SUaaVE

SUpporting acceptance of automated VEhicle

Deliverable 1.2. Model and guidelines depicting key psychological factors that explain and promote public acceptability of CAV among different user groups

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AUTHOR	
Participant Partners(s)	RuG
Deliverable Leader	drs J.M.M. Post
Author(s)	drs. J.M.M. Post, dr. A.B. Ünal, dr. J.L. Veldstra,

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Legal disclaimer

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Terminology and Acronyms

CAV		Connected Automated Vehicle
CI		Confidence Interval
D		Deliverable
df		Degrees of Freedom
EU		European Commission
ISE model		Instrumental Symbolic Environmental model
M		Mean
N		Number of participants
SD		Standard Deviation
TAM		Technology Acceptance Model
TPB		Theory of Planned Behavior
VRU		Vulnerable Road User

EXECUTIVE SUMMARY

In this deliverable, we describe the development of the psychological acceptance model with the intention to explain public acceptability of CAV among different types of user groups within the EU. In order to develop this model, focus groups (*N* = 70) and a large scale survey (*N* = 3783) were conducted within multiple European countries. We first discuss the findings of the focus groups, followed by the results of the large scale survey. We also discuss some differences with respect to aspects that are more or less important based on country, gender, whether someone is a vulnerable road user or not, and whether someone has a driver's license or not.

We proposed and found that acceptability is predicted by attributes, perceived adoption norm, and perceived behavioral control, in which attributes is the strongest predictor. Attributes include seven distinct perceived characteristics of CAV: perceived safety, perceived convenience, perceived pleasure, perceived control, perceived status-enhancement, perceived environmental sustainability, and trust in CAV technology. Out of these, perceived safety, perceived convenience, and perceived environmental sustainability were the strongest predictors of acceptability.

We also found that attributes, in turn, are influenced by individual differences. The main individual differences that influenced attributes are personal values (mainly egoistic and biospheric values), cycling and driving frequency, and need for control. Additionally, we found that sometimes the effect of attributes on acceptability is moderated by individual differences. For example, the effect of perceived status-enhancement on acceptability is strong when the perceived adoption norm is low, but weak when the perceived adoption norm is high. We provide some initial guidelines on how to enhance acceptability of CAV based on these results.

Our current model is the first model that is tailored to CAV specifically, and has great predictive value for a behavioral model (it explains around 60% of all variance in acceptability). In the following months, we will conduct scenario studies and driving simulation experiments to determine if contextual factors can influence attributes or perhaps influence acceptability directly. With the driving simulation experiments we can also confirm the relationship between acceptability and acceptance. As such, we will expand and adjust the model accordingly, aiming at improving its already high predictive power further.

In short, this deliverable lays the foundation for all following research of the SUaaVE project on the acceptance of CAV. In this deliverable we present and validate the first model that explains acceptability of CAV specifically with great predictive power. Lastly, we provide some initial guidelines on how to improve acceptability of CAV within the EU.

1. INTRODUCTION AND OBJECTIVES

One of the general goals of SUaaVE is to enhance public acceptance of connected automated vehicles (CAVs) within the EU.

In work package 1, we will develop a social psychological model to explain and promote public acceptability of CAV among different types of user groups (such as passengers and other road users). In deliverable 1.1 we conducted a literature review to explore which factors could potentially influence acceptability of CAV. In the present deliverable we will build upon this literature review to develop and validate the social psychological model that will help predict the acceptability of CAV's.

1.1. Objectives

The key objective of the present deliverable is to describe the development of the psychological model depicting the key predictors of public acceptability for CAV, as well as to test the model fit and to examine the strength of the predictors.

To develop this psychological model, several focus groups (current deliverable; conducted in 4 European countries with 70 participants total) and an extensive literature review (D1.1.) were conducted. The focus groups were conducted to investigate if any other potential factors, that were not found in the literature review of deliverable 1.1, could influence the acceptability of CAV. Based on the findings from the literature and focus groups, we created a psychological model to predict acceptance of CAV. The large scale survey was conducted in 6 different European countries with a large number of participants (3783) and the results were used to assess the actual predictive power of the factors that influence acceptability. Below we will first discuss the conceptual framework for our proposed model, and then report the results of the focus groups followed by the results of the large-scale survey. Finally, we will test our proposed model using the data from the large scale survey. Based on the results we provide some initial guidelines for enhancing the acceptability of CAV within the EU.

Figure 1. Development scheme of the psychological acceptance model

2. CONCEPTUAL FRAMEWORK FOR THE MODEL OF ACCEPTANCE OF CAV

2.1 Theory of Planned Behavior

Three factors (attributes, subjective norms, and perceived behavioral control) determine behavioral intention according to the Theory of Planned Behavior (TPB; Figure 1; Ajzen, 1985). The first factor, attributes, reflects the overall evaluation of performing the behavior. Attributes are based on how desirable the particular consequences of the behavior are, and the belief how likely the behavior will result in these particular consequences. The second factor, subjective norms, reflects the perceived social pressure of relevant reference groups to engage in the behavior. The third factor, perceived behavioral control, reflects how easy or difficult the person believes it is to perform the behavior. De Groot and Steg (2007) used the TPB to explain people's intention to use a transferium and extended the TPB by including egoistic, altruistic, and biospheric concerns (explained in section 2.3.1). We will build on this extended TPB model to explain acceptability and acceptance of CAV.

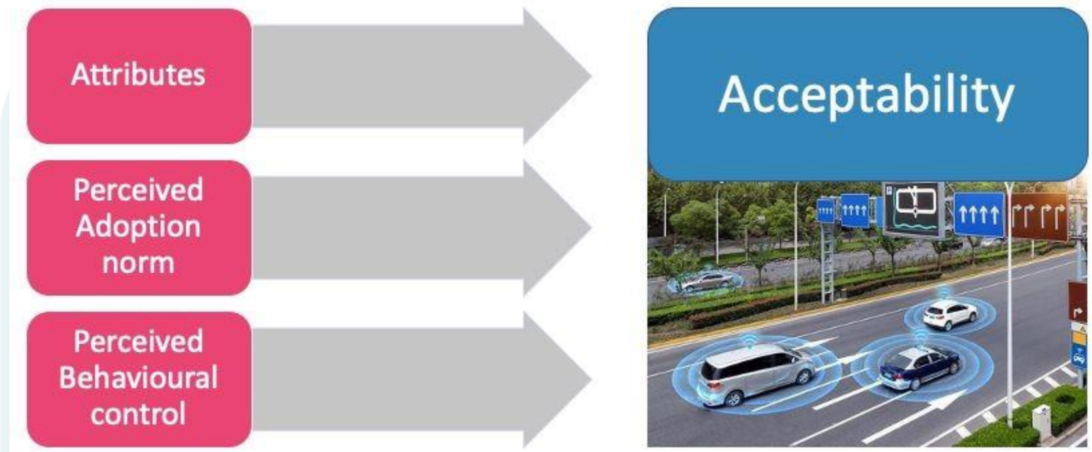


Figure 2. Overview of the Theory of Planned Behavior (Ajzen, 1985)

2.1.1 Attributes

To examine attributes of CAV, we made a distinction between seven perceived characteristics of CAV. The first five of these are commonly mentioned in the current literature, and are also covered in D1.1. These are perceived control (the belief one will have control over the vehicle's behavior), perceived safety (the belief the vehicle will be safe), trust in CAV technology (the belief the vehicle will behave as intended), perceived convenience (the belief the vehicle will meet the user's driving needs), and perceived pleasure (the belief driving in CAV will be pleasant). Two additional perceived characteristics were added after the focus groups: perceived environmental sustainability (the belief CAV will be environmentally friendly) and perceived status-enhancement (the belief owning or driving CAV will increase one's status).

2.1.2 Subjective norms

As CAV is currently not on the market, examining current subjective norms may be difficult. Instead, we used the perceived adoption norm from the extended Instrumental Symbolic Environmental (ISE) model (explained in section 2.2). The perceived adoption norm is the percentage one expects close others (such as family, friends, coworkers, etc.) will adopt CAV when it becomes available. We expect that those who think a high percentage of close others will adopt CAV, are more likely to be accepting of CAV in return.

2.1.3 Perceived behavioral control

TPB posits that the easier it is to perform a behavior, the more likely one will have the intention to perform it. The idea that the ease of use can influence behavior is also present in the Technology Acceptance Model (TAM; Davis, 1985), a model to predict system use of technologies. We have included the perceived behavioral control in our model as well. However, perceived behavioral control may be different between potential users and other road users. For potential users, the ease of using CAV may be important, while for other road users the ease of interacting with CAV may be important.

2.2 Extended Instrumental Symbolic Environmental model

The ISE model posits that adoption likelihood of sustainable behavior is predicted by symbolic (i.e. related to status), instrumental, and environmental attributes, as well as the adoption norm (Noppers et al., 2019). The three types of attributes in the ISE model are reflected in our model for CAV: symbolic attributes are reflected in the current model as perceived status-enhancement, instrumental attributes are reflected as perceived convenience, and environmental attributes as perceived environmental sustainability. The extended ISE model also posits a moderation of the perceived adoption norm on the effect of symbolic attributes on adoption likelihood. When the perceived adoption norm is low, symbolic attributes become more important for potential users. While if the perceived adoption norm is high, symbolic attributes will become less important. We will test for a similar effect in the acceptance of CAV.

2.3 Individual differences

In D1.1 we found that perceived characteristics of CAV may be influenced by individual differences. In our model, we have included three types of individual factors (values, need for control, and type of road user). Other often used variables such as personality and gender have been found to have no effect, or inconsistent results in the existing literature (please refer to D1.1). As such, they are not explicitly included in the model. However, we will examine differences based on gender and country for this deliverable.

2.3.1 Values

Values are guiding principles in life, that can affect beliefs, attitudes, and behaviors, and can color perceptions and cognitions (Schwartz, 1992). People's key values and what they deem important in life may also affect what they find important for CAV. Four major values exist: (1) hedonic; striving for an exciting life, experiencing new things, enjoying life, (2) egoistic; striving for personal wealth, social power, dominance, (3) altruistic; striving for equality, social justice, peace, and (4) biospheric; striving for balance with nature, protecting the earth, preventing pollution (Steg & De Groot, 2012; Steg, Perlaviciute, Van der Werff, & Lurvink, 2014). We expected that different values are related to the importance of different characteristics of CAV. We expected that hedonic values may be related to the importance of convenience and pleasure, that egoistic values may be related to the importance of status-enhancement, that altruistic values may be related to the importance of safety, and that biospheric values may be related to the importance of environmental sustainability. We also expected values may moderate the effect of perceived characteristics on acceptability. For example, we expected that great biospheric values will make the effect of perceived environmental sustainability on acceptability stronger.

2.3.2 Need for control

The second individual factor is the need for control. The belief that a person has control over the environment and events in one's life is vital for someone's well-being. The perception of control is both desirable, as well as a psychological necessity (Leotti, Iyengar, & Ochsner, 2010). People differ on a general level of motivation to control events, in other words the need for control is an individual difference (Burger & Cooper, 1979). The feeling of being in control is an integral part of driving. The lack of control over autonomous vehicles may decrease the acceptability of these vehicles, especially for people with a high need for control. (for example Howard & Dai, 2014). We expected that people with a high need for control perceive to have less control over CAV. Moreover, we expected that for people with a high need for control the effect of perceived control on acceptability becomes stronger.

2.3.3 Type of road user

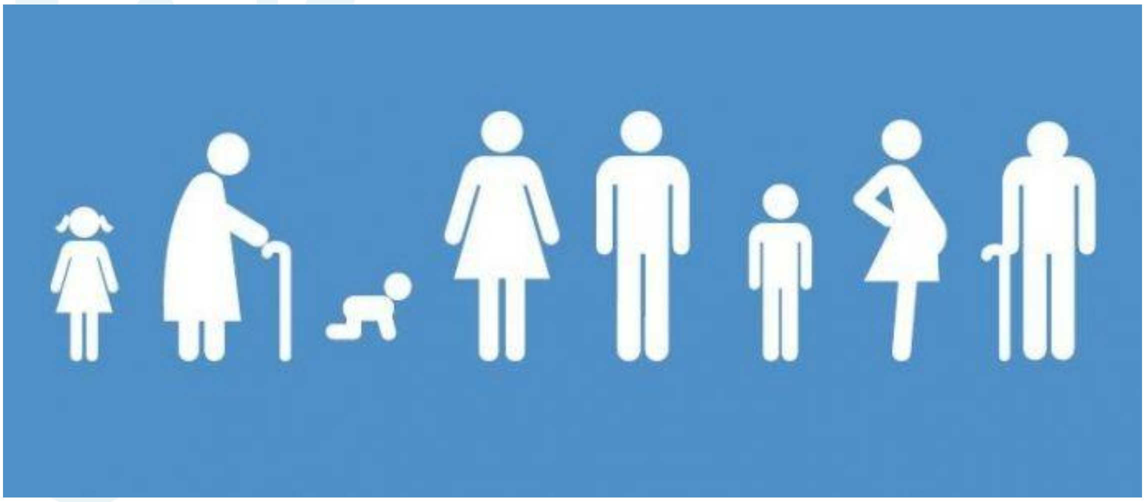


Figure 3. Different types of persons

What type of road user someone is may influence their perception of CAV. Potential users may be more focused on how CAV can meet their driving needs, while potential other road users (such as cyclists and pedestrians) may be more focused on how to interact with CAV on the road. Moreover, car users may have different perceptions of what a car should be like or how it should behave.

Cyclists and pedestrians typically rely on non-verbal cues given by the car's driver (for example eye contact, waving a hand, and posture) to assess whether it is safe to cross the road (Deb, Rahman, Strawderman, & Garrison, 2018). When a computer system is controlling the car, non-verbal communication becomes impossible. Multiple times researchers have suggested that the inability to communicate with CAV as a pedestrian or cyclist could not only decrease perceived safety, but affect trust as well (Deb, Rahman, Strawderman, & Garrison, 2018; Habibovic et al., 2018; Deb, Strawderman, & Carruth, 2018). We therefore expected that those who frequently cycle may find CAV less safe, have less trust in CAV technology, and find CAV less acceptable. On the other hand, previous research has found that more experience with (CAV) technology leads to greater trust and perceived safety of CAV (e.g. Penmetsa et al., 2019). A qualitative study by Bennett, Vijaygopal, & Kottasz (2019) also indicated physically disabled people with an interest in technology had greater trust in CAV. We expected that interest in technology may play a moderating role, in that greater interest in technology weakens the effect of cycling frequency on perceived safety and trust.

Drivers, compared to non-drivers, expect that automated vehicles can enhance performance (Qu et al., 2019). The more driving experience a person has, the more often they drive, and the more often they have been involved in conventional car-based traffic crashes, the more likely they are to perceive automated vehicles as a safer alternative for their daily transportation (Montoro et al., 2019). We expected that driving frequency is linked to perceived safety. It has been found that people prefer manual control over automation if they believe that they are more capable of executing a behaviour themselves as compared to the automated system (Lee & Moray, 1994). This could impair their trust in an automated system such as CAV. As such, we expected that driving frequency will be associated with trust in CAV technology.

Previous research has found that more experience with (CAV) technology leads to greater trust and perceived safety of CAV (e.g. Penmetsa et al., 2019). A qualitative study by Bennett, Vijaygopal, & Kottasz (2019) also indicated physically disabled people with an interest in technology had greater trust in CAV. We expected that both technology interest and experience with car technology may moderate the effect of driving frequency on perceived safety and trust in CAV technology.

2.4 General overview of the proposed model

We expect that acceptability of CAV is predicted by attributes of CAV (perceived characteristics), the perceived adoption norm, and perceived behavioral control. Attributes, in turn, are predicted by individual differences. Lastly, we expect that acceptability and acceptance are related. Please refer to Figure 4 for a schematic overview.

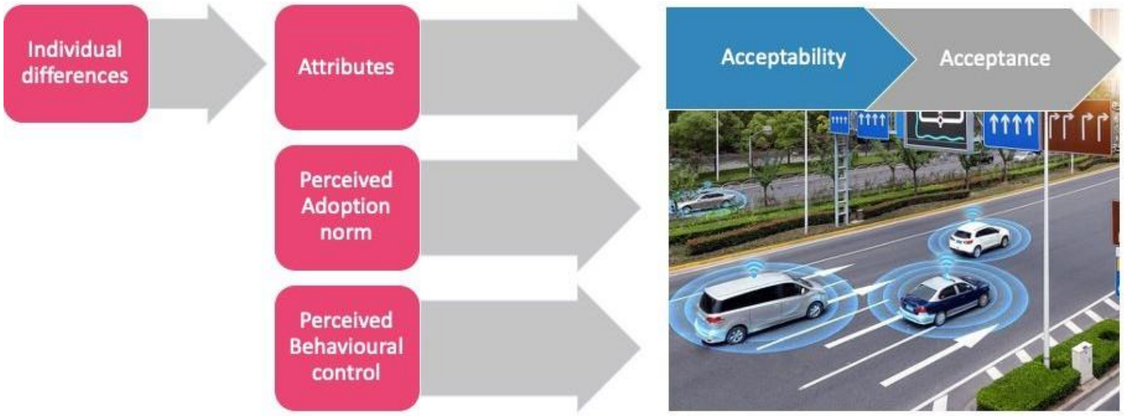


Figure 4. Overview of the proposed model of acceptance of CAV

3. FOCUS GROUPS

In order to assess if other psychological factors could influence acceptability of CAV that were not found in the current literature (D1.1), several focus groups were held. They took place from late 2019 to early 2020. Several partners participated: RuG, IBV, IFSTTAR, CRF, and VED. The total sample size was 70, and included participants from Spain, Italy, France, and the Netherlands.

