likelihood as the fitting procedure and Oblimin as a rotation method, the results can be found in Table 23.

Table 23: Pattern matrix for AV shared (ML, Oblimin rotation)

	Factor	
Indicator	1	2
Safety (PE1)		0.463
Time (PE2)	0.767	
Costs (PE3)	-0.640	
Environment (PE4)	0.459	
Comfort (PE5)	0.613	
Operation (EE1)		0.621
Legal (EE2)		0.363
Learning (EE3)		0.827
Social (SI1)	0.855	
Peer (SI2)	0.920	
Authorities (SI3)	0.319	

**** Values below 0.30 are omitted***

Table 23 shows that 2 constructs are formed, the first construct contains the PE2 to PE5 indicators together with the indicators that were placed under the Social Influences construct. The second construct contains the PE1 (Safety) indicator together with the indicators that were placed under the Effort Expectancy construct. The causes of these changes to the structural model are likely similar as those for the AV owned model. However, it is notable that the performance and social indicators are correlated with each other. This shows that respondents associate the performance of a shared AV system together with the amount of social/peer pressure they will likely experience.

This new model with the two constructs Performance/Social (P/S) and Effort Expectancy (EE) was used in the CFA to test the influence of these constructs on the Behavioural intention. After updating the model by removing the indicators PE1, PE3, PE4 and SI3 the best model fit was reached. The outcome of the CFA with the updated model can be found in Figure 27.

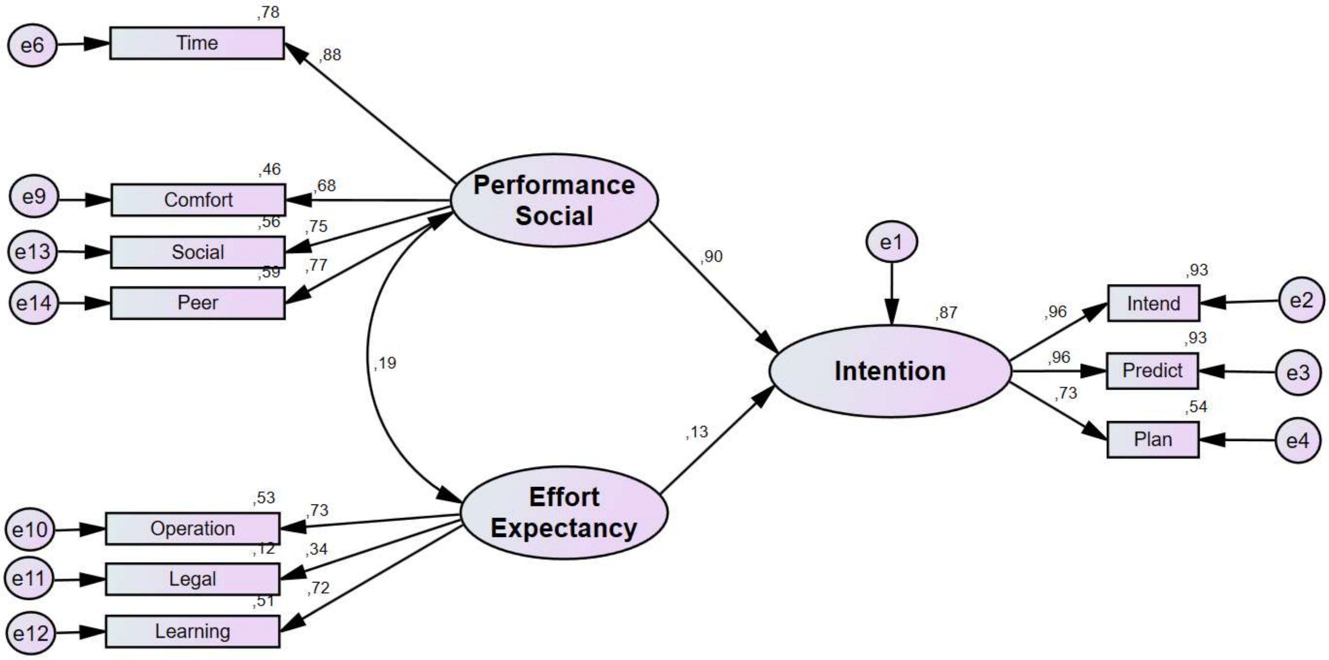


Figure 27: Output updated model, standardized estimates (AV Shared)

The model fit values and construct reliability scores can be found in the tables below.

Table 24: Model fit values (AV shared, original model)

Fit criteria	Threshold value	Actual value
Chi-square test	>0.05	0.001
CMIN/DF	≥1.0 - ≤5.0 (<2.0)	1.994
GFI	>0.90	0.907
CFI	>0.90 / >0.95	0.959
RMSEA	<0.08 / <0.05	0.090
NFI	>0.90	0.922
TLI/NNFI	>0.90 / >0.95	0.942

Table 25: Construct reliability scores (AV shared, Original model)

Construct	# of indicators	Average factor loadings	AVE	CR
P/S	4	0.77	0.597	0.854
EE	3	0.60	0.386	0.633
BI	3	0.89	0.797	0.921

Table 26: Construct regression weights (AV shared, original model)

Relation	Estimate	Standardized estimate	Standard error (S.E)	P-value
P/S ---> BI	0.894	0.899	0.069	***
EE ---> BI	0.220	0.130	0.107	0.04
SI --> BI	-	-	-	-

In contrast to the AV owned system the results for the AV shared system show poor model fit indices even when improving the model by removing 4 indicators. Next to the model fit values the Chi-square test is significant and the RMSEA score is too high. In addition both the AVE and CR scores for the EE constructs are below the threshold value. The results suggest that the proposed model is better fit to assess the behavioural intention of an owned AV system than a shared AV system.

5.2.1. Effects of stated importance on AV shared model

Similar as for the owned AV system the stated importance will be also tested with the AV shared model to see if the model fit will be improved. Firstly the original data from the survey is modified to include the stated importance from the respondents. Since the data is modified a new EFA is required to see if there are new construct being formed. This new EFA on the data that included the stated importance showed the same results as the previous model with 2 constructs being formed: Performance/Social and Effort Expectancy. Unlike the AV owned model a good model fit was reached with the stated importance included for all eleven indicators.

