Deliverable 1.1 Identification of potential psychological factors influencing the passenger and road user acceptance of CAV

Post, J. M. M. ; Veldstra, J. L.; Ünal, A. B.

SUaaVE

SUpporting acceptance of automated VEhicle

Deliverable 1.1. Identification of potential psychological factors influencing the passenger and road user acceptance of CAV

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

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Terminology and Acronyms

CAV	Connected Automated Vehicles
WP	Work Package
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned Action
HAD	Highly-Autonomous Driving
AV	Automated Vehicle
ADAS	Advanced Driver Assistance System
ACC	Adaptive Cruise Control

EXECUTIVE SUMMARY

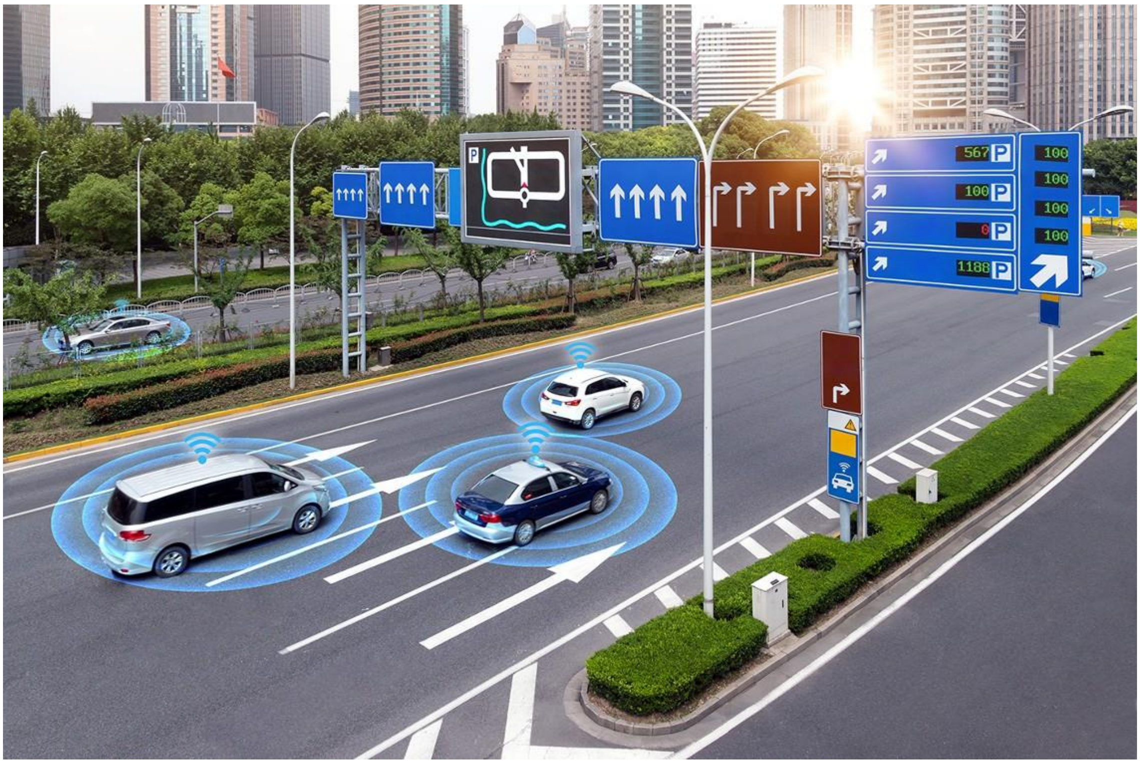
In this first deliverable (D1.1) of WP1, we aim at providing a literature review on psychological factors affecting acceptability and acceptance of CAV. Automated vehicles are expected to dominate the road environment in the near future, yet public acceptability of particularly high levels of automation (L4 and L5) is questionable. The human dimensions of a transition to a fully automated road environment is important to take into account in order to increase acceptability of CAV: when people accept this technology, it is also more likely that they will buy it or use it. In the current deliverable, we provide an account of the most relevant social psychological factors that would play a role in affecting acceptability judgements.

The literature search has been carried out by having an overview of key publications on acceptability and acceptance of technology. Notably, we first talk about models on technology acceptance in general. These models identified various factors that are key for acceptability, such as individual factors (i.e., age, gender, personality) and system characteristics (i.e., levels of automation). In addition, there has been an emphasis on perceived usefulness and ease of use as important perceptual factors to influence acceptability. Yet, several other perceptual factors, such as perceived trust and perceived safety have been shown to play a crucial role in affecting acceptability judgements. We identified these main social psychological factors based on current literature, and summarized key findings.

Our main conclusion is that the acceptability of CAV is a complex process involving several individual, social, cognitive and perceptual factors. We propose that a revised model of acceptance of CAV is needed which is more holistic in terms of factors covered.