Figure 5. Development scheme of the psychological acceptance model

3.1 Method

3.1.1 Procedure and questionnaire

RuG provided all partners with a script and questionnaires. Each partner translated the questionnaires to their own language. IFSTTAR provided everyone with a short movieclip (around 3 minutes in length) to show participants what driving in a CAV is like. Ethical approval for conducting the focus groups was given by the Ethical Committee of Psychology of the RuG. Some partners obtained additional ethical approval from their own ethical committees.

Participants were first given an information form, detailing what the aims of the study were and what was expected of participants, and an informed consent form. After signing the informed consent form participants completed a short questionnaire individually. The questionnaire contained questions related to demographics, driving behavior, in-car technology use, and interest in technology (scale adapted from Haboucha, Ishaq, and Shiftan (2017)). After completing the questionnaire, participants introduced themselves and were asked what comes to mind when thinking about CAV. They were then shown the short movieclip, along with a neutral description of CAV. After this, participants individually filled out short questionnaires, alternated by rounds of discussion. Qualitative results were obtained in two ways during the focus groups: (1) participants could write any comments they had after each section and (2) participants discussed each topic within their group. Group discussions were led by the test leaders, who had received several discussion questions on each topic beforehand. Several topics were discussed in this manner: (1) acceptability, (2) safety, risk, and trust, (3) convenience, pleasure, and comfort, (4) perceived benefits and costs, and motives, (5) control, (6) ethical and legal issues, (7) importance of different characteristics of CAV and conclusions. The focus groups followed the method of Focus Group based-on Collective Questionnaire Sessions (FoG-CoQS) developed by Bellet, Paris, and Marin-Lamellet (2018).

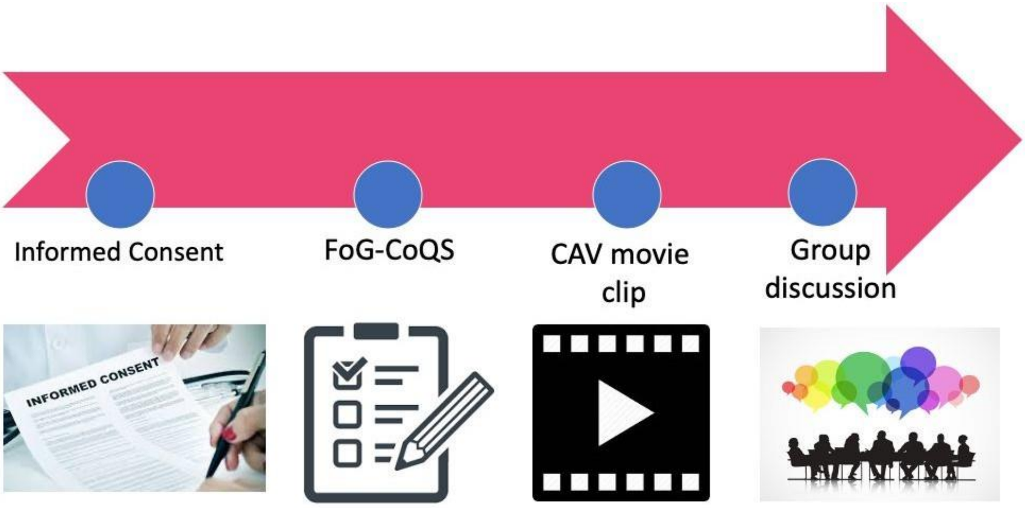


Figure 6. Focus groups timeline.

Due to COVID-19 and the lockdown in the Netherlands, RuG conducted the focus groups online in a survey-like matter, and discussion rounds were omitted. Participants received the same questions and were randomly shown the part of the movieclip in an urban context of the part of the movieclip in a highway context.

3.1.2 Sample

All partners collected data from normal middle aged drivers, additionally, partners assessed specific vulnerable road user groups i.e. cyclists, pedestrians, anxious drivers/low experienced drivers, older passengers, younger passengers, and persons with physical disabilities.

The total sample consisted of 70 participants, with a mean age of 40.84 (the youngest participant was 20 years old, and the oldest was 71 years old). Most participants were male (61.4%), and had a university degree (47.1%). For an overview of the sample per category, please refer to Table 1 below. Please note participants may fall into multiple categories (for example, both middle aged drivers and high frequency drivers).

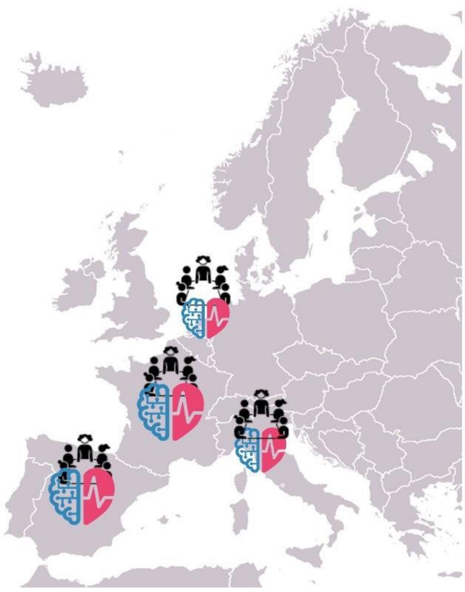


Figure 7. Focus groups participating countries (i.e. Netherlands, Spain, France and Italy).

Table 1. Focus group sample overview.

Participant type	N	Age (range / mean)	Gender (women / men)
Young drivers	21	20-30 / 26	8 / 13
Middle aged drivers	32	31-54 / 39	13 / 19
Older drivers	17	56-71 / 64	6 / 11
Anxious drivers / Low frequency drivers	26	24-67 / 42	12 / 14
High frequency drivers	32	20-72 / 44	10 / 22
VRUs (Disabled persons, pedestrians, and cyclists)	21	24-67 / 44	8 / 13

3.2 Results

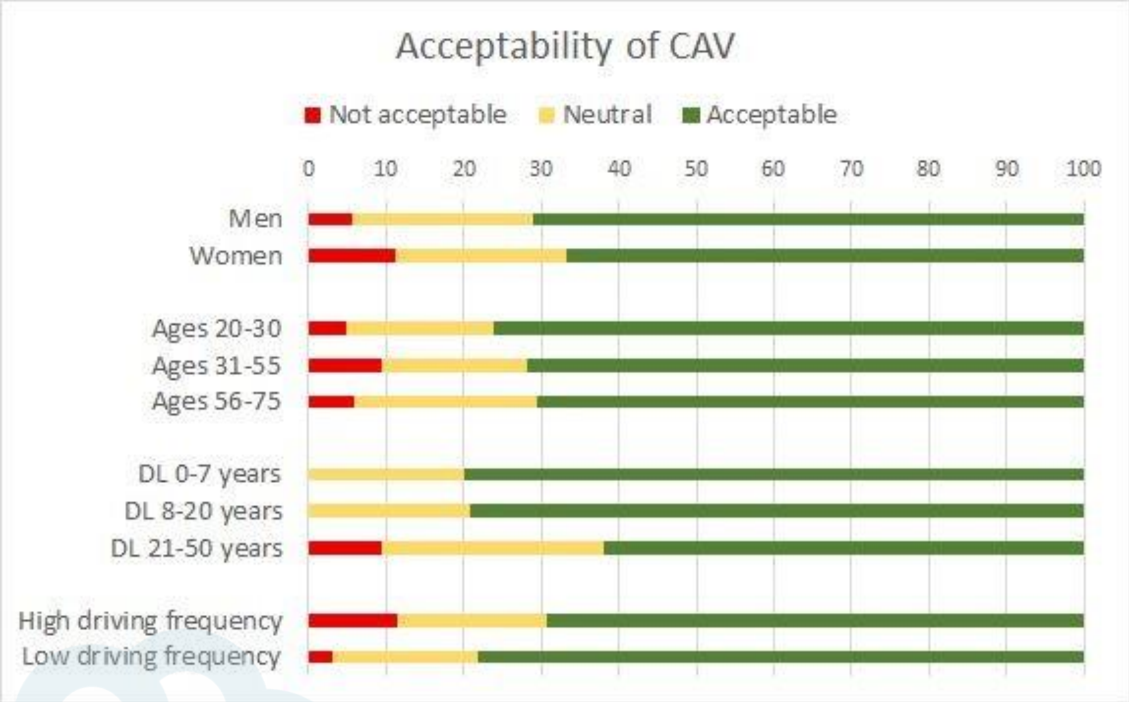
3.2.1 Individual differences

Acceptability of CAV was measured at three different points: before participants watched the movie and read the description, right after reading the description and watching the movie, and again after the group discussions. To assess acceptability, we took the mean of all these measurement points.

3.2.1.1 Age, gender, and driving experience

To examine acceptability based on participants' age, three age groups were created. The youngest group consisted of participants between the ages of 20 and 30 (30% of the sample), the middle age group consisted of participants between the ages of 31 and 55 (46% of the sample), and the oldest age group consisted of participants between the ages of 56 and 75 (24% of the sample). In order to compare the effects of driving experience on acceptability, three sub-groups were created. Namely an in-experienced group who had had their driver's license for less than a year to 7 years (18% of the sample), an experienced group who had had their driver's license for 8 to 20 years (44% of the sample), and a greatly experienced group who had had their driver's license for 21 to 50 years (38% of the sample). Although the cut-offs for these groups are arbitrary, we tried to create groups that had enough participants in them for comparison. To compare high frequency and low frequency drivers, we created two subgroups in which those who scored below average on driving frequency were categorized as low frequency drivers and vice versa.

Men, younger participants, participants with less driving experience, and low frequency drivers appear to be more accepting of CAV than women, older participants, participants with more driving experience, and high frequency drivers (please refer to Graph 1).

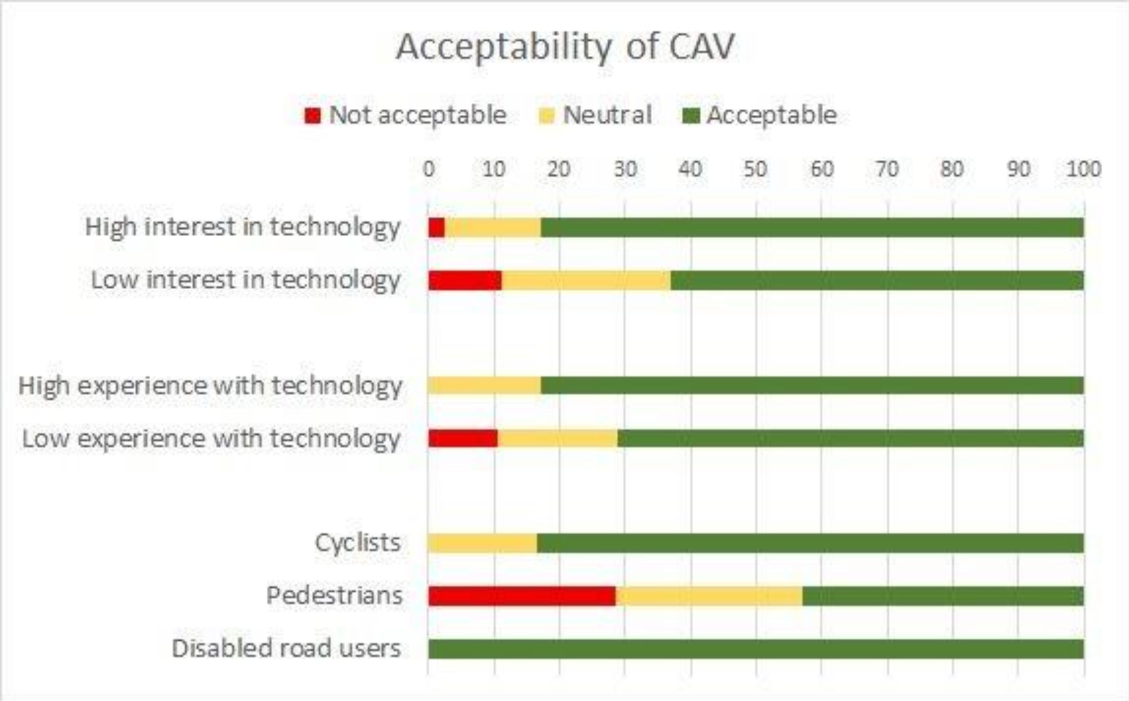


Graph 1. Acceptability of CAV, based on gender, age, and driving experience

3.2.1.2 Technology interest, experience with car technology, and vulnerable road user groups

We categorized participants as high or low interest in technology based on if they scored higher or lower than the average on the technology interest scale. Participants answered several questions on which in-vehicle technologies they had and how often they used those technologies. Based on this, we also categorized participants as high or low experience with car technology based on if they scored higher or lower than the average on this scale. Finally, we looked at three distinct vulnerable road user groups: pedestrians, cyclists, and participants with physical disabilities.

CAV is more acceptable for participants with a high interest in technology, with more experience with car technology, and for cyclists and disabled road users than for participants with low interest in technology, with less experience with car technology, and pedestrians (please refer to Graph 2).



Graph 2. Acceptability of CAV, based on technology interest, experience with car technology, and for vulnerable road user groups

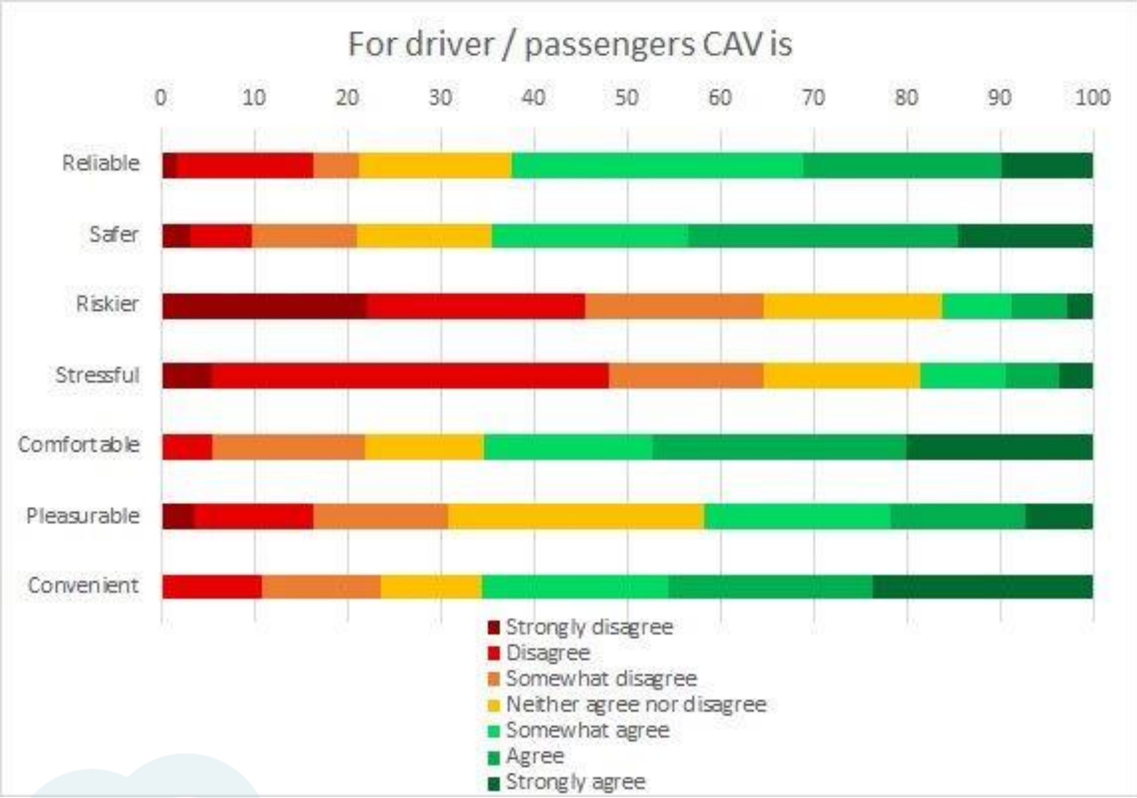
3.2.2 Perceived characteristics (attributes)