After weighing the indicators with their stated importance the best model fit was achieved after removing the indicators PE2 (Time) PE3 (Cost) and EE2 (Legal Restrictions). The remaining indicators formed the same structural model as found in Table 23. A comparison of the model without importance and including importance can be found in Table 27.

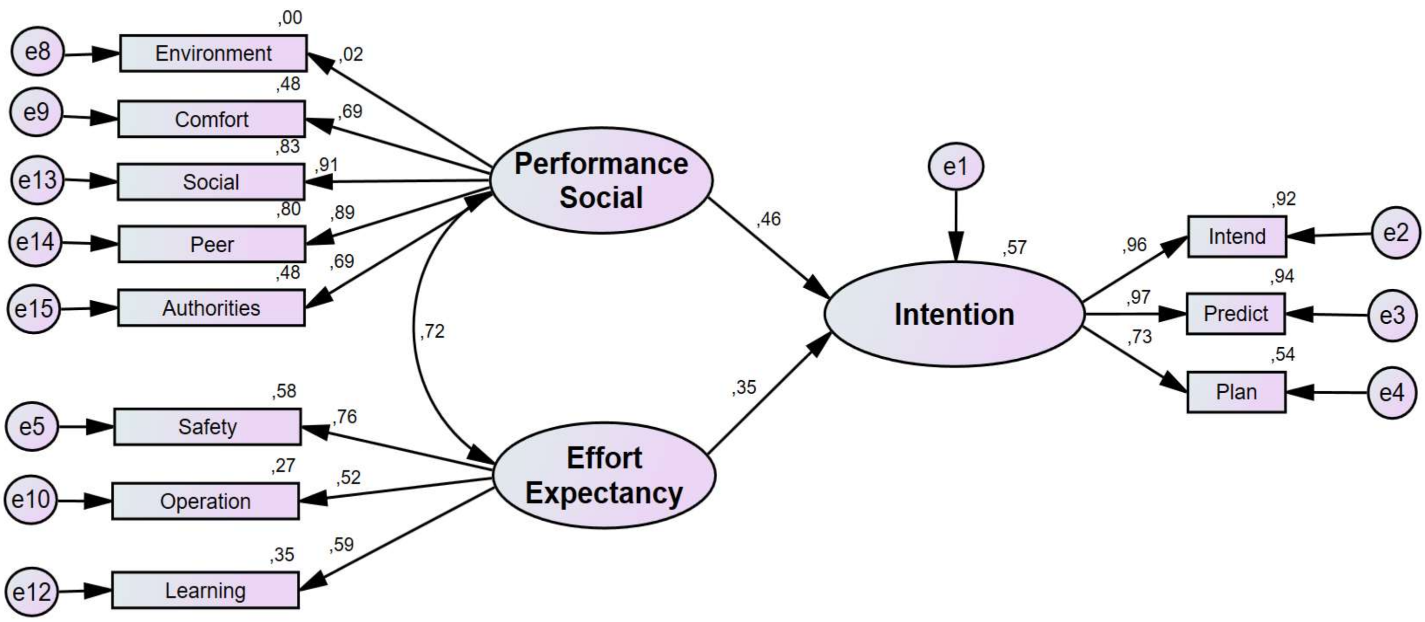


Figure 28: Output updated model including importance, standardized estimates (AV Shared)

Table 27: Comparison of model with and without including importance (AV shared)

Fit criteria	Without importance	Including importance
Chi-square	0.001	0.015
CMIN/DF	1.994	1.539
GFI	0.907	0.920
CFI	0.959	0.972
RMSEA	0.090	0.066
NFI	0.922	0.925
TLI/NNFI	0.942	0.963

Construct	AVE	AVE (importance)	CR	CR (importance)
P/S	0.597	0.528	0.854	0.848
EE	0.386	0.312	0.633	0.475
BI	0.797	0.797	0.921	0.921

Relation	Standardized estimate	Standardized estimate (importance)	P-value	P-value (importance)
P/S ---> BI	0.899	0.459	***	***
EE --> BI	0.130	0.355	0.04	0.02

The comparison shows a notable improvement over the model that did not include the stated importance. Although the results are improved they are still not ideal, especially the AVE/CR scores for the EE construct are below the threshold values. In addition the Environment (PE4) indicator has nearly zero effect on the latent construct Performance/Social but removing this indicator reduces the overall model fit values. It can be concluded that while including stated importance improves the model, and it is recommended to incorporate this in future research, the proposed model has to be modified to reliably investigate the behavioural intention of shared AV.

5.2.1. Multi-group analysis AV Shared

As with the owned AV system the multi-group analysis is used to see if the effects of the moderator groups are significant by comparing the Chi-square statistic between the unconstrained models with the fully constrained models.

The best performing model will be used during the multi-group analysis for the shared AV system. This means that the multi-group analysis will be performed with the data including the stated importance and the structural model found in Table 23 but without the indicators PE2 (Time) PE3 (Cost) and EE2 (Legal Restrictions). The results for each moderator group can be found below.

Age:

Table 28: Results Chi-Square difference test for Age moderator (AV Shared)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	113.808	82	0.012	40.630	25	**0.025**
Fully constrained	154.438	107	0.002			

The results show that the P-value of the Chi-square difference is below 0.05 (0.025) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant. As a result the regression weights in the structural model between the two moderator groups “55-65” and “66+” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of age in case of the AV-Shared system.

Gender:

Table 29: Results Chi-Square difference test for Gender moderator (AV Shared)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	96.077	82	0.137	31.936	25	**0.160**
Fully constrained	128.013	107	0.081			

The results show that the P-value of the Chi-square difference is above 0.05/0.10 (0.160) which means that the chi-square difference between the unconstrained model and the fully constrained model is not significant. As a result the regression weights in the structural model between the two moderator groups “Male” and “Female” do not significantly differ from each other and are invariant. This refutes that there is a moderation effect of gender in case of the AV-Shared system. While there is no significant difference on the model level there may still be a difference between the groups in the measurement model between the latent constructs and its indicators.