3.2.2.1 Safety, risk, and trust

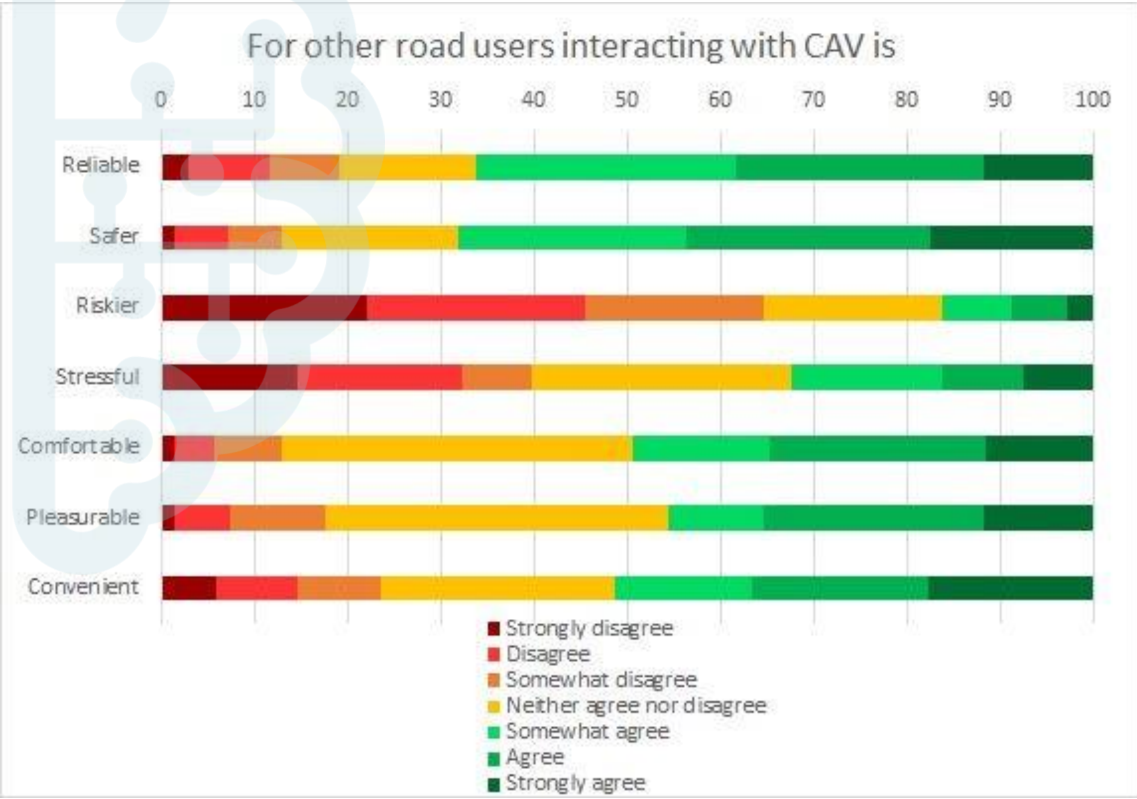
Participants were asked questions related to safety, risk, and trust for both the driver/passengers of CAV and other road users interacting with CAV. Participants generally believed that CAV, in comparison with a manual vehicle, would be safer, less riskier, and more reliable for both driver/passengers and other road users (please refer to Graph 3 and 4).

3.2.2.2 Convenience, pleasure, and comfort

Participants were asked questions related to convenience, pleasure, and comfort for both the driver/passengers of CAV and other road users interacting with CAV. Participants generally believed that CAV, in comparison with a manual vehicle, would be more convenient, more comfortable, and less stressful but also less pleasurable for driver/passengers. For other road users, interacting with CAV is believed to be slightly more convenient, comfortable, and pleasurable, and slightly less stressful than interacting with a manual vehicle, or participants expect no difference between the two (please refer to Graph 3 and 4).



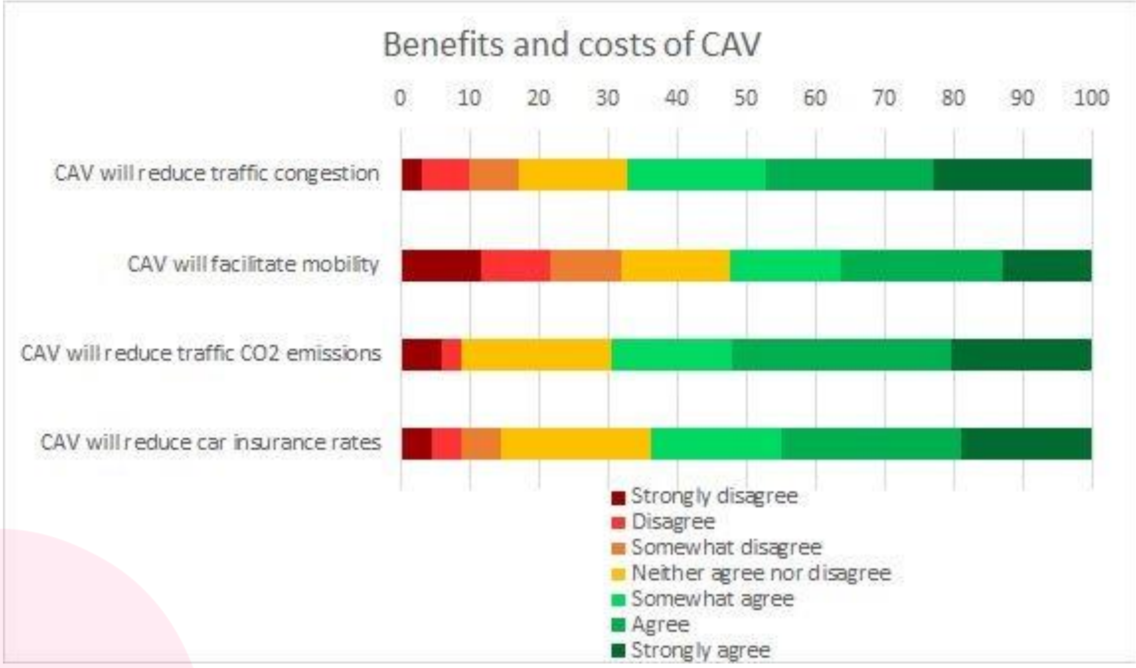
Graph 3. Perceived characteristics of CAV for driver / passengers



Graph 4. Perceived characteristics of CAV for other road users

3.2.3 Perceived benefits and costs, and motives

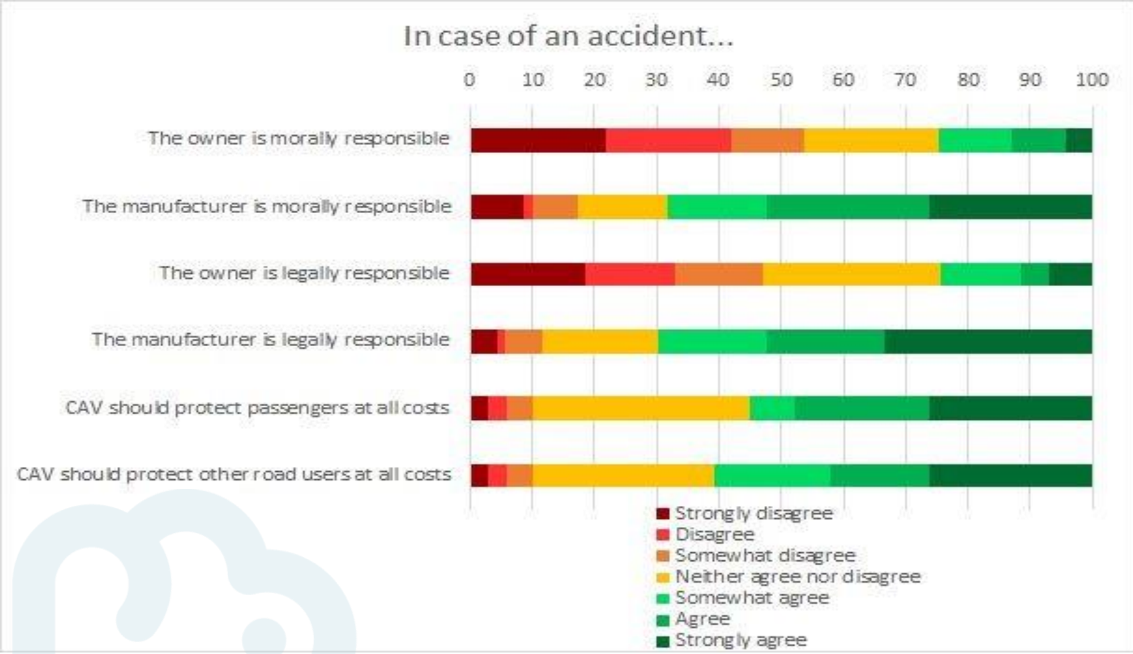
Participants were asked some questions about potential costs and benefits of CAV. They were positive about CAV's potential to reduce car insurance rates, traffic congestion, and traffic CO_2 emissions. Slightly more than half of the drivers were positive that CAV could facilitate their mobility (please refer to Graph 5).



Graph 5. Benefits and costs of CAV

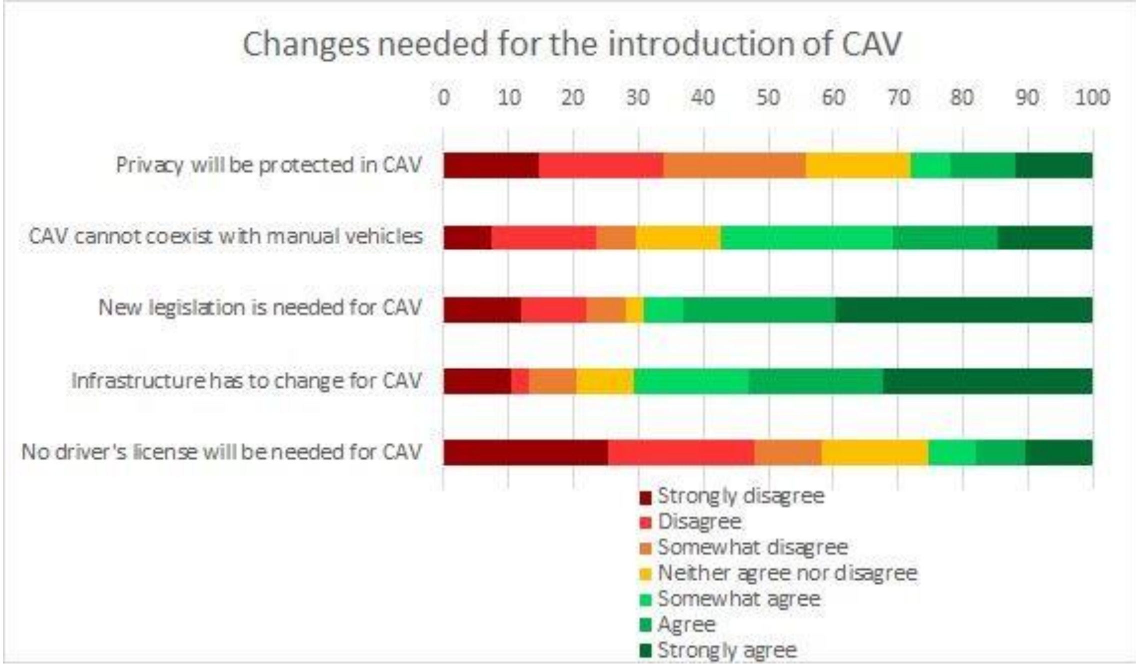
3.2.4 Ethical and legal issues

Participants were asked who would be responsible in case of an accident in which a CAV is involved. The general tendency was to keep the manufacturer both legally and morally responsible. Participants were also asked who CAV should protect in case of an accident. These questions proved difficult, because participants wanted to both protect passengers and other road users at all costs (please refer to Graph 6).



Graph 6. Issues regarding an accident in which CAV is involved

Finally, participants were asked some questions about how the introduction of CAV could lead to various changes. First, participants did not think that CAV and manual vehicles should coexist on public roads. Secondly, participants were worried that their privacy would not be protected in CAV. Thirdly, participants believed that both new legislation and changes in the current infrastructure are required before CAV is introduced. Lastly, participants believed that a driver's license will still be required for CAV. Please refer to Graph 7.



Graph 7. Changes needed for the introduction of CAV

3.2.4 Qualitative results (discussions)

Some concerns participants had and expressed, as well as the topics with the most heated discussions will be reported below.

To start with, participants are worried about having both manual and autonomous vehicles on the road at the same time. They think dedicated lanes for autonomous vehicles would be better if the traffic is a mix of manual and autonomous vehicles. Other participants think they should not coexist at all. Most participants believe the infrastructure has to change (drastically) to accommodate CAV.

Participants point out that autonomous transportation already exists, namely airplanes. However, they agree autonomous transportation by car may be more difficult to achieve.

In terms of safety, there is no consensus on the safety of autonomous vehicles. Some believe they themselves are better drivers than autonomous vehicles. For example, one participant commented that they could see a pedestrian earlier than a sensor could detect them. This participant believes the gain in safety from autonomous vehicles would come mainly from preventing inexperienced drivers to drive manually. Other participants do believe autonomous vehicles are safer than manual vehicles under all conditions and are capable of detecting people and objects quicker than a human could see them. An autonomous vehicle is never distracted or fatigued like a human driver. Some think a person can react better in non-common situations, while an autonomous vehicle can react better in common situations. In common situations, the CAV's behavior will be more predictable than a manual car, which could also be more convenient for other road users.

Many other road users said it is important to know which vehicle is a CAV and which is a manual vehicle. A sticker or logo could be used for this. Some participants indicate they want to receive a signal when the CAV has detected them (as pedestrian or cyclist). Other participants dislike not being able to communicate with the driver, which makes some participants feel unsafe.

While many participants believed the driving pleasure would be (almost) completely lost, they think autonomous vehicles will eliminate stress factors and increase comfort for passengers. Other participants indicate driving autonomously would increase their stress, especially at the beginning. The stress could decrease if everything goes well. Many indicate the stress response depends mainly on trust in the vehicle: if they trust the vehicle, it will not lead to more stress.

In terms of legal liability, a few participants indicate legal liability of the vehicle owner could depend on maintenance. If the vehicle is poorly maintained, the owner is legally responsible; otherwise the manufacturer is responsible. Most participants think the legislation must drastically change to make legal liability clear. A few participants think the passengers would still to some extent be morally responsible in case of an accident, even if the passengers are not legally responsible. In case of an emergency, many participants believe the CAV should not prioritize the passengers over other road users. They think the CAV should be 'neutral'. Others think CAV should prioritize passengers, just like a manual driver would.

In a related vein, some participants think a new type of driver's license will be required for CAV. In order to get the license, people should learn how to operate a CAV, how the administration works, and what to do in case of an error.

Even if the vehicle is 100% autonomous, some drivers would still like to be able to take over control. On the other hand, some participants indicated a normal driver's license will be required if the possibility of taking over control remains. This would mean an autonomous vehicle cannot facilitate the mobility of persons who are unable to get a normal driver's license. Others also indicate to like the idea of CAV when they are tired or have been drinking, in which cases they would normally not drive.

In terms of environmental sustainability of CAV, most participants do not think about how CAV could reduce CO_2 emission by driving closer to each other (platooning) than manual cars or by reducing traffic jams. As such, most participants think electric cars would be better to reduce CO_2 caused by traffic. They also fear an increase in mobility will increase traffic and congestion, which will in turn increase CO_2 emission. Some suggest making CAV electric.

One of the potential issues of CAV is the sharing of data. Most participants believe the sharing of data is not problematic, as long as private data is not shared. Only data needed for the algorithms (and that helps society) and data that is anonymous should be shared. If privacy cannot be guaranteed, CAV may not be acceptable to several participants.

3.3 Conclusion

The focus groups show that people see both potential benefits and drawbacks of CAV. The main benefits that people expect are an increase of safety, convenience and comfort, mainly for the driver/passengers. The main drawbacks that people expect are a loss of driving pleasure, control, and privacy (through data-sharing). While these themes were also present in the literature review (D1.1), some other themes were discussed in the focused groups as well. For instance, some participants were actively thinking about the environmental impact of CAV and indicated they would find CAV more acceptable if it was electric. Some participants also indicated seeing CAV as a status-product, for example by stating CAV would be expensive and should not be available to everyone. Based on these results of the focus groups, we decided to add two new attributes to the model: perceived environmental sustainability and perceived status-enhancement.