Experience:

Table 30: Results Chi-Square difference test for Experience moderator (AV Shared)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	167.601	123	0.005	92.212	50	**0.000**
Fully constrained	259.813	173	0			

The results show that the P-value of the Chi-square difference is below 0.05 (0.000) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant. As a result the regression weights in the structural model between the three moderator groups “Non-drivers”, “Drivers low experience” and “Drivers high experience” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of experience in case of the AV-Shared system.

Income:

Table 31: Results Chi-Square difference test for Income moderator (AV Shared)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	112.337	82	0.015	35.541	25	**0.079**
Fully constrained	147.878	107	0.005			

The results show that while the P-value of the Chi-square difference is not below 0.05 it is below 0.10 (0.079) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant at the 0.10 level. As a result the regression weights in the structural model between the two moderator groups “Below average income” and “Above average income” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of income in case of the AV-Shared system.

Health:

Table 32: Results Chi-Square difference test for Health moderator (AV Shared)

Model	Chi-square	DF	P-value	Δ Chi-square	Δ DF	P-value
Unconstrained	113.060	82	0.013	50.780	25	**0.002**
Fully constrained	163.840	107	0.000			

The results show that the P-value of the Chi-square difference is below 0.05 (0.002) which means that the chi-square difference between the unconstrained model and the fully constrained model is significant. As a result the regression weights in the structural model between the two moderator groups “No health issues” and “At least one health issue” significantly differ from each other and are not invariant. This confirms that there is some form of moderation effect of health in case of the AV-Shared system.

Table 33 gives an overview of the results of the multi-group analysis for the shared AV system and contains the (standardized) estimates of the two latent constructs (P/S and EE), their probability value, and the standard errors for each individual moderator group.

Table 33: Results of multi-group analysis, relation between constructs and BI (AV Shared)

Constructs	Unstandardized estimate	Standardized estimate	P value	S.E.
Performance/Social (P/S)				
55-65 (age)	0.863	0.559	***	0.253
66+	0.587	0.333	0.086	0.342
Effort Expectancy (EE)				
55-65	1.268	0.312	0.059	0.672
66+	1.250	0.395	0.081	0.716
Performance/Social (P/S)				
Male	1.068	0.493	***	0.305
Female	0.830	0.445	0.546	1.376
Effort Expectancy (EE)				
Male	1.485	0.394	0.009	0.572
Female	0.206	0.074	0.924	2.152
Performance/Social (P/S)				
Non-drivers	-0.481	-0.337	0.361	0.527
Drivers low experience	0.643	0.325	0.441	0.833
Drivers high experience	0.817	0.461	0.013	0.330
Effort Expectancy (EE)				
Non-drivers	2.163	0.739	0.118	1.384
Drivers low experience	1.318	0.373	0.419	1.631
Drivers high experience	1.231	0.386	0.061	0.656
Performance/Social (P/S)				
Below average income	0.619	0.282	0.229	0.514
Above average income	0.366	0.278	0.257	0.323
Effort Expectancy (EE)				
Below average income	1.654	0.510	0.062	0.887
Above average income	1.502	0.506	0.100	0.912
Performance/Social (P/S)				
No health issues	0.899	0.497	0.001	0.276
At least one health issue	-0.201	-0.112	0.734	0.591
Effort Expectancy (EE)				
No health issues	1.151	0.322	0.057	0.605
At least one health issue	2.053	0.714	0.073	1.144

6. Conclusions and recommendations

The aim of this thesis was to find out if elderly have the intention of using automated vehicles in the future and what the main reasons for adapting or not adapting AV are. With the help of the previous chapters an answer to the research question and sub-questions will be given.

Which methods are best suited to investigate the acceptance of AV among elderly?

As long as automated vehicle are not freely available to the majority of the population the acceptance of AV among elderly has to be investigated through stated usage intention. A review of the available models and techniques showed that a modified UTAUT model in combination with structural equation modelling is best suited to research the acceptance of AV among elderly. It is important that the modifications to the UTAUT model are adapted towards the acceptance criteria for elderly and the use of automated vehicles.

Which personal characteristics influence the decision to use AV or not?

The research results showed that all of the socio economic factors that were considered (Age, Gender, Experience, Income and Health) have a significant impact on the usage intention of either the AV system, SAV system, or both systems. Other personal characteristics such as education or geographical location were not investigated.

What type of automated vehicles is preferred by the elderly population?

There is a preference in the usage intention for owned AV compared to the shared AV system although some groups within the elderly population prefer the shared AV system.

Main research question:

To what extent will the elderly population in the Netherlands use automated vehicles in the future and what are the possible factors influencing the adoption rates of AV?

With a share of around 65% the majority of the respondents is at least somewhat positive (score of 3 or higher) towards both owned and shared AV. However the group that was (very) positive (score of 4 or higher) towards owned AV (±50%) is twice as high as for shared AV (±25%). The main causes for these differences can be found in the perceived increase in travel time for SAV and the fact that respondents rate the social/peer pressure for using a shared AV very low while the analysis shows that these indicators have a big impact on the Behavioural intention

In the next part of this chapter additional background information is provided on the answers to the research questions. This includes a summary of the main findings for the individual constructs, moderator groups, implementation of stated choice in the model, differences between the AV and SAV system and finally a reflection on the methods that were used. The last part of this chapter is used to provide improvements to the methods used in this thesis and recommendations for future research.

6.1. Main findings

In order to give a more in-depth answer to the research question(s) this paragraph will be used to give an overview of the main findings of this thesis research. These findings are split up into multiple subjects. First the main findings for each type of AV are detailed, chapter 6.1.1 covers the owned AV and chapter 6.1.2 covers the shared AV system. These chapters go into detail on what models were used and what the main influences on the behavioural intention of respondents is for each mode. The next section explains which moderator groups significantly differ from each other and what might explain these differences. Finally section 6.1.5 compares the findings of the AV system with the SAV system on the differences in usage intention, performance indicators and general model fit.

6.1.1. AV owned

Using the data gathered from the survey two main constructs were formed during the Exploratory Factor Analysis (EFA): the Performance/Effort and Social Influences constructs. Both constructs and their influence on the behavioural intention are discussed below.

Performance/Effort:
This construct included the original indicators from the Performance Expectancy (PE) (Safety, travel time, travel cost, environment and comfort) together with the indicators from the Effort Expectancy construct (Comfort, Operation difficulty, and learning difficulty). Because of the high correlation between these indicators the EFA placed them under one single construct: Performance/Effort.

The confirmative factor analysis showed that there is strong positive relation between the Performance/Effort and the behavioural intention with a total (standardized) effect of 0.91. This means that for elderly both the performance and required effort of an owned AV system is the determining factor in deciding to use such a system or not. Seven of the original eight indicators had a significant impact on the performance with operation/learning difficulty being the most important and environment the least important (Figure 26).

Although both constructs were combined the indicators originally put under effort were found to have the most influence on this new construct. Especially operation/learning difficulty have a large effect on this new construct which matches with the findings of (Renaud & Biljon, 2008) that ease of use/learning are a significant factor in technology adoption by elderly. The indicator for legal restrictions had to be removed because it did not have a significant effect on the behavioural intention. This is likely because the restrictions mentioned in the survey currently only apply to people aged 75+ while the sample included only a few people in this age group.

Social Influences:
The Social Influences (SI) construct measures the effect that Social pressure, peer pressure, and pressure from the authorities has on the behavioural intention. In the AV owned model the effect of the SI construct on the behavioural intention was found to be statistically significant but also much lower (0.11) than the Performance/Effort construct (0.91). All three indicators (Social pressure, Peer influence and pressure from authorities) are about equally important in measuring SI with peer influence being the most important and social pressure the least (Figure 26). This shows that elderly are not heavily influenced by outside (social) pressure when deciding to use an owned AV system or not.

6.1.2. AV shared

For the shared AV system two different constructs were formed during the Exploratory Factor Analysis (EFA): the Performance/Social and Effort Expectancy (EE) constructs. Both constructs and their influence the behavioural intention are discussed below.

Performance/Social
During the EFA of the Shared AV system 4 of the Performance Expectancy construct indicators (Travel time, Travel cost, Environment and comfort) were grouped with the indicators originally placed under the Social Influences construct (Social pressure, Peer Pressure and pressure from authorities). Looking at the results from the best performing model, which included stated importance, the new Performance/Social construct has a total standardized effect of 0.46 (Figure 28) which puts it well below the effects of the Performance/Effort construct found in the AV shared model. The Environment indicator (PE4) has a very minor effect while the effects the social pressure and peer influence indicators on the Performance/Social construct are very large. It is evident that the social indicators have a much bigger impact on this new construct suggesting that these social characteristics have a large influence in the usage intention of a shared AV system.

Effort Expectancy:
The Effort Expectancy (EE) construct was added in the original theoretical model to measure the effects of the amount of effort required (Learning difficulty, Operation difficulty and legal issues) for using the AV system. For the Shared AV system the original EE construct remained intact but also included the Safety (PE1) indicator. In the model that included the stated importance the effect of the EE construct on the behavioural intention is much higher (0.35) compared to the other models. By including safety in the EE construct the regression weight for this construct is increased while at the same time lowering the regression weight for the Performance/Social construct. This also causes a high correlation between these two constructs because the safety indicator correlates with both constructs.

6.1.3. Moderator groups

To test if certain personal characteristics have an influence on the behavioural intention and which factors might cause this difference a multi-group analysis was performed for both the AV systems. In addition the average scores of the usage intention questions (intend, plan and predict) are also compared between groups. The following moderator groups were considered during the analysis:

- Age (55-65 and 66+)
- Gender (Male and Female)
- Experience (Non-drivers, drivers low experience and drivers high experience)
- Income (Below average income and Above average income)
- Health (No health issues and at least one health issue)

Age: The analysis showed that the two age groups “55-65” and “66+” are invariant in the AV owned model and not invariant in the AV shared model. This means that age does have a moderation effect in the case of the SAV system but not for the owned AV system.

Interesting to note is that for the owned AV system the effects of the Social influence construct are not significant for the 55-65 age group but significant for the 66+ group (Table 22). This could be explained by the fact that elderly are more motivated by social norms when choosing to adapt a new technology (Morris & Venkatesh, 2000).

For respondents in the 55-65 age group the average rating for the usage intention is 3.52 for the owned AV system and 2.22 for Shared AV. The average usage intention of the 66+ age group is 2.76 for owned AV and 2.76 for Shared AV. People in their pre-pension age are more likely to use an owned AV system in the future than people aged 66+. This could be caused by the fact that people aged 55-65 are more likely to still have a regular job which requires a regular use of a vehicle. Although the usage intention of the SAV is slightly higher for the 66+ age group both groups are not very positive towards the SAV system.

Gender: For the moderator group “Gender” it was found that the two gender groups “Male” and “Female” are not invariant in the AV owned model and invariant in the AV shared model. This means that Gender does have a moderation effect in the case of the owned AV system but not for the SAV system.

In the case of the owned AV system the effects of the SI construct were significant for females but not for males. In addition the effect of Performance/Effort is stronger for men than for women (Table 22). For the SAV system the effect of the Effort Expectancy construct is significant for males while it is not significant for females. This shows that males find the amount of effort required for using both AV systems more important than females.

The average usage intention of the male group is 3.34 for owned AV and 2.25 for Shared AV. The average usage intention of the female group is 2.72 for owned AV and 2.96 for Shared AV. This shows that males are more likely to use an owned AV system and females more likely to use a SAV system in the future.

Experience: The multi-group analysis showed that the three experience groups “non-drivers”, “Drivers low experience” and “Drivers high experience” are not invariant for both the AV owned and the AV shared system. This means that Experience does have a moderation effect for the AV owned as well as the AV shared system.

In the case of the owned AV the influence of the SI construct is not significant for the “Drivers high experience” group while it is significant for the other two groups. For the Shared AV both the Performance/Social and EE construct are significant for the “Drivers high experience” group while they are not significant for the other two groups. By combining the Performance and Social indicators into one construct it becomes difficult to show the underlying effects of the non-driving group and drivers with low technology experience on the behavioural intention.

The average usage intention of the non-driving group is 2.44 for owned AV and 3.07 for Shared AV. The average usage intention of drivers with low technology experience is 2.95 for owned AV and 2.47 for Shared AV. The average usage intention of drivers with high technology experience is 3.58 for owned AV and 2.18 for Shared AV. The non-driving group has a preference for SAV while the drivers with high technology experience have a clear preference for the owned AV.