Aside from benefits and drawbacks, other issues were discussed. People believe changes are needed to incorporate CAV: the infrastructure has to be adapted, new legislation will be needed, and a clear division of responsibility in case of an accident has to be made. Moreover, a co-existence of CAV and manual vehicles is not desirable. Some drivers overestimate their own driving skill, leading to lower acceptability of CAV. Other road users want some way to communicate with the 'driver', or at least want to know which vehicle is driving autonomously. Overall, only a small portion of the participants was vehemently against CAV, while most participants were slightly on the positive side.

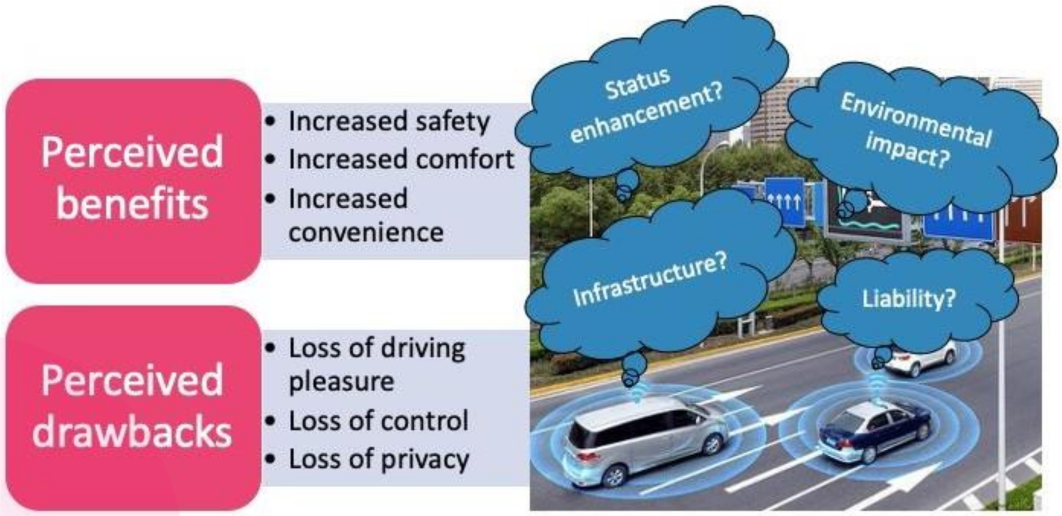


Figure 8. Focus groups outcomes.

4. LARGE SCALE SURVEY

Figure 9. Development scheme of the psychological acceptance model

Using the literature review conducted for deliverable 1.1 and the results from the focus groups as input, a large scale survey was conducted in April 2020. In this survey, all potential psychological factors influencing acceptability of CAV were measured to determine their significance and strength. The results of this survey were used to build a psychological model that predicts the acceptability of CAV. A third party, Dynata, was hired to collect the data (final sample *N* = 3783) in six European countries: the Netherlands, the United Kingdom, Germany, France, Spain, and Italy.

4.1 Method

4.1.1 Summary of concepts and hypotheses

In the large scale survey we included concepts found in the literature review (D1.1), the focus groups (section 2), and existing models that explain behavior.

4.1.1.1 Perceived characteristics

First, the perceived characteristics that could influence acceptability of CAV were defined. In D1.1, we defined 5 perceived characteristics found in the current literature. These are perceived control (the belief one will have control over the vehicle's behavior), perceived safety (the belief the vehicle will be safe), trust in CAV technology (the belief the vehicle will behave as intended), perceived convenience (the belief the vehicle will meet the user's driving needs), and perceived pleasure (the belief driving in CAV will be pleasant). Two additional perceived characteristics were added after the focus groups (see 3.3): perceived environmental sustainability (the belief CAV will be environmentally friendly) and perceived status-enhancement (the belief owning or driving CAV will increase one's status). We expected that all perceived characteristics influence acceptability.

4.1.1.2 Individual differences

Second, the individual differences that could influence the perceived characteristics were defined. We included the four major values: egoistic, altruistic, hedonistic, and biospheric values. The need for control, interest in technology, experience with car technology, cycling and driving frequency, and whether the participant had some type of disability that prevented them from driving were included as well. We expected that individual differences will influence the perceived characteristics, and may play moderating roles as well.

4.1.1.3 Other variables used in existing models

Lastly, we added additional variables that are included in existing models that predict behavior. We examined the Theory of Planned Behavior (TPB), a very general model that explains intentions and behaviors, the Technology Acceptance Model (TAM), a model that explains acceptance of technological innovations, and the extended Instrumental, Symbolic, and Environmental (ISE) model, a model that explains adoption likelihood of sustainable innovations.

We included perceived behavioral control (the belief as to how easy or difficult it would be to perform the behavior), which is used in both TPB and TAM, expected adoption norm (what percentage of close others the person believes will adopt CAV), which is used in both TPB and ISE, and the moderating effect of expected adoption norm from ISE.

4.1.2 Procedure and questionnaire

The large scale survey was conducted as an online questionnaire. The survey was translated by a professional translator of Dynata to all languages, and the translations were checked by the partners (native speakers). Participants first received information about the study's aims and what was expected of them, and they were asked for informed consent. After giving consent, the survey started.

Participants were first asked about their values to measure egoistic, altruistic, hedonistic, and biospheric values (Schwartz, 1992), using the same methodology as Steg, Perlaviciute, van der Werff, and Lurvink (2012). Next, participants were given a short neutral description of what a CAV is, followed by 21 statements to which they could agree or disagree (7-point Likert scales). The statements assessed different characteristics of CAV: (1) perceived control, (2) perceived pleasure, (3) perceived safety, (4) perceived convenience, (5) trust in CAV technology, (6) perceived status-enhancement, and (7) perceived environmental sustainability. The statements were adapted from existing literature or created for this survey. Participants were also asked to indicate how important each characteristic of CAV is to them.

Next, participants were asked about their driving and cycling behavior, use of in-car technology, interest in technology (scale adapted from Haboucha, Ishaq, and Shiftan, 2017), their perceived behavioral control, what percentage of their friends and family they expected to adopt CAV, acceptability of CAV (scale adapted from De Groot and Steg, 2007), need for control (scale adapted from Burger and Cooper, 1979), and demographics. Finally, participants were thanked and could leave any comments they had.

4.1.3 Sample

In total, we aimed at about 650 valid responses per country (total *N* ~ 3900). In total, 7600 responses were collected. Responses were excluded from the sample if: (1) they completed less than 80% of the survey, (2) they completed the survey in under 3 minutes (estimated time of completion was 10-15 minutes), (3) they clicked the same answer on each question (straightlining) on questions where they were explicitly asked to include variation in their answers or on reverse-coded questions, (4) they left nonsense (such as random words or numbers, or comments that clearly indicated they did not fill out the survey seriously) in the comment box in combination with signs of straightlining. The final sample consisted of 3783 participants in total (the Netherlands: 637, the United Kingdom: 630, Germany: 626, France: 625, Spain: 637, and Italy: 628).

Participants' age ranged from 18 to 72 years old, with a mean of 42.8 years, and is relatively evenly spread (20.7% is 30 or younger, 19.8% is 55 or older). In total 50.9% of participants is female, and 0.9% (34 participants) have at least one physical disability due to which they cannot drive. The largest group (37.5%) has a university education or higher, followed by secondary vocational education (25.3%), higher professional education (21.2%), high school (14.9%), and finally elementary school or less (1.1%). In terms of car usage, 7.4% does not have a driver's license, 72.7% owns a car, 32.2% drives every day, and 13% drives rarely (a couple of times a month or less). For an overview of the sample per country, please refer to Table 2 below.

Figure 10. Large scale survey participating countries (i.e. United Kingdom, Germany, Netherlands, Spain, France and Italy).

Table 2. Large scale survey sample overview

Country	N	Percentage of women	Age (range / mean)	Largest education level group	Percentage of drivers	Participants with disabilities
United Kingdom	630	51.9%	18-65 / 43	University or higher, 43.5%	82.0%	1.6%
The Netherlands	637	50.7%	18-72 / 44	Secondary vocational education, 36.1%	86.6%	1.4%
Germany	626	49.4%	18-65 / 43	Secondary vocational education, 45.0%	89.1%	1.8%
France	625	49.6%	18-70 / 43	University or higher, 45.4%	92.6%	0.2%
Spain	637	49.3%	18-70 / 43	University or higher, 51.3%	92.3%	0.3%
Italy	628	51.4%	18-67 / 42	University or higher, 39.6%	94.6%	0.2%

4.2 Results

We analyzed the data to test our proposed model. The result section of the large scale survey is structured in the following manner:

1. Reliability of used scales (4.2.1); to test some concepts we created our own scales, we tested if these scales were reliable.
2. General inspection of the data (4.2.2); we looked at how participants rated CAV in general and the mean scores are reported.
3. Confirmatory Factor Analysis (CFA) (4.2.3); we hypothesized that attributes are divided into 7 independent variables, namely the perceived characteristics. We performed a CFA to test whether or not they are independent factors.
4. Perceived characteristics (attributes) influencing acceptability (4.2.4); we tested the first part of the model, namely that attributes influence acceptability. We examined all perceived characteristics separately, as well as together.
5. Individual differences influencing attributes (4.2.5); we tested the second part of the model, namely that individual differences (values and need for control) influence attributes.
6. Differences between user groups (4.2.6); CAV should be acceptable for all kinds of different user groups. We analyzed acceptability, attributes, and importance of attributes among several user groups.
7. Perceived adoption norm (4.2.7); we tested the third part of the model, namely that perceived adoption norm can act as a moderator.
8. The test of the full model is presented in section 5.

4.2.1 Reliability of used scales

In the large scale survey we adapted items from existing literature to form scales and also created some items specifically for the survey. With Cronbach's Alpha we examined if these items formed reliable scales and have good internal consistency. The results are presented in the table below. Most scales have good (0.7 - 0.8), very good (0.8 - 0.9) or excellent (> 0.9) internal consistency (Tavakol & Dennick, 2011).

Table 3. Reliability of scales in the large scale survey

Scale	Number of items	Cronbach's Alpha
Acceptability	4	0.959
Hedonism	4	0.800
Altruism	4	0.810
Egoism	4	0.757
Biospherism	4	0.901
Need for control	3	0.679
Interest in technology	4	0.794

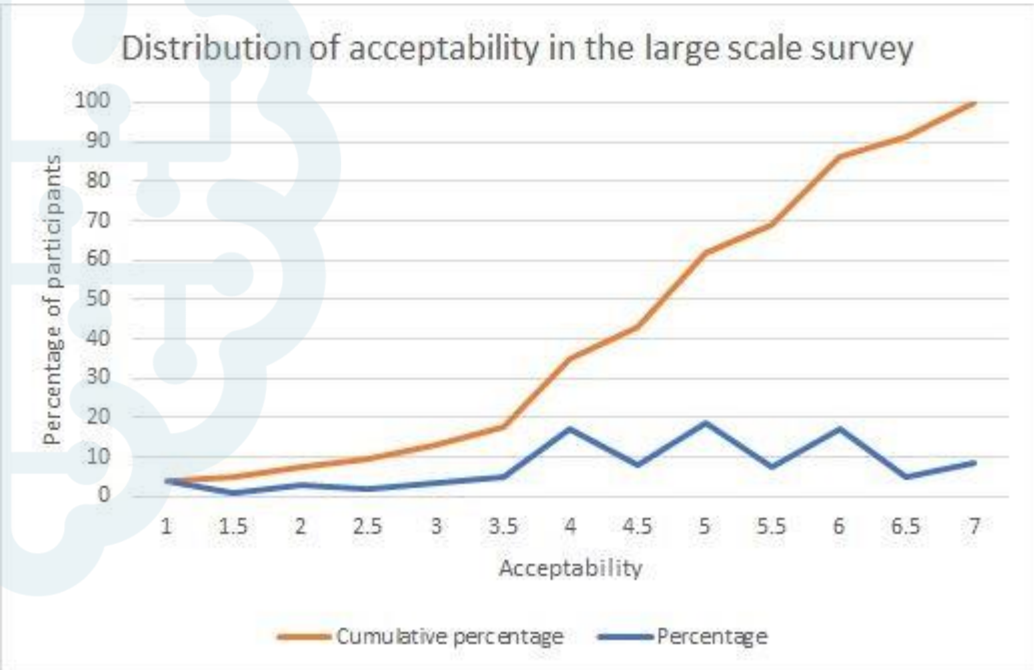
Experience with car technology	8	0.896
Perceived control	3	0.666
Perceived pleasure	3	0.795
Perceived safety	3	0.729
Perceived convenience	3	0.877
Trust in CAV technology	3	0.885
Perceived status-enhancement	3	0.923
Perceived environmental sustainability	3	0.943

4.2.2 Mean scores

4.2.2.1 Acceptability of CAV

The mean acceptability of CAV is 4.7 on a scale from 1 (completely unacceptable) to 7 (completely acceptable), meaning the participants were slightly positive towards CAV. The distribution (graph below) shows the acceptability is skewed to the positive side.

Graph 8. Distribution of acceptability in the large scale survey

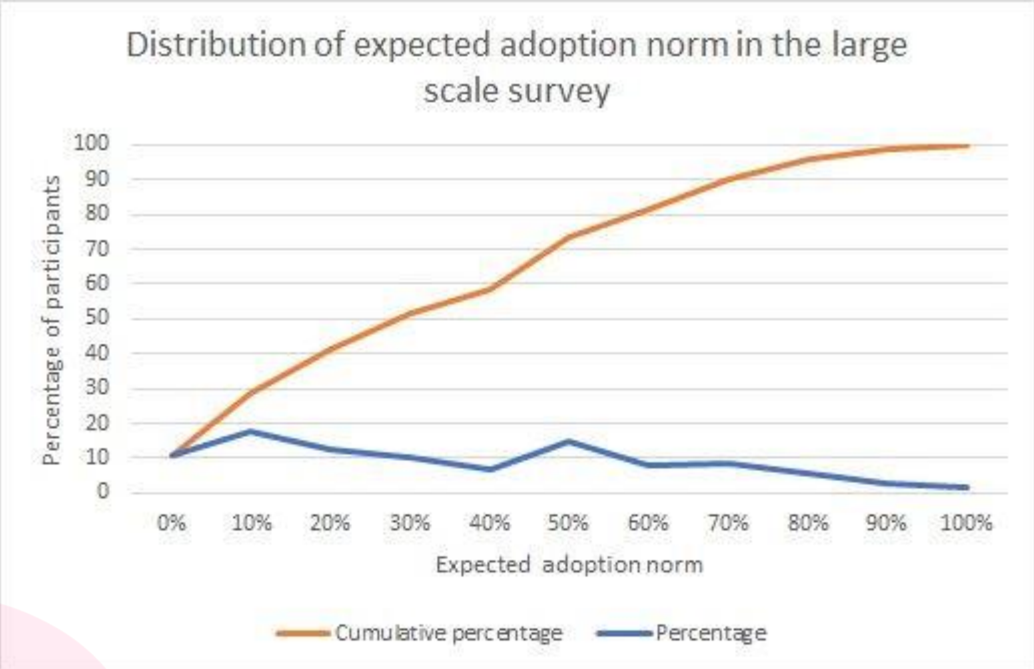


4.2.2.2 Expected adoption norm

Participants were asked what percentage of significant others (family, friends, co-workers, etc.) would adopt CAV when they become available. This question was answered on a 11-point Likert scale ranging from 1 (0%) to 11 (100%). The mean expected adoption norm was 4.7

(~35%). The distribution was skewed to the negative side, meaning participants generally did not think CAV would be widely adopted (for example, 80% of participants expected an adoption norm below 60%).

Graph 9. Distribution of expected adoption norm in the large scale survey



4.2.2.3 Perceived characteristics of CAV

In the large scale survey several perceived characteristics were measured: perceived control, perceived pleasure, perceived safety, perceived convenience, trust in CAV technology, perceived status-enhancement and perceived environmental sustainability. In the table below the mean scores and standard deviations for the perceived characteristics of the full sample are displayed. The scales ranged from 1 to 7, in which for example a low score on perceived safety indicates that participants do not think CAV is safe. As can be seen in the table, participants rated CAV the highest on environmental sustainability, and the lowest on status-enhancement. Participants were neither very positive nor negative about the aspects of CAV.

Table 4. Means and standard deviations of the perceived characteristics of CAV for the full sample

Perceived characteristic	Mean	SD
Perceived control	3.670	1.280
Perceived pleasure	3.912	1.365
Perceived safety	4.133	1.211
Perceived convenience	4.249	1.505
Trust in CAV technology	4.378	1.555

Perceived status-enhancement	3.411	1.630
Perceived environmental sustainability	4.480	1.431

4.2.2.4 Importance of perceived characteristics

Aside from asking participants how they perceived CAV, they were also asked to indicate how important each perceived characteristic was to them. In the table below the mean scores and standard deviations for the importance ratings of the full sample are displayed. The importance ratings were asked on a scale from 1 to 7, in which lower scores indicate less importance. As can be seen in the table, participants rated all characteristics as very important, except for status-enhancement.