Income: The two income groups "Below average income" and "Above average income" are not invariant for both the AV owned and the AV shared system. This means that Income does have a moderation effect for the AV owned as well as the AV shared system.

In case of the owned AV system the P/E construct was found to be significant for both groups but more important for the "above average income" group. The effect of the SI construct is significant for the "Below average income" group but not for the "Above average income" group. In case of the Shared AV system the effect of the P/S construct was found to be not significant for both groups and the EE construct significant for both groups

The average usage intention of the below average income group is 2.73 for owned AV and 2.85 for Shared AV. The average usage intention of the above average income group is 3.64 for owned AV and 2.12 for Shared AV. It is clear that people with a higher income are more likely to use the owned AV system and people with a lower income have a slight preference for the Shared AV system.

Health: The multi-group analysis revealed that the two Health groups "No health issues" and "At least one health issue" are not invariant for both the AV owned and the AV shared system. This means that Health does have a moderation effect for both systems.

For the owned AV system the effect of the P/E construct is significant for both groups and the effect of the social construct is significant for the group with no health issues but not significant for the group with at least one health issue. For the shared AV system the P/E construct is significant for the group with no health issues but not significant for the group with at least one health issue. The EE construct is significant for both groups although the effect is considerably higher for the group with at least one health issue showing that the required effort is more important to people with health issues.

The average usage intention of the group with no health issues is 3.39 for owned AV and 2.28 for Shared AV. The average usage intention of the group with at least one health issue is 2.54 for owned Av and 3.00 for Shared AV. This confirms that for people with health issues a Shared AV system is more attractive.

6.1.4. Implementation of stated importance

Chapters 5.2.3 and 5.2.1 showed that including stated importance in the measurement model did not improve the model for the owned AV system. The results showed that the model fit values were poorer compared to the model without importance added. In addition some of the regression weights showed unrealistic values (above 1.0) suggesting that the data, including importance, does not correctly fit the model (Table 16).

However, for the shared AV system notably improved results were found when including importance in the measurement model. While no reliable results could be reached from the original model without importance the model that included this showed somewhat acceptable results (Table 27). The new model showed reasonable model fit values but the internal reliability scores (AVE and CR) of the EE construct were not acceptable. In order to reach a truly acceptable model fit it is likely that different indicators should be used to measure the Effort Expectancy construct.

It can be concluded that by including stated importance in the measurement model for the Shared AV system a more reliable model can be constructed which also keeps a larger part of the original UTAUT model intact. For the owned AV system including stated importance resulted in a poorer performance of the overall model and several of the modified indicators showed very bad factor loadings compared to the original results. This is likely caused by the fact that the perceived importance of respondents does not always correspond with their actual decision making when choosing to use a transport mode or not.

6.1.5. Comparison AV and SAV systems

During this thesis two different types of automated vehicle systems were examined, one system that is owned privately and one system that is shared among users and operates like a taxi service. A descriptive analysis of the survey results that the owned AV system was seen more favourably by the younger age group, males, drivers, higher income groups and people with no health issues. The shared AV system was preferred by females, non-drivers, people with a lower income and people who suffered from at least one health issue (eyes, hearing, hands or feet). The older age group (66+) did not show a clear preference and seem reluctant in their intention of using either system.

The SEM analysis showed that because of the underlying correlations between indicators separate models had to be formulated for owned AV and shared AV system. Having separate models makes it difficult to compare both systems with each other but there are some distinct differences in the analysis results between the owned and shared AV systems.

The exploratory factor analysis for the owned AV system showed a correlation between the indicators of the Performance Expectancy construct and the Effort Expectancy construct (Figure 26). While for the shared AV system the indicators of the Performance and Social constructs were related. In addition it was found that there is also a high correlation between this new Performance/Social construct and the Effort Expectancy construct (Figure 28). This shows that how the respondents think about the performance and required effort of the shared AV system is closely related to the social/peer pressure they experience which is not the case for the owned AV system. Social norms are more important when considering to use a shared AV system which makes sense since shared mobility is still an emerging market and its use is not widespread. For the owned AV system the scores of the performance is closely related to how much effort is required to use the system.

The owned AV system provided a better model fit and construct reliability compared to the shared AV system which would indicate that the proposed theoretical model and questions used in the survey are better fitted for the AV system. But at the same time the inclusion of stated preference in the measurement model turned out to have a positive effect on the model fit for the shared AV while there was a negative effect for the owned AV model.

6.2. Reflection on methods used

In addition to the main research goal this study also tried to show that the UTAUT model is suitable for testing acceptability of AV among elderly. The theoretical model was formulated after making adjustments to the original proposed by (Venkatesh et al., 2003) with the help of the literature study. This model was then tested with the help of data gathered during an online survey which showed that several big changes to the model had to be made. While the original indicators remained intact new constructs had to be formulated with these indicators. Not all parts of the UTAUT model proved to be a reliable predictor in the usage intention of AV. However, good results were found with a limited sample size which shows that the proposed model can be used to investigate the usage intention of AV among elderly.

The inclusion of two separate types of AV resulted in a lot of additional work because each type required a separate model. Although this made the comparison between the owned and shared AV more difficult some key differences could be identified which will be helpful in future research. The data analysis also showed that the proposed model works better for owned AV compared to the shared AV. This is likely caused by the fact that the same base model was used for both systems but the literature that was used to formulate this model mainly focused on the owned AV systems. The inclusion of additional moderator groups (Health and Income) proved to be useful since all of the proposed groups had a significant impact on the behavioural intention for either one of the AV systems or both of them.

The data was collected through an online survey and even though the analysis of the respondents showed a varied sample there was an overrepresentation of males and people with technology experience. This is a drawback of only having an online survey which cannot reach elderly which do not have access to a computer with internet.

6.3. Recommendations for future research

While this report has shown that the proposed model can work in predicting the behavioural intention of AV among elderly several aspects could be improved in future research. Firstly the sample size of 123 that was used during the SEM analysis proved to be sufficient when removing poor performing indicators/constructs but with the use of a larger sample size it is possible that a more complete model can be used. When following the recommendations of (Kline, 2015) the sample size of the proposed model should be above 200. Some researchers even suggest a sample size of 200 to 400 is required regardless of the model complexity (Jackson, 2003).