Table 5. Means and standard deviations of the importance of characteristics of CAV

Characteristic	Mean	SD
Importance of control	6.07	1.15
Importance of pleasure	5.21	1.59
Importance of safety	6.45	1.02
Importance of convenience	5.63	1.25
Importance of trust in CAV technology	6.07	1.14
Importance of status-enhancement	3.22	2.08
Importance of environmental sustainability	5.61	1.39

4.2.3 Confirmatory Factor Analysis of perceived characteristics

In order to test if the perceived characteristics each form distinguishable constructs, a confirmatory factor analysis was conducted in R with the lavaan package (Rosseel, 2012). The goal of the confirmatory factor analysis is to test if the attributes are all separate factors, in other words, that they are independent of each other.

Multiple items were skewed, ranging from -0.505 to 0.402. This violates the assumption that variables are normally distributed. As such, all items were log-transformed to correct for this skewness. A model was fit in which the items only loaded onto their latent variable (the perceived characteristic they should measure), using a robust maximum likelihood estimator. Additionally, we allowed for covariance between the residuals of the reverse coded items. The reasoning for this is that all reverse coded items had weaker correlations with the other items in their scale, indicating that participants either had difficulty understanding the reverse coded items, or did not read those items correctly. By allowing the residuals of all these reverse coded items to covary, it is possible to correct for the participants' misunderstanding of these items. This model was significant, χ^2 (df = 163) = 1837.992, p < .001. This model had a good fit, RMSEA = .052 [95% CI: .051 - .054], AIC = 61169.255, sample-size adjusted BIC = 61377.188.
The covariances between the reverse coded items were all significant, all p-values were smaller than .001, and z-values ranged from -8.599 to 14.143. The factors loadings of this

model can be seen in Table 6 below. The factor loadings of this analysis are not indications of how items should be weighed, because the analysis always forces the first item to be constrained to 1.

The results from this CFA show that the attributes are indeed independent factors, just as hypothesized.

Table 6. Factor loadings of the perceived characteristics

Perceived characteristic	Item	Estimate / SD	z	p
Perceived control	1	1.000		
	2	0.726 / 0.052	13.929	<.001***
	3	0.640 / 0.054	11.854	<.001***
Perceived pleasure	1	1.000		
	2	1.452 / 0.047	30.886	<.001***
	3	1.404 / 0.048	29.165	<.001***
Perceived safety	1	1.000		
	2	0.719 / 0.023	30.605	<.001***
	3	0.730 / 0.026	28.344	<.001***
Perceived convenience	1	1.000		
	2	0.942 / 0.017	55.789	<.001***
	3	0.865 / 0.018	48.842	<.001***
Trust in CAV technology	1	1.000		
	2	0.974 / 0.016	59.317	<.001***
	3	0.994 / 0.019	51.513	<.001***
Perceived status-enhancement	1	1.000		
	2	1.068 / 0.013	82.267	<.001***
	3	1.034 / 0.014	72.880	<.001***
Perceived environmental sustainability	1	1.000		
	2	1.070 / 0.016	67.537	<.001***
	3	1.049 / 0.017	61.675	<.001***

The first item of each scale is always constrained to 1, *** = significant at the .001 level

4.2.4 Perceived characteristics influencing acceptability

In deliverable 1.1 we posited that how participants perceive CAV influences their acceptability of CAV. In the large scale survey several perceived characteristics were measured: perceived control, perceived pleasure, perceived safety, perceived convenience, trust in CAV technology, perceived status-enhancement and perceived environmental sustainability. Each perceived characteristic was measured using three items. To calculate the values for the perceived characteristics, we took the average of the all three items. Although we found in the CFA (4.2.3) that participants had had some difficulties with the reverse coded items, the scales were still reliable (see section 4.2.1 for Cronbach's Alpha scores).

First, separate regression analyses were run to investigate if each perceived characteristic indeed is related to acceptability. Different control variables were included per analysis, based on the literature review of deliverable 1.1. For a full overview of these separate analyses, please refer to Table 7 at the end of this paragraph. All analyses were run in two steps: in the first step the control variables were tested for their influence on acceptability, in the second step the perceived characteristic was added. This way, the added effect of the perceived characteristic could be estimated. In all following tables, we always show the results of the model of the second step. We only use the first step to estimate the additional effect the perceived characteristic has on top of the control variables.

4.2.3.1 Perceived control

First was tested if greater perceived control is associated with greater acceptability of CAV. Two control variables were included in this analysis: gender and experience with car technology. Howard & Dai (2014) found that women were more concerned with low control than males regarding self-driving cars. Kyriakidis, Happee, and de Winter (2015) found that drivers who have experience with automation technology in their cars (for example cruise control) perceived to have greater control over self-driving cars.

The model including the control variables was significant, F (df = 1, 3374) = 250.564, $p < .001$. Greater perceived control was related to greater acceptability, controlling for gender and experience with car technology. Please refer to Table 7 for the coefficients.

4.2.3.2 Perceived pleasure

Next was tested if greater perceived pleasure is associated with greater acceptability of CAV. Two control variables were included in this analysis: gender and age. Men anticipate more pleasure when thinking about self-driving cars (Hohenberger, Spörrle, & Welpe, 2016). Moreover, sensation seeking is higher among males and young people (Becker & Axhausen, 2017), which may be related to pleasure.

The model including the control variables was significant, F (df = 1, 3778) = 855.493, $p < .001$. Greater perceived pleasure was related to greater acceptability, controlling for gender and age. Please refer to Table 7 for the coefficients.

4.2.3.3 Perceived safety

It was tested if greater perceived safety is associated with greater acceptability of CAV. Two control variables were included in this analysis: education and age. In a previous study, older people rated the safety of self-driving cars higher than younger people (Gold et al., 2015), and people with a higher education rated self-driving cars as safer than people with lower education (Montoro et al., 2019).

The model including the control variables was significant, F (df = 1, 3772) = 627.856, $p < .001$. Greater perceived safety was related to greater acceptability, controlling for education and age. Please refer to Table 7 for the coefficients.

4.2.3.4 Perceived convenience

Following safety, it was tested if greater perceived convenience is associated with greater acceptability of CAV. Two control variables were included in this analysis: driving frequency and age. With age comes cognitive decline, which could make driving more difficult, and CAV more convenient (Gold et al., 2015). Moreover, compared to non-drivers, drivers believe self-driving cars are more useful, especially if they drive frequently and long distances (Qu et al., 2019; Shin, Tada, & Managi, 2019).

The model including the control variables was significant, F (df = 1, 3776) = 1251.652, $p < .001$. Greater perceived convenience was related to greater acceptability, controlling for driving frequency and age. Please refer to Table 7 for the coefficients.

4.2.3.5 Trust in CAV technology

Next was tested if greater trust in CAV technology is associated with greater acceptability of CAV. Two control variables were included in this analysis: experience with car technology and age. Gold and colleagues (2015) found that drivers with experience with automation car technology (such as cruise control) also trusted the technology of self-driving cars more. Two separate studies found that older people had greater trust in CAV than younger people (Regan et al., 2017; Schaefer et al., 2014).

The model including the control variables was significant, F (df = 1, 3373) = 644.367, $p < .001$. Greater trust in CAV technology was related to greater acceptability, controlling for experience with car technology and age. Please refer to Table 7 for the coefficients.

4.2.3.6 Perceived status-enhancement

It was tested if greater perceived status-enhancement is associated with greater acceptability of CAV. Two control variables were included in this analysis: gender and age. Status-seeking is higher among males and younger persons (Goldsmith, Flynn, & Kim, 2010).

The model including the control variables was significant, F (df = 1, 3778) = 371.005, $p < .001$. Greater perceived status-enhancement was related to greater acceptability, controlling for gender and age. Please refer to Table 7 for the coefficients.

4.2.3.7 Perceived environmental sustainability

Finally, it was tested if greater perceived environmental sustainability is associated with greater acceptability of CAV. Two control variables were included in this analysis: education and age. People with higher education and younger people are more likely to adopt sustainable innovations (for example Nguyen et al., 2019).

The model including the control variables was significant, F (df = 1, 3774) = 502.419, $p < .001$. Greater perceived environmental sustainability was related to greater acceptability, controlling for education and age. Please refer to Table 7 below for the coefficients.

In general, a greater β of the perceived characteristic implies a stronger effect on acceptability. To compare the strength of all perceived characteristics with each other, we performed a separate analysis in section 4.2.3.8.

Table 7. Separate regression analyses of perceived characteristics of CAV influencing acceptability of CAV

		β				
Perceived Control	Perceived control	0.332	18.315	< .001***	.182	.081
	Gender: Female	-0.118	-2.586	.010**		
	Experience with car technology	0.224	18.315	< .001***		
Perceived Pleasure	Perceived pleasure	0.674	48.942	< .001***	.405	.378
	Gender: Female	-0.240	-6.524	< .001***		
	Age	-0.001	-0.418	.676		
Perceived Safety	Perceived safety	0.807	55.607	< .001***	.466	.438
	Education: Elementary school	-0.403	-2.374	.018*		
	Education: High school	-0.200	-3.720	< .001***		
	Education: Vocational	-0.126	-2.766	.006**		
	Education: Professional	-0.056	-1.168	.243		
	Age	-0.006	-4.392	< .001***		
Perceived Convenience	Perceived convenience	0.688	59.978	< .001***	.499	.478
	Driving frequency	-0.020	-2.041	.041*		
	Age	0.002	1.138	.255		
Trust in CAV technology	Trust in CAV technology	0.505	37.116	< .001***	.364	.260
	Experience with car technology	0.122	9.164	< .001***		
	Age	-0.007	-4.557	< .001***		
Perceived Status-Enhancement	Perceived status-enhancement	0.415	31.328	< .001***	.228	.201

	Gender: Female	-0.154	-3.659	< .001***		
	Age	-0.003	-1.995	.046*		
Perceived Environmental Sustainability	Perceived environmental sustainability	0.606	45.499	< .001***	.372	.344
	Education: Elementary	-0.424	-2.306	.021*		
	Education: High school	-0.195	-3.361	.001***		
	Education: Vocational	-0.141	-2.851	.004**		
	Education: Professional	-0.084	-1.629	.103		
	Age	-0.006	-4.177	< .001***		

The reference category for gender is in all cases male, the reference category for education is in all cases university; * = significant at the .05 level, ** = significant at the .01 level, *** = significant at the .001 level.

4.2.3.8 All perceived characteristics

After confirming that all perceived characteristics separately influenced acceptability, a regression was run with all perceived characteristics predicting acceptability. This model was significant, F (df = 7, 3764) = 856.891, $p < .001$, $R^2 = .614$. All perceived characteristics, except perceived status-enhancement, were significantly positively associated with acceptability of CAV. Please refer to the table below for the coefficients and effect sizes of each individual perceived characteristic. The results indicate that the strongest predictors are perceived safety, perceived convenience, and perceived environmental sustainability.

Table 8. Coefficients and effect sizes of all perceived characteristics predicting acceptability

	β			η
Perceived control	0.035	2.684	.007**	.002
Perceived pleasure	0.127	7.341	< .001***	.014
Perceived safety	0.300	16.062	< .001***	.064
Perceived convenience	0.256	13.995	< .001***	.049
Trust in CAV technology	0.104	7.970	< .001***	.017
Perceived status-enhancement	-0.016	-1.293	.196	.000
Perceived environmental sustainability	0.200	14.412	< .001***	.052

** = significant at the .01 level, *** = significant at the .001 level.

4.2.5 Individual differences influencing perceived characteristics

As appeared from the literature review (see D1.1.), individual differences may influence how people perceive CAV. In the large scale survey we examined three types of individual differences that seem to be particularly relevant in studying their influence on CAV: values, the need for control, and what type of road user someone is. Differences between user groups are discussed in section 4.2.6.

Values

Values are guiding principles in life, that can affect beliefs, attitudes, and behaviors, and can color perceptions and cognitions (Schwartz, 1992). People's key values and what they deem important in life may also affect what they find important for CAV. In the large scale survey four major values were measured: (1) hedonic; striving for an exciting life, experiencing new things, enjoying life, (2) egoistic; striving for personal wealth, social power, dominance, (3) altruistic; striving for equality, social justice, peace, and (4) biospheric; striving for balance with nature, protecting the earth, preventing pollution (Steg & De Groot, 2012; Steg, Perlaviciute, Van der Werff, & Lurvink, 2014). We expected that different values are related to the importance of different characteristics of CAV. We expected that hedonic values may be related to the importance of convenience and pleasure, that egoistic values may be related to the importance of status-enhancement, that altruistic values may be related to the importance of safety, and that biospheric values may be related to the importance of environmental sustainability.

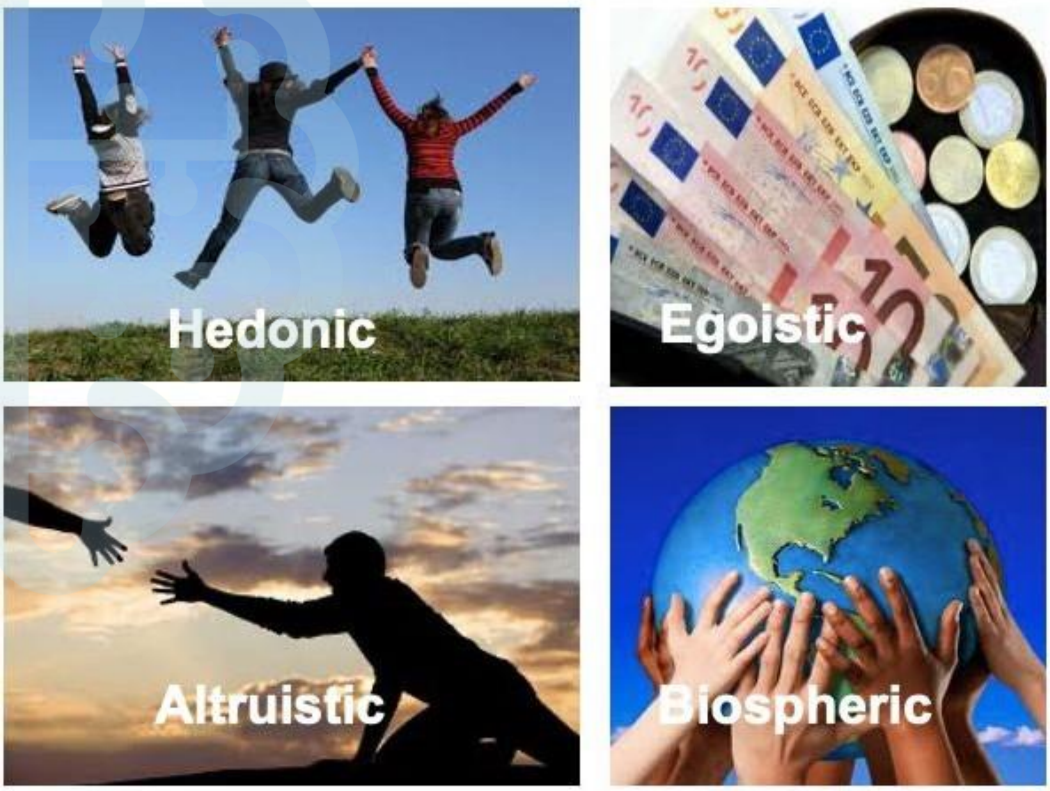


Figure 11. Four types of values.

Need for control

The second individual factor is the need for control. The belief that a person has control over the environment and events in one's life is vital for someone's well-being. The perception of control is both desirable, as well as a psychological necessity (Leotti, Iyengar, & Ochsner, 2010). People differ on a general level of motivation to control events, in other words the need for control is an individual difference (Burger & Cooper, 1979). The feeling of being in control is an integral part of driving. The lack of control over autonomous vehicles may decrease the acceptability of these vehicles (for example Howard & Dai, 2014). We examined if the need for control affected perceived control of CAV, and in turn affected acceptability.

4.2.5.1 Values

Separate regression analyses were conducted in which hedonistic, altruistic, egoistic, and biospheric values predicted the importance of characteristics of CAV. The results are in Table 9 below. We see that hedonic values indeed are related to greater importance of convenience and pleasure, that egoistic values are related to greater importance of status-enhancement, that altruistic values are related to greater importance of safety, and that biospheric values are related to greater importance of environmental sustainability. Aside from these expected effects, some additional effects of values were found. Most notably, egoistic values were related to less importance of safety, altruistic values were related to greater importance of convenience, control, trust in CAV technology, and pleasure.

Table 9. Importance of characteristics of CAV predicted by personal values

		β			
Importance of safety	Hedonistic	.082	6.271	<.001***	.154
	Altruistic	.184	10.870	<.001***	
	Egoistic	-.111	-10.364	<.001***	
	Biospheric	.087	5.699	<.001***	
Importance of convenience	Hedonistic	.139	8.573	<.001***	.133
	Altruistic	.179	8.526	<.001***	
	Egoistic	.011	0.804	.421	
	Biospheric	.078	4.100	<.001***	
Importance of control	Hedonistic	.092	6.264	<.001***	.138
	Altruistic	.175	9.092	<.001***	
	Egoistic	-.061	-4.958	<.001***	
	Biospheric	.116	6.687	<.001***	

Importance of environmental sustainability	Hedonistic	-0.057	-3.732	<.001***	.378
	Altruistic	.079	3.985	<.001***	
	Egoistic	.022	1.737	.083	
	Biospheric	.549	30.851	<.001***	
Importance of trust in CAV technology	Hedonistic	.082	5.532	<.001***	.133
	Altruistic	.154	8.068	<.001***	
	Egoistic	-.069	-5.661	<.001***	
	Biospheric	.132	7.678	<.001***	
Importance of pleasure	Hedonistic	.151	7.080	<.001***	.094
	Altruistic	.131	4.788	<.001***	
	Egoistic	.117	6.729	<.001***	
	Biospheric	.049	1.961	.050*	
Importance of status-enhancement	Hedonistic	-.013	-0.524	.600	.271
	Altruistic	-.053	-1.664	.096	
	Egoistic	.657	32.317	<.001***	
	Biospheric	.019	0.666	.505	

* = significant at the .05 level, *** = significant at the .001 level.

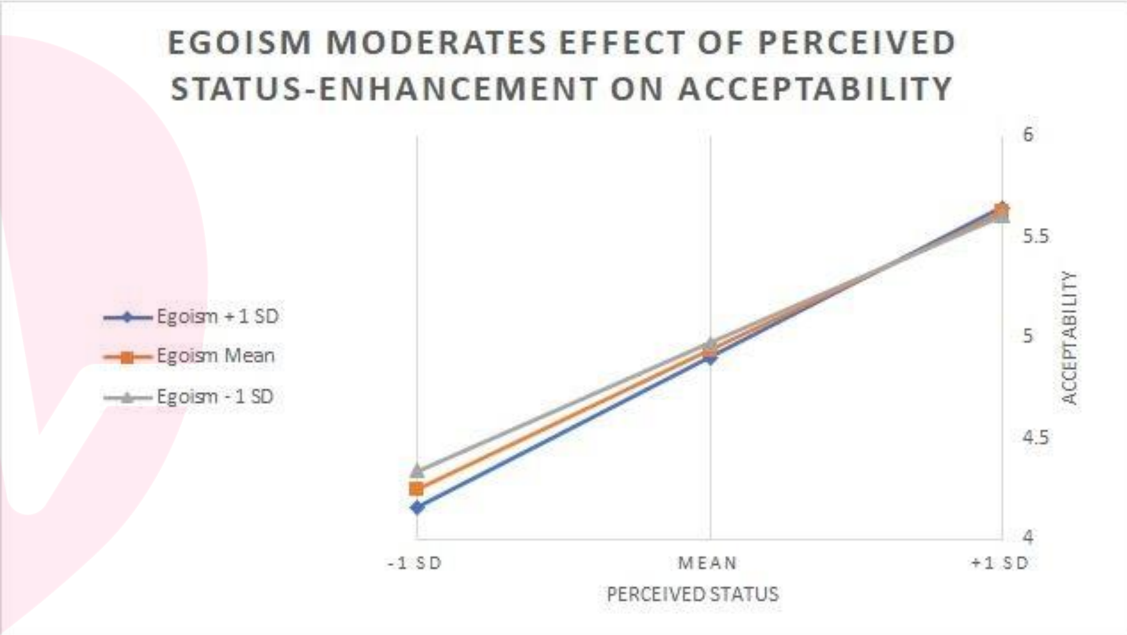
The results show that if the perceived characteristic and someone's values align, the perceived characteristic is more important to them. Please note that environmental sustainability is important to those with biospheric values, convenience and pleasure are more important to those with hedonic values, and status-enhancement is more important to those with egoistic values.

Next was assessed if people's values could moderate effects of perceived characteristics on acceptability. We expected that the perceived characteristics that are most important to people with specific values could moderate the effect of those perceived characteristics on acceptability. In other words, we expected that the effect of perceived characteristics is stronger when it aligns with a person's values. We restricted ourselves to testing the potential moderation effects to those with a theoretical basis and with strong effects on importance ratings. We first tested whether hedonic values moderate the effect of perceived convenience on acceptability. As control variables age and driving frequency were included (see 4.2.3.4). In step 1 of the regression analysis the control variables were entered predicting acceptability, in step 2 both hedonic values and perceived convenience were added, and in step 3 the interaction was added. The interaction is the moderating effect. We found that the interaction was not significant (β = -0.002, t (df = 3771) = -0.288, p = .773), meaning that greater hedonic values do not result in a stronger effect of perceived convenience on acceptability. However, both hedonic values (β = 0.047, t (df = 3772) = 3.962, p < .001) and perceived convenience (β = 0.681, t (df = 3772) = 58.588, p < .001) were significantly positively related to acceptability.

Second, we tested whether hedonic values moderate the effect of perceived pleasure on acceptability. As control variables age and gender were included (see 4.2.3.2). The interaction was not significant (β = -0.011, t (df = 3773) = 1.240, p = .215), meaning that greater hedonic values do not result in a stronger effect of perceived pleasure on acceptability. However, both hedonic values (β = 0.099, t (df = 3774) = 7.876, p < .001) and perceived pleasure (β = 0.662, t (df = 3774) = 48.172, p < .001) were significantly positively related to acceptability.

Third, we investigated whether egoistic values moderate the effect of perceived status-enhancement on acceptability. As control variables age and gender were included (see 4.2.3.6). Egoism moderated the effect of perceived status-enhancement on acceptability (β = 0.020, t (df = 3774) = 2.676, p = .007, R^2 of the moderation effect = .001). A graph of this moderation effect can be seen below. As can be seen, when perceived status-enhancement is low, people with great egoistic values rate CAV as less acceptable. However, when the perceived status-enhancement is high, CAV is always acceptable.

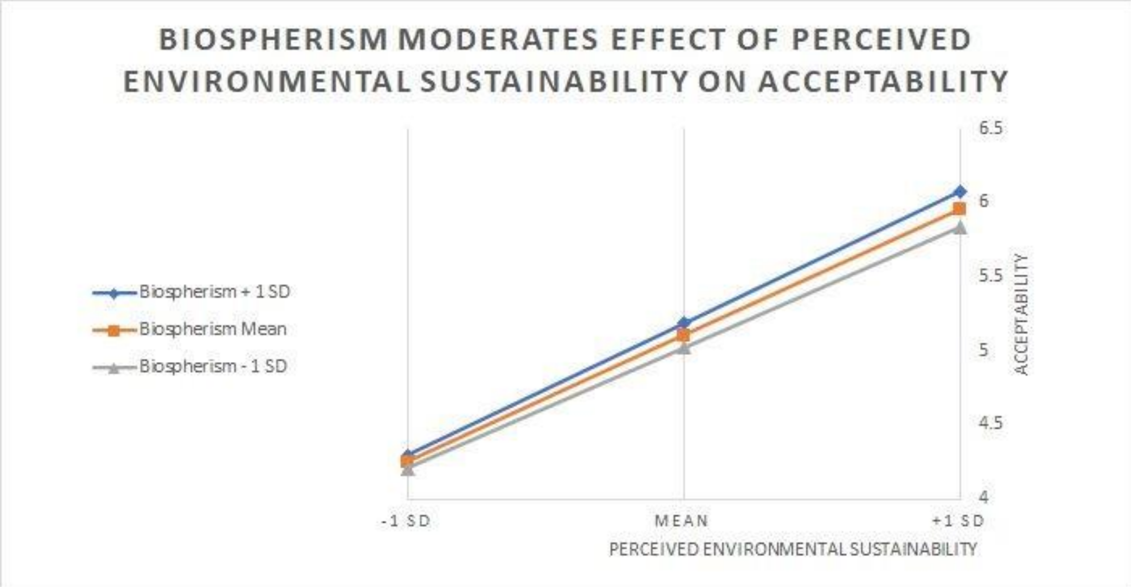
Graph 10. Egoism moderates effect of perceived status-enhancement on acceptability



When the perceived status-enhancement of CAV is low, people scoring high on egoistic values find CAV less acceptable. When the perceived status-enhancement of CAV is high, egoistic values do not matter; CAV is always more acceptable.

Fourth, we tested whether biospheric values moderate the effect of perceived environmental sustainability on acceptability. As control variables age and education were included (see 4.2.3.7). Biospherism moderated the effect of perceived environmental sustainability on acceptability (β = 0.018, t (df = 3768) = 2.040, p = .041, R^2 of the moderation effect = .001). As can be seen in Graph 11 below, acceptability increases when people perceive the CAV to be environmentally sustainable and when biospheric values are high. These findings indicate that environmental sustainability makes CAV more acceptable especially for people with biospheric values.

Graph 11. Biospherism moderates effect of perceived environmental sustainability on acceptability

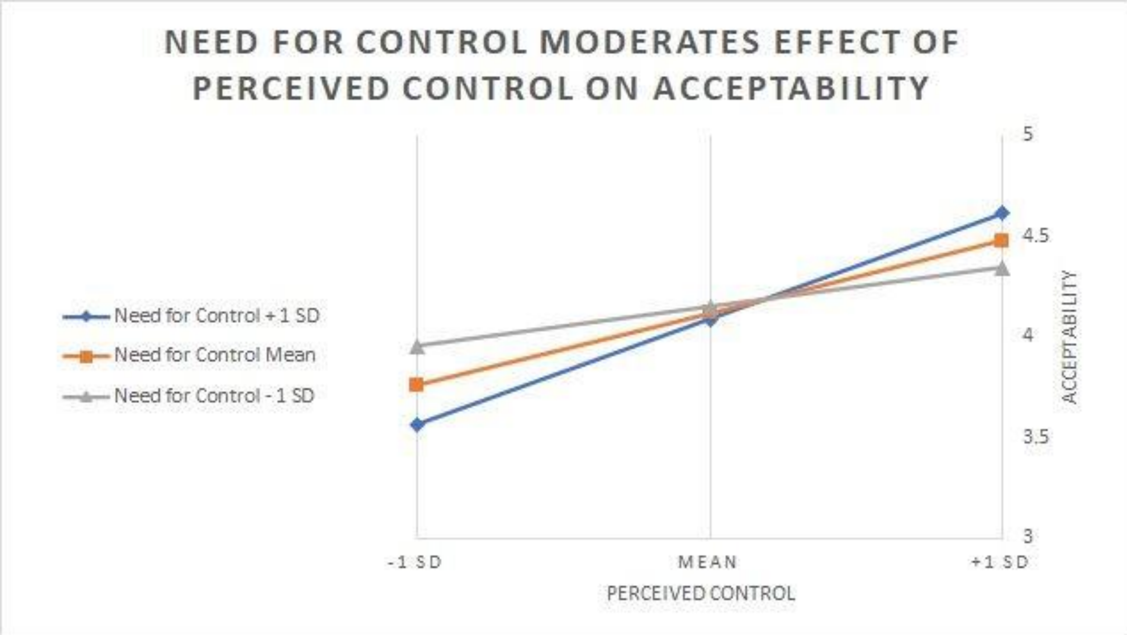


When the perceived environmental sustainability of CAV is high, people scoring high on biospheric values find CAV more acceptable. When the perceived environmental sustainability of CAV is low, biospheric values do not matter; CAV is always less acceptable.

4.2.5.2 Need for control

Can need for control influence perceived control? A regression analysis in two steps was conducted. In the first step the control variables gender and experience with car technology were entered to predict perceived control (see 4.2.3.1), and in the second step the need for control was added. As expected, need for control had a negative effect on perceived control (β = -0.079, *t* (df = 3372) = -3.674, $p < .001$, R^2 of need for control = .004). Next was assessed if need for control also functions as a moderator between perceived control and acceptability. As control variables gender and experience with car technology were included again (see 4.2.3.7). Need for control moderated the effect of perceived control on acceptability (β = 0.126, *t* (df = 3370) = 6.141, $p < .001$, R^2 of the moderation effect = .009). A graph of this moderation effect can be seen below. Visual inspection of the graph would reveal that when the perceived control of CAV is low, people scoring high on the need for control rate CAV as especially less acceptable. On the other hand, when the perceived control is high, people scoring high on the need for control rate CAV as especially more acceptable.

Graph 12. Need for control moderates effect of perceived control on acceptability



When the perceived control of CAV is low, people scoring high on need for control find CAV less acceptable. On the other hand, when perceived control of CAV is high, people scoring high on need for control find CAV more acceptable.

4.2.6 Differences between user groups

For differences between user groups, we examined effects of cycling and driving frequency, and also examined differences between drivers versus non-drivers, vulnerable road users (VRUs) versus non-VRUs, men versus women, and differences between participants from different countries.

Figure 12. Drivers and cyclists, Attribution: https://www.vecteezy.com/free-vector/background

It is impossible to categorize persons as typical drivers versus typical cyclists or other road-users, as there is a significant positive correlation between driving frequency and cycling frequency (Pearson correlation = .088, N = 3781, p < .001). This means that people who frequently cycle are also likely to frequently drive. Indeed, 402 participants both cycle and drive (nearly) every day. Likewise, 340 participants neither cycle nor drive (almost) never.

Instead of comparing typical drivers versus typical cyclists, we will focus on cycling and driving frequency separately. This also allows us to draw a clearer picture of the general population, instead of focusing on extremes (comparing people who only drive with people who only cycle).

4.2.6.1 Cycling frequency

First we assessed if cycling frequency influenced how safe CAV is perceived to be. Cyclists and pedestrians typically rely on non-verbal cues given by the car's driver (for example eye contact, waving a hand, and posture) to assess whether it is safe to cross the road (Deb, Rahman, Strawderman, & Garrison, 2018). When a computer system is controlling the car, non-verbal communication becomes impossible. Those who frequently cycle may therefore find CAV less safe and less acceptable.

All analyses in this paragraph were conducted in two steps: in step one the control variables were entered predicting perceived safety or trust in CAV technology, and in step two the predictor of interest was added.

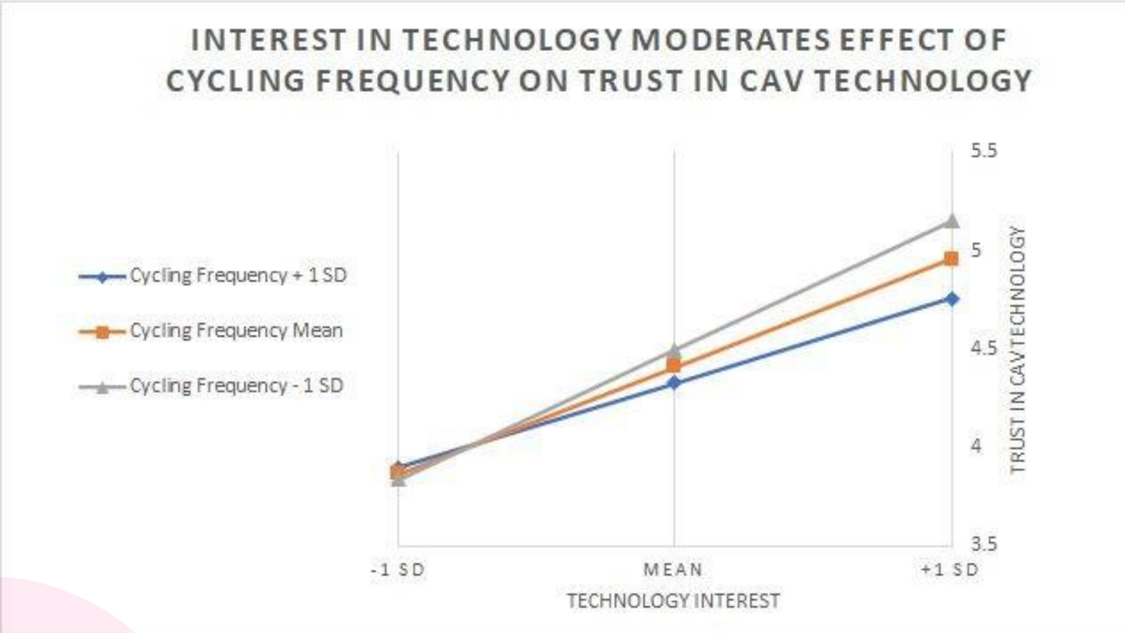
As control variables age and education were included (see 4.2.3.3). Greater cycling frequency was related to lower perceived safety of CAV, controlling for age and education (β = -0.076, t (df = 3771) = -6.005, p < .001, R^2 of cycling frequency = .009). Likewise, greater driving frequency was related to lower perceived safety of CAV, controlling for age and education (β = -0.052, t (df = 3771) = -4.199, p < .001, R^2 of driving frequency = .005). When both cycling and driving frequency were added as predictors, they both remained significant, controlling for age and education (cycling frequency β = -0.072, t (df = 3769) = -5.677, p < .001; driving frequency β = -0.046, t (df = 3771) = -3.698, p < .001; R^2 of driving frequency and cycling frequency = .013).