The survey that was used to gather the data was exclusively distributed online which means that elderly without access to a computer with internet or elderly who do not use the internet at all could not participate in the survey. Since elderly do not use computers as much as younger people this could mean that the people who participated in the survey do not accurately represent the elderly population of the Netherlands. Future research could try to sample a more accurate representation of elderly people in the Netherlands by doing one-on-one interviews in addition to an online survey. This would also require a different set-up of the survey, possibly without using video, to explain the AV systems. The sample should also include more people aged 75+ which have actually experienced some of the legal restrictions that apply to elderly drivers in the Netherlands.

Including stated importance in the dataset for the measurement model improved the results for the Shared AV model but not for the owned AV model. A recommendation for future research is to explore the inclusion of stated importance when investigating the behavioural intention for shared AV since the results of this research indicate this improves the reliability of the model. Alternatively it is also a possibility to include attitude as a separate construct that directly influences the behavioural intention as proposed by (Osswald et al., 2012). This would require different questions in the survey that instead of asking respondents attitude towards modal choice indicators (safety, travel time etc.) would directly ask their attitude on automated vehicles and automation in general.

Finally it is recommended to conduct similar studies in the future to see how the perception of AV changes over time. Performing longitudinal studies is also suggested by (Venkatesh et al., 2003) since having more experience may change the perception and adoption of AV technologies. This could also provide insight into the effects of new AV technologies, availability of information or promotional campaigns on the behavioural intention.

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Attachments

I. Survey design
II. Survey design (Dutch)

I. Survey (English)

Personal information

1. What is your year of birth? 19___

2. What is your gender?
   - o Male
   - o Female

3. What are, within your household, the most important sources of income? (multiple answers possible)
   - ☐ Work
   - ☐ Pension
   - ☐ AOW
   - ☐ Other
   - ☐ I rather not share this information

4. What is your households' average disposable income per month?
   - o Less than €1000, -
   - o Between €1000, - and €1500, -
   - o Between €1500, - and €2000, -
   - o Between €2000, - and €2500, -
   - o Between €2500, - and €3000, -
   - o Between €3000, - and €4000, -
   - o More than €4000, -
   - o I rather not share this information

5. Do you own a valid driver's licence (type b)?
   - o Yes
   - o No

5.1 If Yes: Do you currently own a car?

o Yes o No

5.2 If Yes: Roughly how many KM's do you drive per year?
- o I don't drive anymore
- o Less than 1.000km
- o 1.000-2.500km
- o 2.500-5.000km
- o 5.000-10.000km
- o 10.000-15.000km
- o 15.000-20.000km
- o 20.000-25.000km
- o 25.000-30000km
- o More than 30.000km

5.3 If Yes:

I am expecting that I will drive less in 5 years from now than I do now

Strongly disagree	o	o	o	o	o	Strongly agree

Please answer this question if you currently do not own a driver's licence or currently do not drive at all:

6 Please indicate how much these factors influenced your decision to not get your driver's licence or to stop driving

	Not at all 1	2	3	4	5 A lot
A. Health related issues	o	o	o	o	o
B. Too expensive	o	o	o	o	o
C. I didn't want to renew my driver's licence	o	o	o	o	o
D. Safety during driving	o	o	o	o	o

7 Do you suffer from any of the following health conditions?

A. Reduced eyesight
   - ○ Yes ○ No

B. Hearing problems
   - ○ Yes ○ No

C. Limited use of arms or fingers
   - ○ Yes ○ No

D. Limited use of legs or feet
   - ○ Yes ○ No

Please answer these questions if you answered yes on any of the above:

7.1. I feel that these conditions limit me in my ability to travel to activities

Strongly disagree	○	○	○	○	○	Strongly agree

7.2. I feel that these conditions prevent me from driving a car

Strongly disagree	○	○	○	○	○	Strongly agree

8 How familiar are you with the following driver support technologies?

	Never heard of this	*Heard of this but never used*	*Used occasionally*	*Used frequently*
a. In-car navigation system	○	○	○	○
b. Cruise control	○	○	○	○
c. Adaptive cruise control	○	○	○	○
d. Park assist/ automated parking	○	○	○	○
e. Blind-spot assistance	○	○	○	○
f. Collision warning/prevention system	○	○	○	○
g. Lane departure warning	○	○	○	○

Pre-explanation Questions

		1	2	3	4	5	
I find that safety is an important factor in choosing a transportation mode	Strongly disagree	○	○	○	○	○	Strongly agree
For me the travel time is an important factor in choosing a transportation mode	Strongly disagree	○	○	○	○	○	Strongly agree
I find that travel comfort is an important factor in choosing a transportation mode	Strongly disagree	○	○	○	○	○	Strongly agree
For me the costs of travelling are an important factor in choosing a transportation mode	Strongly disagree	○	○	○	○	○	Strongly agree
The environmental impact I make when travelling is important to me	Strongly disagree	○	○	○	○	○	Strongly agree
Having to share a vehicle with other people would bother me	Strongly disagree	○	○	○	○	○	Strongly agree
Having to share rides with other people would bother me	Strongly disagree	○	○	○	○	○	Strongly agree
It is important that it is easy to use a travel mode	Strongly disagree	○	○	○	○	○	Strongly agree
I approve of the current regulatory restrictions on driving by elderly (such as a health checks and mandatory renewal of driver licence at the age of 75)	Strongly disagree	○	○	○	○	○	Strongly agree
Needing to learn how to use a new travel mode is a barrier for using it	Strongly disagree	○	○	○	○	○	Strongly agree
People who are important to me often influence my behaviour	Strongly disagree	○	○	○	○	○	Strongly agree
Seeing people around me using a new technology makes it more likely for me to use it as well	Strongly disagree	○	○	○	○	○	Strongly agree
Advice from the authorities often influences my behaviour	Strongly disagree	○	○	○	○	○	Strongly agree