Secondly was assessed if cycling frequency influences trust in CAV technology. Multiple times researchers have suggested that the inability to communicate with CAV as a pedestrian or cyclist could not only decrease perceived safety, but affect trust as well (Deb, Rahman, Strawderman, & Garrison, 2018; Habibovic et al., 2018; Deb, Strawderman, & Carruth, 2018). As control variables age and experience with car technology were included (see 4.2.3.5). Greater cycling frequency was indeed related to lower trust in CAV technology, controlling for age (β = -0.092, t (df = 3778) = -5.653, p < .001, R^2 of cycling frequency = .008).

Thirdly, moderation effects were assessed. Previous research has found that more experience with (CAV) technology leads to greater trust and perceived safety of CAV (e.g. Penmetsa et al., 2019). A qualitative study by Bennett, Vijaygopal, & Kottasz (2019) also indicated physically disabled people with an interest in technology had greater trust in CAV. Moreover, in the focus groups we found that participants with great interest in technology were more accepting of CAV and viewed CAV more positively than people with less interest in technology.

Could interest in technology moderate the effect of cycling frequency on perceived safety? As control variables age and education were included (see 4.2.3.3). In step 1 the control variables were entered in the regression to predict perceived safety, in step 2 both cycling frequency and technology interest were added, and in step 3 the interaction was added. The interaction is the moderation. The interaction was not significant (β = -0.015, t (df = 3773) = -1.839, p = .066) meaning that the negative effect of cycling frequency on perceived safety is not different between people with high and low interest in technology. We also tested if technology interest moderates the effect of cycling frequency on trust in CAV technology. As control variable age was included (see 2.3.3.5). Technology interest moderates the effect of cycling frequency on trust in CAV technology (β = -0.051, *t* (df = 3775) = -4.712, *p* < .001, R^2 of moderation = .005). A graph of this moderation effect can be seen below. We found that people who have a great interest in technology trust CAV technology more, especially so if they do not cycle frequently.

Graph 13. Interest in technology moderates effect of cycling frequency on trust in CAV technology



People who both have a great interest in technology and do not cycle frequently have greater trust in CAV technology than people who have less interest in technology.

4.2.6.2 Driving frequency

We assessed if driving frequency influenced the perceived safety of CAV. Drivers, compared to non-drivers, expect that automated vehicles can enhance performance (Qu et al., 2019). The more driving experience a person has, the more often they drive, and the more often they have been involved in conventional car-based traffic crashes, the more likely they are to perceive automated vehicles as a safer alternative for their daily transportation (Montoro et al., 2019). Is driving frequency linked to perceived safety and in turn to acceptability?

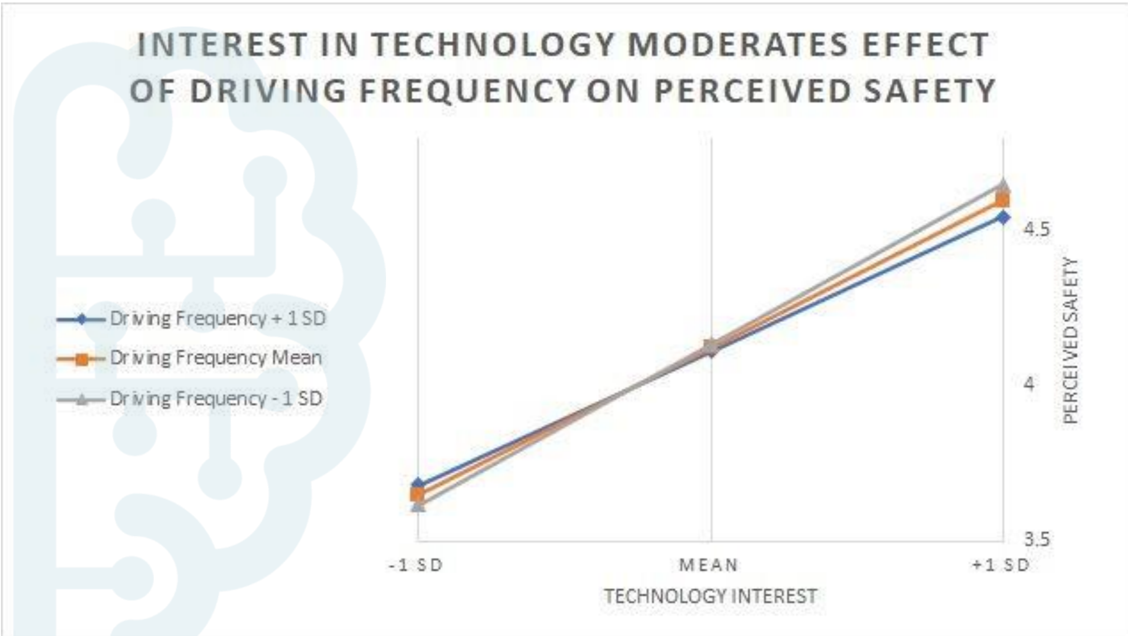
All analyses in this paragraph were conducted in two steps: in step one the control variables were entered predicting perceived safety or trust in CAV technology, and in step two the predictor of interest was added.

As control variables age and education were included (see 4.2.3.3). Greater driving frequency was related to lower perceived safety of CAV, controlling for age and education (β = -0.052, t (df = 3771) = -4.199, p < .001, R2 of driving frequency = .005). When both cycling and driving frequency were added as predictors, they both remained significant, controlling for age and education (cycling frequency β = -0.072, t (df = 3769) = -5.677, p < .001; driving frequency β = -0.046, t (df = 3771) = -3.698, p < .001; R2 of driving frequency and cycling frequency = .013).

Secondly was assessed if driving frequency influences trust in CAV technology. It has been found that people prefer manual control over automation if they believe that they are more capable of executing a behaviour themselves as compared to the automated system (Lee & Moray, 1994). In the focus groups, we found that some drivers indeed overestimate their own driving skill, which could impair their trust in an automated system such as CAV. As such, we tested if driving frequency was associated with trust in CAV technology. As control variables age and experience with car technology were included (see 4.2.3.5). Driving frequency did not influence trust in CAV technology, controlling for age and experience with car technology (β =0.020, t (df = 3772) = 0.857, p = .857).

Thirdly, moderation effects were assessed. Previous research has found that more experience with (CAV) technology leads to greater trust and perceived safety of CAV (e.g. Penmetsa et al., 2019). A qualitative study by Bennett, Vijaygopal, & Kottasz (2019) also indicated physically disabled people with an interest in technology had greater trust in CAV. Moreover, in the focus groups we found that participants with great interest in technology were more accepting of CAV and viewed CAV more positively than people with less interest in technology. We examined if technology interest moderates the effect of driving frequency on perceived safety. As control variables age and education were included (see 4.2.3.3). In step 1 the control variables were entered in the regression to predict perceived safety, in step 2 both driving frequency and technology interest were added, and in step 3 the interaction was added. The interaction term in the moderation. Technology interest moderated the effect of driving frequency on perceived safety (β = -0.020, t (df = 3768) = 2.454, p = .014, R^2 of moderation = .001). A graph of this moderation effect can be seen below. We found that people with great interest in technology view CAV as safer, especially so if they do not drive frequently.

Graph 14. Interest in technology moderates effect of driving frequency on perceived safety



People who both have a great interest in technology and do not drive frequently perceive CAV to be safer than people who have less interest in technology.

We also tested whether technology interest moderates the effect of driving frequency on trust in CAV technology. As control variables age and experience with car technology were included (see 2.3.3.5). The interaction was not significant (β = -0.013, t (df = 3769) = -0.819, p = .413). This means that there is no effect of driving frequency on trust in CAV technology, nor does it differ between people with high or low interest in technology.

Finally, we assessed if experience with car technology is a moderating variable. We tested if experience with car technology moderates the effect of driving frequency on perceived safety. As control variables age and education were included (see 2.3.3.3). The interaction was not significant (β = -0.006, t (df = 3767) = -0.491, p = .623). This indicates that the negative effect of driving frequency on perceived safety is not different between people with little or much experience with car technology. Lastly, we examined if experience with car technology moderates the effect of driving frequency on trust in CAV technology. As control variable age was included (see 2.3.3.5). The interaction was not significant (β = -0.029, t (df = 3771) = -1.866, p = .062). This means that there is no effect of driving frequency on trust in CAV technology, nor does it differ between people with little or much experience with car technology.

4.2.6.3 Non-drivers versus drivers

Aside from examining effects of driving and cycling frequency, possible differences between participants who hold a driver's license (regardless of their driving frequency) and who don't were examined. People who drive may have different conceptions of what a car is, and what is important for a car than people who have never driven. In total 280 participants indicated not having a driver's license (7.4% of the sample). Paired sample t-tests were conducted to find differences between drivers on the one hand and non-drivers on the other hand on acceptability of CAV and perceived characteristics of CAV. We opted for paired sample t-tests, so we could control for inequality of variances due to a big difference in sample size. All results can be seen in Table 10 below. Although drivers and non-drivers did not differ on acceptability of CAV, drivers were more positive about control, safety, status-enhancement, and environmental sustainability, and had greater trust in CAV technology than non-drivers.

Table 10. Differences between drivers & non-drivers on attributes and acceptability of CAV.

Scale	Drivers (M/SD)	Drivers N	Non-drivers (M/SD)	Non-drivers N	t	df	p
Acceptability	4.72/1.46	3503	4.58/1.47	280	1.442	3781	.149
Perceived control	3.69/1.28	3503	3.41/1.22	280	3.578	3781	<.001***
Perceived pleasure	3.90/1.37	3502	4.09/1.29	280	-2.420	331.034	.016*
Perceived safety	4.15/1.21	3501	3.90/1.19	278	3.273	3777	.001***
Perceived convenience	4.26/1.50	3501	4.16/1.50	280	1.073	3779	.283
Trust in CAV technology	4.41/1.55	3502	3.94/1.55	280	4.897	3780	<.001***
Perceived status-enhancement	3.44/1.63	3502	3.03/1.57	280	4.079	3780	<.001***
Perceived environmental sustainability	4.50/1.43	3501	4.27/1.39	280	2.629	328.318	.009**

* = significant at the .05 level, ** = significant at the .01 level, *** = significant at the .001 level.

Additionally, paired sample t-tests were conducted to find differences between drivers on the one hand and non-drivers on the other hand on the importance of perceived characteristics of CAV. All results can be seen in Table 11 below. Drivers significantly find it more important that the CAV has qualities of pleasure, convenience, and status-enhancement than non-drivers.

Table 11. Differences between drivers and non-drivers on the importance of characteristics of CAV

Scale	Drivers (M/SD)	Drivers N	Non-drivers (M/SD)	Non-drivers N	t	df	p
Importance of control	6.08/1.13	3503	5.93/1.34	280	1.762	311.731	.079
Importance of pleasure	5.25/1.58	3502	4.68/1.74	280	5.341	316.710	<.001***
Importance of safety	6.45/1.02	3503	6.44/1.12	280	0.165	3781	.869
Importance of convenience	5.64/1.24	3502	5.45/1.34	280	2.318	318.456	.021*
Importance of trust in CAV technology	6.07/1.13	3503	6.06/1.24	280	0.169	317.210	.866
Importance of status-enhancement	3.27/2.08	3503	2.62/1.91	280	5.481	334.304	<.001***
Importance of environmental sustainability	5.62/1.37	3503	5.46/1.59	280	1.713	312.945	.088

* = significant at the .05 level, *** = significant at the .001 level.

4.2.6.4 Vulnerable road users

The sample included a few persons with physical disabilities that prevent them from driving (*N* = 34), who are vulnerable road users. Aside from disabilities, older persons can be vulnerable road users, too, due to cognitive and physical decline. The sample included 431 persons who are 60 years old or older. This led to a total sample of 459 persons who were categorized as vulnerable road users (12.1% of the sample). Paired sample t-tests were conducted to find differences between vulnerable road users on the one hand and all other participants on the other hand on acceptability of CAV and perceived characteristics of CAV. We opted for paired sample t-tests, so we could correct for inequality of variances due to different sample sizes. All results can be seen in Table 12 below. Vulnerable road users scored significantly lower on all perceived characteristics and acceptability of CAV.

Table 12. Differences between vulnerable road users and all other participants on perceived characteristics and acceptability of CAV

Scale	VRU (M/SD)	VRU N	Others (M/SD)	Others N	t	df	p
Acceptability	4.34/1.58	459	4.76/1.44	3324	5.314	568.336	<.001***
Perceived control	3.48/1.37	459	3.70/1.27	3324	3.125	571.026	.002**

Perceived pleasure	3.46/1.37	459	3.97/1.35	3324	7.644	3780	<.001***
Perceived safety	3.87/1.29	459	4.17/1.19	3320	4.675	571.698	<.001***
Perceived convenience	3.66/1.55	459	4.33/1.48	3322	9.094	3779	<.001***
Trust in CAV technology	4.11/1.67	459	4.42/1.53	3323	3.753	569.400	<.001***
Perceived status-enhancement	2.74/1.50	459	3.50/1.63	3323	9.503	3780	<.001***
Perceived environmental sustainability	4.19/1.49	458	4.52/1.42	3323	4.644	3779	<.001***

** = significant at the .01 level, *** = significant at the .001 level.

Additionally, paired sample t-tests were conducted to find differences between vulnerable road users on the one hand and all other participants on the other hand on the importance of perceived characteristics of CAV. All results can be seen in Table 13 below. Vulnerable road users believe control, safety, environmental sustainability, and trust in CAV technology is more important than other participants. Other participants believe status-enhancement is more important than vulnerable road users. The groups do not differ on the importance of pleasure and convenience.

Table 13. Differences between vulnerable road users and all other participants on importance of perceived characteristics of CAV

Scale	VRU (M/SD)	VRU N	Others (M/SD)	Others N	t	df	p
Importance of control	6.32/1.10	459	6.03/1.15	3324	-5.096	3781	<.001***
Importance of pleasure	5.18/1.69	459	5.21/1.58	3323	0.352	573.766	.725
Importance of safety	6.66/0.86	459	6.42/1.04	3324	-5.510	659.191	<.001***
Importance of convenience	5.64/1.33	459	5.63/1.24	3323	-0.155	3780	.877
Importance of trust in CAV technology	6.23/1.14	459	6.05/1.14	3324	-3.095	3781	.002**
Importance of status-enhancement	2.65/1.95	459	3.30/2.08	3324	6.665	612.062	<.001***
Importance of environmental sustainability	5.80/1.39	459	5.59/1.39	3324	-3.154	3781	.002**

** = significant at the .01 level, *** = significant at the .001 level.

4.2.6.5 Gender differences

Regression analyses were conducted to find differences between men and women on acceptability of CAV and perceived characteristics of CAV. We controlled for age and education level. All results can be seen in Table 14 below. Women scored significantly lower on almost all perceived characteristics and acceptability of CAV.

Table 14. Differences between men and women on perceived characteristics and acceptability of CAV while controlling for age and education level

	Gender: female (β/SD)			η
Acceptability	-0.272 / 0.047	-5.799	<.001***	.009
Perceived control	-0.204 / 0.041	-4.914	<.001***	.006
Perceived pleasure	-0.056 / 0.043	-1.288	.198	.000
Perceived safety	-0.272 / 0.039	-6.985	<.001***	.013
Perceived convenience	-0.338 / 0.047	-7.144	<.001***	.013
Trust in CAV technology	-0.333 / 0.050	-6.683	<.001***	.012
Perceived status-enhancement	-0.303 / 0.051	-5.889	<.001***	.009
Perceived environmental sustainability	-0.178 / 0.046	-3.852	<.001***	.004

*** = significant at the .001 level.

Additionally, regression analyses were conducted to find differences between men and women on the importance of perceived characteristics of CAV. We controlled for age and education level. All results can be seen in Table 15 below. Women rate all characteristics as more important than men, except status-enhancement. Women care especially more about control and environmental sustainability.

Table 15. Differences between men and women on importance of perceived characteristics of CAV while controlling for age and education level

Scale	Gender: female (β/SD)			η
Importance of control	0.272 / 0.037	7.375	<.001***	.014
Importance of pleasure	0.139 / 0.052	2.694	.007**	.002
Importance of safety	0.151 / 0.033	4.567	<.001***	.005
Importance of convenience	0.200 / 0.041	4.933	<.001***	.006
Importance of trust in CAV technology	0.164 / 0.037	4.459	<.001***	.005

Importance of status-enhancement	-0.257 / 0.067	-3.839	<.001***	.004
Importance of environmental sustainability	0.331 / 0.045	7.384	<.001***	.014

** = significant at the .01 level, *** = significant at the .001 level.

4.2.6.6 Country differences

We tested if the effects of the perceived characteristics on acceptability were equal or different depending on participants' country. We did not have specific hypotheses, because the literature review (D1.1) did not suggest any cultural differences. There were significant differences between the samples of each country on education level, cycling frequency, driving frequency, physical disabilities, need for control, experience with car technology, interest in technology, values, and car ownership. As such, differences between countries may be due to a difference in the samples on any of these variables. This makes the analysis of country differences unreliable. Only the greatest differences will be discussed below, we will not provide the statistics for these analyses due to their unreliability.

We tested all perceived characteristics separately, controlling for the same variables as mentioned in 4.2.3.1 to 4.2.3.7. We split the data based on country and inspected the β for each country. The β provides information about both the direction (positive or negative) and the strength of the effect. We also inspected the mean scores of the importance ratings of perceived characteristics.

Perceived control had a much stronger positive effect on acceptability for French participants, and a much weaker positive effect on acceptability for both Spanish and Italian participants, compared to participants from other countries. There were no substantial differences on the importance ratings of control between countries.

There were no substantial differences between countries on the effect of perceived pleasure and perceived safety on acceptability. Participants from Spain rated pleasure as slightly less important than participants from other countries.

Perceived convenience had a weaker positive effect on acceptability for Spanish participants compared to participants from all other countries. Interestingly, participants from Spain and Italy rated convenience as slightly more important than participants from other countries. This indicates that participants may not be completely aware of what they find important in CAV.

Trust in CAV technology had a weaker positive effect on acceptability for French participants compared to participants from all other countries. Participants from the UK rated trust as slightly more important than participants from other countries.

Perceived status-enhancement had a weaker positive effect on acceptability for both Dutch and German participants compared to participants from other countries. Participants from Italy rated the importance of status higher, while participants from the Netherlands rated the importance of status lower than participants from other countries.

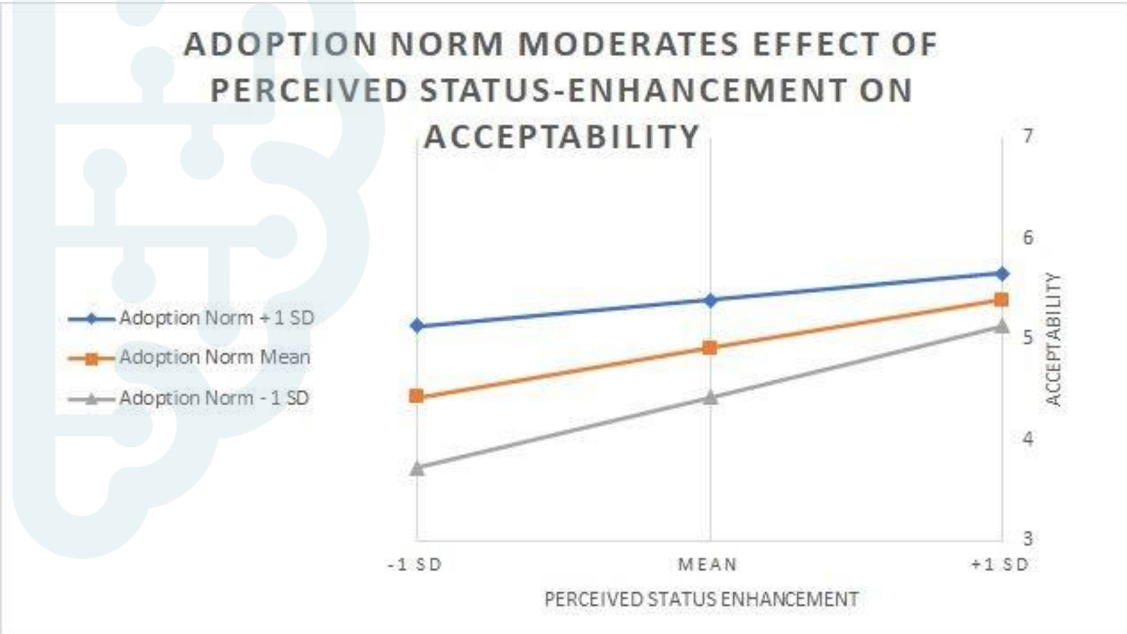
Perceived environmental sustainability had a slightly stronger positive effect on acceptability for German participants compared to participants from all other countries. Participants from Spain and Italy rated environmental sustainability as more important than participants from other countries.

4.2.7 Perceived adoption norm

Finally, the last factor influencing acceptability is the perceived adoption norm. As CAV is not available yet, people may differ on what percentage of their important others (friends, family, coworkers, etc.) they think will adopt CAV in the future. If they expect many of their important others will adopt CAV, they may find CAV more acceptable due to social influence, as for example in the Technology Acceptance Model (Malhotra & Galletta, 1999). Moreover, previous research on electric cars found that when the perceived adoption norm is low, symbolic attributes (such as status-enhancement) become more important for potential users (Noppers, Keizer, Milanovic, & Steg, 2019). We expect that the perceived adoption norm will moderate the effect of perceived status-enhancement on acceptability.

A regression analysis in three steps was conducted. In the first step the control variables gender and age were entered to predict acceptability (see 4.2.3.6), in the second step perceived adoption norm and perceived status-enhancement were added, and in the third step the interaction was added. The interaction is the moderation effect. Perceived adoption norm moderated the effect of perceived status-enhancement on acceptability (β = -0.051, t (df = 3376) = -11.624, p < .001, R^2 of the moderation effect = .024). A graph of this moderation effect can be seen below. Inspection of the graph reveals that when the perceived adoption norm is high, perceived status-enhancement does not affect acceptability of CAV much. However, when the perceived adoption norm is low, perceived status-enhancement becomes a strong predictor of CAV; in that CAV is less acceptable when the status-enhancement is low, and more acceptable when the status-enhancement is high.

Graph 15. Perceived adoption norm moderates effect of perceived status-enhancement on acceptability



When the perceived adoption of CAV is high, perceived status-enhancement does not affect acceptability much. However, when both the perceived adoption norm and perceived status-enhancement are low, CAV becomes less acceptable.

5. TESTING THE MODEL

5.1 Measures in the large-scale survey

The data from the large scale survey was used to test the model. In the large-scale survey measures were included to reflect the factors in the TPB. For attributes, we measured the perceived characteristics which were found to be important for acceptability in D1.1. Just like De Groot and Steg (2007), we included egoistic (perceived status-enhancement), altruistic (perceived safety), and biospheric (perceived environmental sustainability) concerns. To calculate participants' attributes, the averages of all the seven perceived characteristics were summed and then divided by 7. The result is a scale from 1 to 7, in which 1 is a very negative belief of CAV's attributes and 7 a very positive one.

For subjective norms, participants were asked what percentage of friends, family members, and coworkers they thought would adopt CAV in the future when they would be available (i.e. perceived adoption norm). For perceived behavioral control, participants indicated to what extent they believed they would be able to use CAV in the future when they would be available.

5.2 General overview of the model

Aside from the three factors from the TPB, the results from the large-scale survey show that individual differences (for example values) can affect how people perceive CAV and which characteristics of CAV are less or more important to them. We propose that individual differences should be included as a factor in the model predicting acceptance of CAV. As argued in D1.1, we would also like to make a distinction between acceptability (attitudinal evaluation of CAV or intention to use) and acceptance (attitude after experiencing or actual adoption of CAV). Including these extra factors, a general overview of the proposed model can be seen in Figure 13 below.

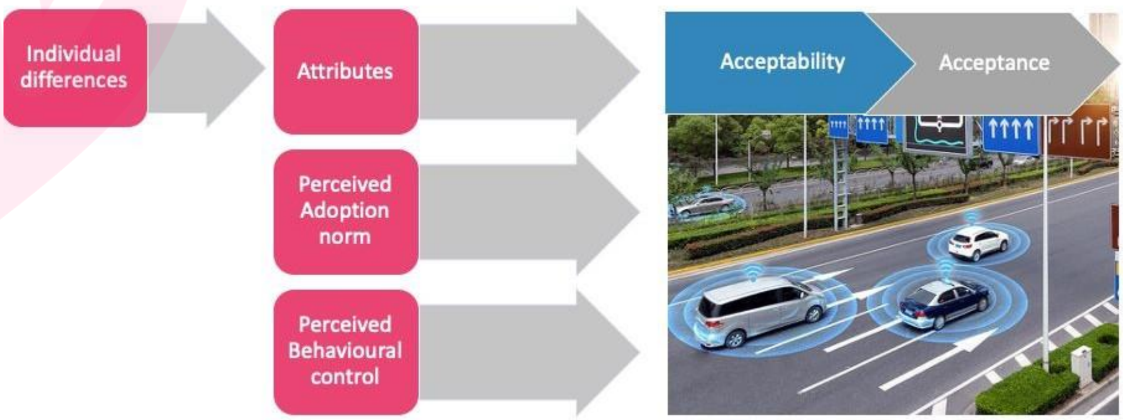


Figure 13. Overview of the proposed model of acceptance of CAV

5.3 Testing the model

How individual differences affect the perceived characteristics of CAV and the importance thereof can be read in sections 4.2.5 and 4.2.6. We will now restrict ourselves to testing the three factors of the TPB (attributes, perceived adoption norm, and perceived behavioral control) affecting the acceptability of CAV. A regression analysis was run in which acceptability was predicted by attributes, perceived adoption norm and perceived behavioral control. The model was significant, F (df = 3, 3764) = 1605.849, $p < .001$, $R^2 = .597$. Attributes, perceived adoption norm and perceived behavioral control each had positive effects on the acceptability of CAV. The found estimates can be seen in Figure 14 below. Attributes had the strongest effect on acceptability. The results show that this model has high predictive power: it can explain about 60% of variance in acceptability with only attributes, perceived adoption norm, and perceived behavioral control.

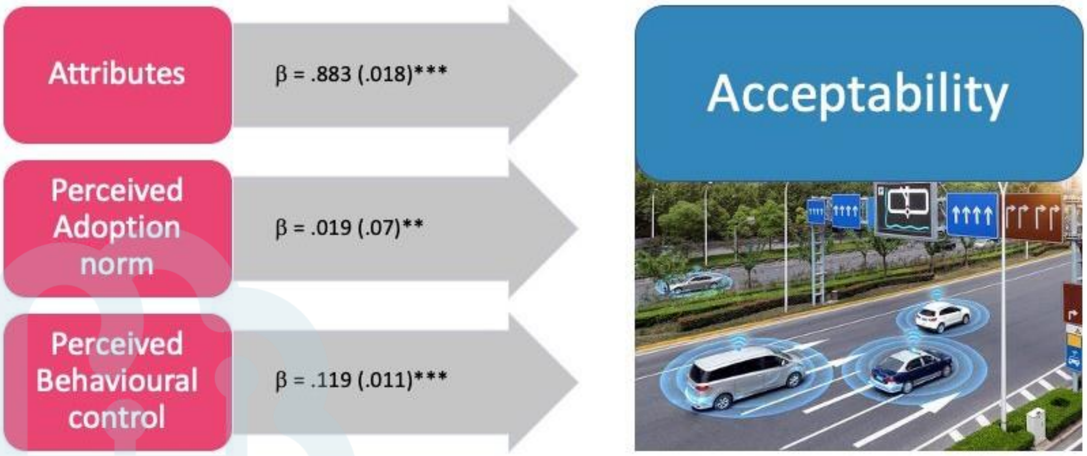


Figure 14. Model predicting acceptability of CAV with estimates

Standard errors are in parentheses, *** = significant at the .001 level, ** = significant at the .01 level

Finally, to examine which attributes are the strongest predictors of acceptability, a regression analysis was run in which all 7 perceived characteristics predicted acceptability. The model was significant, F (df = 7, 3764) = 856.891, $p < .001$, $R^2 = .614$. The strongest predictors were perceived safety, perceived convenience, and perceived environmental sustainability. Please refer to Figure 15 for the estimates. Perceived control had a relatively smaller, but significant effect on acceptability. Perceived status-enhancement became non-significant in this model. This is likely the case because the effect of perceived status-enhancement on acceptability of CAV depends on the perceived adoption norm (see section 4.2.7), as well as on egoistic values (see section 4.2.5.1).

Figure 15. Strength of attributes on acceptability of CAV. Standard errors are in parentheses, ** = significant at the .01 level, *** = significant at the .001 level

6. TECHNICAL & SCIENTIFIC IMPACTS

In this deliverable we have proposed and validated a social psychological model that explains acceptability of CAV. This is the first model that is tailored to the acceptability of CAV specifically, which means this model is an innovation compared to general behavioral models. Moreover, this model has very high predictive power (nearly 60% of all variance in acceptability can be explained with only attributes, perceived behavioral control, and perceived adoption norm). With this model, we have gained insight into what aspects of CAV are the most important for acceptability. These insights can be used by manufacturers and marketers to increase acceptability of CAV. For this purpose we have compiled some initial guidelines in section 6.1.

The model lays the foundation for all following research of the SUaaVE project on acceptance. The results described in this deliverable are also the first step to determine how to increase acceptance of CAV. This is a scientific advancement; no psychological model that explains the acceptability of CAV specifically existed.

6.1 Guidelines

Based on the results described in this deliverable, we can provide some initial guidelines on how to improve acceptability of CAV within the EU.

- **Attributes have the strongest impact on acceptability**, so manufacturers and marketers should strive to enhance the perceived characteristics of CAV.
- More specifically, the **most effective attributes are perceived safety, perceived convenience, and perceived environmental sustainability.** Enhancing these should be the focus for manufacturers and marketers. For instance, these attributes could be emphasized in marketing, advertising, and information campaigns.
- **Perceived status-enhancement can improve acceptability of CAV when the perceived adoption norm is low.** This means that at the deployment of CAV, we could enhance acceptability by framing it as a status product. However, the effectiveness of perceived **status-enhancement decreases if the perceived adoption norm is high**. Once CAV has managed to gain a decent foothold in the market-share of personal vehicles, CAV does not have to be seen as a status product anymore to enhance acceptability. **Hence, emphasizing the status-enhancing aspect of CAV would particularly be effective in the early adoption phase of this innovation.**
- **Perceived environmental sustainability is a strong predictor of acceptability**, and environmental issues were widely discussed in the focus groups. It seems some **people would prefer CAV to be an electric vehicle**, or to at least be a partially non-fossil fuelled vehicle. Both designing CAV accordingly, as well as **emphasizing the environmental sustainability of CAV in marketing, advertising, and information campaigns may enhance acceptability.**
- **People with great interest in technology are more accepting of CAV**. On the contrary, greater driving and cycling frequency are related to lower perceived safety of CAV, as well as lower trust in CAV technology. Technology interest sometimes moderates these effects. **Perhaps acceptability can be increased by presenting CAV as a**

technological gadget, or by showing excellent safety ratings in real road environments.

- Marketers could design different promotional materials based on the **target audience**. **People with high biospheric values find CAV generally more acceptable if it is environmentally friendly. People with high egoistic values find CAV more acceptable if it could enhance their status**. Lastly, people with a high need for control find CAV more acceptable if they believe they have some control over the vehicle's behavior.

7. CONCLUSION

We have developed and tested the social psychological model to explain and promote public acceptability of CAV among different types of user groups. We have also provided some initial guidelines to enhance acceptability of CAV. The project has achieved the objectives of this deliverable.

We find that acceptability is predicted by attributes of CAV, perceived adoption norm, and perceived behavioral control, in which attributes is the strongest predictor. Attributes of CAV consist of seven distinct perceived characteristics of CAV: perceived safety, perceived convenience, perceived pleasure, perceived control, perceived status-enhancement, perceived environmental sustainability, and trust in CAV technology. Out of these perceived characteristics, **perceived safety, perceived convenience, and perceived environmental sustainability are the strongest predictors of public acceptability of CAV.**

We also find that attributes are influenced by individual differences, and sometimes the effect of attributes on acceptability is moderated by individual differences as well. **The main individual differences that influence attributes are values (mainly egoistic and biospheric), cycling and driving frequency, and need for control**.

The data from the large scale survey supports the proposed model. **Nearly 60% of all variance in acceptability can be explained by only attributes, perceived behavioral control, and perceived adoption norm.** This is a rather high percentage of explained variance for a behavioral model. Our model is an innovation because this is the first model that is tailored to CAV specifically, and it has high predictive value. Moreover, the data from 6 different European countries support the model.

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