Post- explanation expectations

Automated vehicles (Owned)							
Behavioural intention		**1**	**2**	**3**	**4**	**5**	
I intend to use this system when it becomes available	Strongly disagree	○	○	○	○	○	Strongly agree
I predict to use this system when it becomes available	Strongly disagree	○	○	○	○	○	Strongly agree
I plan to use this system when it becomes available	Strongly disagree	○	○	○	○	○	Strongly agree
Performance expectancy							
Using this system would improve my safety on the road	Strongly disagree	○	○	○	○	○	Strongly agree
Using this system would reduce my travel time	Strongly disagree	○	○	○	○	○	Strongly agree
Travelling with this system would be more expensive than current travel modes	Strongly disagree	○	○	○	○	○	Strongly agree
Using this system will have a lower environmental impact compared to conventional travel by car	Strongly disagree	○	○	○	○	○	Strongly agree
This system will allow me to perform other tasks (such as sleeping or working) while driving	Strongly disagree	○	○	○	○	○	Strongly agree
Effort expectancy							
I would find this system easy to use	Strongly disagree	○	○	○	○	○	Strongly agree
I would expect this system to remove the driving restrictions (renewal of drivers licence) which are in place for elderly	Strongly disagree	○	○	○	○	○	Strongly agree
It would be easy for me to learn how to operate this system	Strongly disagree	○	○	○	○	○	Strongly agree
Social influences							
Having people who are important to me using this system will make me more likely to use it as well	Strongly disagree	○	○	○	○	○	Strongly agree
People who are important to me would think that I should use this system.	Strongly disagree	○	○	○	○	○	Strongly agree
In general, the authorities would think that I should use this system	Strongly disagree	○	○	○	○	○	Strongly agree

Automated vehicles (Shared)							
Behavioural intention		**1**	**2**	**3**	**4**	**5**	
I intend to use this system when it becomes available	Strongly disagree	○	○	○	○	○	Strongly agree
I predict to use this system when it becomes available	Strongly disagree	○	○	○	○	○	Strongly agree
I plan to use this system when it becomes available	Strongly disagree	○	○	○	○	○	Strongly agree
Performance expectancy							
Using this system would improve my safety on the road	Strongly disagree	○	○	○	○	○	Strongly agree
Using this system would reduce my travel time	Strongly disagree	○	○	○	○	○	Strongly agree
Travelling with this system would be more expensive than current travel modes	Strongly disagree	○	○	○	○	○	Strongly agree
Using this system will have a lower environmental impact compared to conventional travel by car	Strongly disagree	○	○	○	○	○	Strongly agree
This system will allow me to perform other tasks (such as sleeping or working) while driving	Strongly disagree	○	○	○	○	○	Strongly agree
Effort expectancy							
I would find this system easy to use	Strongly disagree	○	○	○	○	○	Strongly agree
I would expect this system to remove the driving restrictions (renewal of drivers' licence) which are in place for elderly	Strongly disagree	○	○	○	○	○	Strongly agree
It would be easy for me to learn how to operate this system	Strongly disagree	○	○	○	○	○	Strongly agree
Social influences							
Having people who are important to me using this system will make me more likely to use it as well	Strongly disagree	○	○	○	○	○	Strongly agree
People who are important to me would think that I should use this system.	Strongly disagree	○	○	○	○	○	Strongly agree
In general, the authorities would think that I should use this system	Strongly disagree	○	○	○	○	○	Strongly agree

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II. Survey (Dutch)

Persoonlijke informatie

1. Wat is uw geboortejaar? 19__

2. Wat is uw geslacht?
   - o Man
   - o Vrouw

3. Wat zijn, binnen uw huishouden, de belangrijkste bronnen van inkomen? (Meerdere antwoorden mogelijk)
   - ☐ Werk
   - ☐ Pensioen
   - ☐ AOW
   - ☐ anders
   - ☐ Ik deel deze informatie liever niet

4. Wat is, binnen uw huishouden, het gemiddelde besteedbaar inkomen per maand?
   - o Minder dan €1000,-
   - o Tussen €1000,- en €1500,-
   - o Tussen €1500,- en €2000,-
   - o Tussen €2000,- en €2500,-
   - o Tussen €2500,- en €3000,-
   - o Tussen €3000,- en €4000,-
   - o Meer dan €4000,-
   - o Ik deel deze informatie liever niet

5. Bent u in het bezit van een geldig rijbewijs? (type b)?
   - o ja
   - o Nee

8.1 Zo ja: Bent u momenteel in het bezit van een auto?
- o Ja
- o Nee

8.2 Zo Ja: Grofweg hoeveel KM rijdt u per jaar?
- o Ik rij helemaal niet meer
- o Minder dan 1.000km
- o 1000-2500km
- o 2500-5000km
- o 5000-10.000km
- o 10.000-15.000km
- o 15.000-20.000km
- o 20.000-25.000km
- o 25.000-30000km
- o Meer dan 30.000km

8.3 Zo Ja: In hoeverre bent u het eens met de volgende stelling?

Ik verwacht dat ik over 5 jaar minder rij dan nu

Helemaal mee oneens	o	o	o	o	o	Helemaal mee eens

Gelieve deze vraag te beantwoorden als u momenteel geen rijbewijs bezit of als u gestopt bent met autorijden

6. Kunt U aangeven hoeveel de volgende factoren van invloed zijn geweest op uw beslissing om uw rijbewijs niet te halen of te stoppen met rijden

	Helemaal niet	1	2	3	4	5	Heel veel
A. Gezondheid gerelateerde problemen		o	o	o	o	o	
B. Kosten		o	o	o	o	o	
C. Ik wilde mijn rijbewijs niet verlengen		o	o	o	o	o	
D. Veiligheid tijdens het rijden		o	o	o	o	o	

7. Heeft u last van een of meer van de volgende lichamelijke problemen?

A. Verminderd gezichtsvermogen
  - ○ Ja ○ Nee

B. Gehoorproblemen
  - ○ Ja ○ Nee

C. Beperkt gebruik van armen en/of handen
  - ○ Ja ○ Nee

D. Beperkt gebruik van benen en/of voeten
  - ○ Ja ○ Nee

Gelieve deze vragen te beantwoorden als u 'Ja' antwoordde op een van de bovenstaande vragen:

7.1 Ik heb het gevoel dat deze problemen mij beperken in het reizen naar mijn activiteiten

Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens

7.2. Ik heb het gevoel dat deze problemen mij verhinderen van het besturen van een auto

Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens

8. Hoe bekent bent u met de volgende rij-ondersteunende technologieën?

	Nog nooit van gehoord	*Van gehoord maar nog nooit gebruikt*	*Af en toe gebruikt*	*Regelmatig gebruikt*
a. Navigatie systeem voor auto's	○	○	○	○
b. Cruise control	○	○	○	○
c. Adaptieve cruise control	○	○	○	○
d. Park assist/geautomatiseerd parkeren	○	○	○	○
e. Dode hoek detectie	○	○	○	○
f. Aanrijding waarschuwing/ preventie systeem	○	○	○	○
g. Rijstrook verlatingswaarschuwing	○	○	○	○

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Vragen voor toelichting over systeem

		1	2	3	4	5	
Ik vind veiligheid een belangrijk aspect bij het kiezen van een vervoermiddel	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Ik vind reistijd een belangrijk aspect bij het kiezen van een vervoermiddel	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Reiscomfort is voor mij een belangrijke factor bij het kiezen van een vervoermiddel	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Reiskosten zijn voor mij een belangrijke factor bij het kiezen van een vervoermiddel	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Mijn impact op het milieu tijdens het reizen is belangrijk voor mij	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Het niet in bezit hebben van een eigen auto is een probleem voor mij	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Het moeten delen van autoritten met anderen mensen is een probleem voor mij	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
		1	2	3	4	5	
Ik vind het belangrijk dat een vervoermiddel gemakkelijk is in het gebruik	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
De huidige restricties voor het autorijden door ouderen (zoals een medische keuring en het moeten hernieuwen van het rijbewijs op 75 jarige leeftijd) zijn een goed idee	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Het moeten leren van een nieuwe vorm van reizen is voor mij een belemmering voor het gebruik ervan	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
		1	2	3	4	5	
Ik laat mijn gedrag regelmatig beïnvloeden door mensen uit mijn omgeving	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Als ik mensen uit mijn omgeving gebruik zien maken van nieuwe technologieën is het waarschijnlijker dat ik ze zelf ook zal gaan gebruiken	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens
Adviezen vanuit de overheid hebben vaak invloed op mijn gedrag	Helemaal mee oneens	○	○	○	○	○	Helemaal mee eens

Vragen over het systeem

Automatische voertuigen (Eigen bezit)					
	Helemaal mee oneens	Mee oneens	neutraal	Mee eens	Helemaal mee eens
	1	**2**	**3**	**4**	**5**
Ik heb de intentie om dit systeem te gaan gebruiken zodra het beschikbaar is	○	○	○	○	○
Ik voorspel dat ik dit systeem zal gaan gebruiken zodra het beschikbaar is	○	○	○	○	○
Ik maak plannen om dit systeem te gebruiken zodra het beschikbaar is	○	○	○	○	○
	1	**2**	**3**	**4**	**5**
Met dit systeem zal mijn veiligheid op de weg verbeteren	○	○	○	○	○
Dit systeem zal mijn reistijd verkorten	○	○	○	○	○
Reizen met dit systeem zal duurder zijn dan de huidige reis mogelijkheden	○	○	○	○	○
Reizen met dit systeem heeft een lagere belasting op het milieu vergeleken met een traditionele auto	○	○	○	○	○
Dit systeem laat me andere taken uitvoeren (zoals slapen/ontspannen of werken) tijdens het rijden	○	○	○	○	○
	1	**2**	**3**	**4**	**5**
Ik zal het makkelijk vinden om dit systeem te gebruiken	○	○	○	○	○
Ik verwacht dat dit systeem de huidige restricties op het rijden door ouderen (zoals een medische keuring en het vernieuwen van het rijbewijs) zal wegnemen	○	○	○	○	○
Leren om dit systeem voor het eerst te gebruiken zal gemakkelijk zijn voor mij	○	○	○	○	○
	1	**2**	**3**	**4**	**5**
Als mensen uit mijn omgeving gebruik zouden maken van dit systeem zou ik meer geneigd zijn om het ook te gaan gebruiken	○	○	○	○	○
Ik verwacht dat mensen uit mijn naaste omgeving denken dat ik dit systeem zal moeten gebruiken	○	○	○	○	○
De autoriteiten in het algemeen zouden vinden dat ik dit systeem zou moeten gebruiken	○	○	○	○	○

Automatische voertuigen (Gedeeld)					
	Helemaal mee oneens	Mee oneens	neutraal	Mee eens	Helemaal mee eens
	1	**2**	**3**	**4**	**5**
Ik heb de intentie om dit systeem te gaan gebruiken zodra het beschikbaar is	○	○	○	○	○
Ik voorspel dat ik dit systeem zal gaan gebruiken zodra het beschikbaar is	○	○	○	○	○
Ik maak plannen om dit systeem te gebruiken zodra het beschikbaar is	○	○	○	○	○
	1	**2**	**3**	**4**	**5**
Met dit systeem zal mijn veiligheid op de weg verbeteren	○	○	○	○	○
Dit systeem zal mijn reistijd verkorten	○	○	○	○	○
Reizen met dit systeem zal duurder zijn dan de huidige reis mogelijkheden	○	○	○	○	○
Reizen met dit systeem heeft een lagere belasting op het milieu vergeleken met een traditionele auto	○	○	○	○	○
Dit systeem laat me andere taken uitvoeren (zoals slapen/ontspannen of werken) tijdens het rijden	○	○	○	○	○
	1	**2**	**3**	**4**	**5**
Ik zal het makkelijk vinden om dit systeem te gebruiken	○	○	○	○	○
Ik verwacht dat dit systeem de huidige restricties op het rijden door ouderen (zoals een medische keuring en het vernieuwen van het rijbewijs) zal wegnemen	○	○	○	○	○
Leren om dit systeem voor het eerst te gebruiken zal gemakkelijk zijn voor mij	○	○	○	○	○
	1	**2**	**3**	**4**	**5**
Als mensen uit mijn omgeving gebruik zouden maken van dit systeem zou ik meer geneigd zijn om het ook te gaan gebruiken	○	○	○	○	○
Ik verwacht dat mensen uit mijn naaste omgeving denken dat ik dit systeem zal moeten gebruiken	○	○	○	○	○
De autoriteiten in het algemeen zouden vinden dat ik dit systeem zou moeten gebruiken	○	○	○	○	○