1. INTRODUCTION AND OBJECTIVES

It is estimated that in the near future Connected Automated Vehicles (CAV) will dominate the road environment. Indeed major players in the automotive industry have already invested largely on designing vehicles with Level 4/5 automation and many started pilot testing these vehicles in designated areas (SAE International, 2018). Hence a lot of resources and manpower are being allocated to realizing the goal of fully automated vehicles. Yet, the success of these efforts depends on whether the public would accept connected and automated vehicles and whether they would adapt these vehicles. Indeed acceptance is an important barrier for the diffusion of any innovation in the society, including CAV. If CAV is not accepted by people, then people would not adapt it or use it, meaning that the technology might fail to be put on use. How can we increase acceptability of CAV among people? What kind of psychological factors are particularly relevant to increase acceptability? In Deliverable 1.1. we aim at providing a summary of the current literature on psychological factors that influence the acceptability and acceptance of CAV. In addition, we aim at drawing certain conclusions for different road users, such as elderly drivers and pedestrians, whenever possible.



Connected Automated Vehicles[1]

Acceptance versus Acceptability

In the literature acceptability and acceptance is sometimes used interchangeably. We reason that acceptability refers to one's attitudes and evaluations before the implementation of an innovation whereas acceptance refers to one's attitudes, evaluations and behaviours afterwards, meaning having experienced the innovation (see Schade & Schlag, 2003).

[1] https://saemobilus.sae.org/automated-connected/news/2019/01/the-highs-and-lows-of-automated-a nd-connected-vehicles-in-2018

Acceptability could therefore be expressed as an attitudinal evaluation or intention (e.g. willingness to use CAV as a passenger), whereas acceptance could be expressed as an attitude as well as real behaviour (e.g., adopting an automated vehicle). In the remainder of the Deliverable we will be referring to post-evaluations and behaviour when we talk about acceptance and pre-evaluations and intention when we talk about acceptability. Yet, as people have experience with CAV mostly in experimental settings and not in real-life, the literature review will cover acceptability in the majority of the studies we will talk about.

Previous studies largely focused on acceptability, meaning that investigations in close-to-real setting were scarce. In one particular study that looked into acceptance, scholars found that having experienced a short ride (via a Wizard of Oz approach) on an autonomous public transport shuttle did not necessarily lead to positive evaluations afterwards (Distler, Lallemand, & Bellet., 2018). Notably, participants' safety concerns were relieved but their ratings for the usefulness and effectiveness of fully-automated vehicles decreased. This finding indicates that the sole experience of full-automation is not sufficient to facilitate positive attitudes towards the new technology. We therefore aim at not only comparing acceptability and acceptance, but also studying how to facilitate the development of positive attitudes towards fully-automated vehicles.

2. MODELS PREDICTING THE ACCEPTABILITY OF CAV

Few studies have researched the acceptance of fully automated vehicles before (Payre et al., 2014; Kyriakidis, Happee, & de Winter, 2015; Distler, Lallemand, & Bellet, 2018). Previous studies have focused mainly on Advanced Driver Assistance Systems (ADAS), or partly on highly automated vehicles and most pre-date the public exposure to automated vehicles in the media such as Google car or Uber (Kyriakidis, Happee, & de Winter, 2015). To date we have no knowledge of studies investigating Connected Automated Vehicles so we extrapolate knowledge from other acceptance models to acceptance of CAV.

2.1. Technology Acceptance Model

Originally developed to investigate user acceptance to use computer-based technologies, the Technology Acceptance Model (Davis, 1993; see Figure 1) is based on the premises of the Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975). The TRA is a social psychological model which aims at predicting intentions and behaviour (such as acceptability and acceptance, respectively). Notably, TRA posits that behaviour is directly predicted by intentions, and intentions are directly predicted by attitudes and subjective norms.

Attitudes refer to any positive or negative evaluation of an object, such as automated vehicles. If a person has positive attitudes towards automated vehicles, then we might expect that acceptability of CAV would also be high, whereas a negative attitude is expected to decrease acceptability. Subjective norm refers to one's perceptions regarding what the significant others think the person should do. This construct is related to the social influence that others have on our decisions. Notably, if we think significant others, such as partners, parents, or close friends, have a positive evaluation regarding CAV, this would also affect our evaluations of this innovation. Similar to attitudes, a positive subjective norm would be positively associated with acceptability of CAV.

Later, TRA has been modified with the addition of a new construct called perceived behavioural control, and the model was renamed the "Theory of Planned Behaviour" (TPB; Ajzen, 1985). Perceived behavioural control refers to whether the person believes it is easy and difficult to execute a behaviour, and whether they are able to carry out the behaviour (Ajzen, 1991). Several external and situational factors could affect people's perceptions for ease or difficulty of executing a behaviour. For instance, if there is uncertainty in the market regarding the diffusion of automated vehicles, if there is no legislation yet around liability issues for users of CAV or if the financial cost of using the CAV is somewhat higher than conventional vehicles, individuals could perceive these as a barrier to adapting CAV. In this situation, a low perceived behavioural control would be associated with lower acceptability. Interestingly, TPB posits that perceived behavioural control might also affect behaviour directly, without the mediation of intentions, meaning that low perceived behavioural control could have a direct effect on acceptance, lowering the likelihood to actually use or adapt CAV.

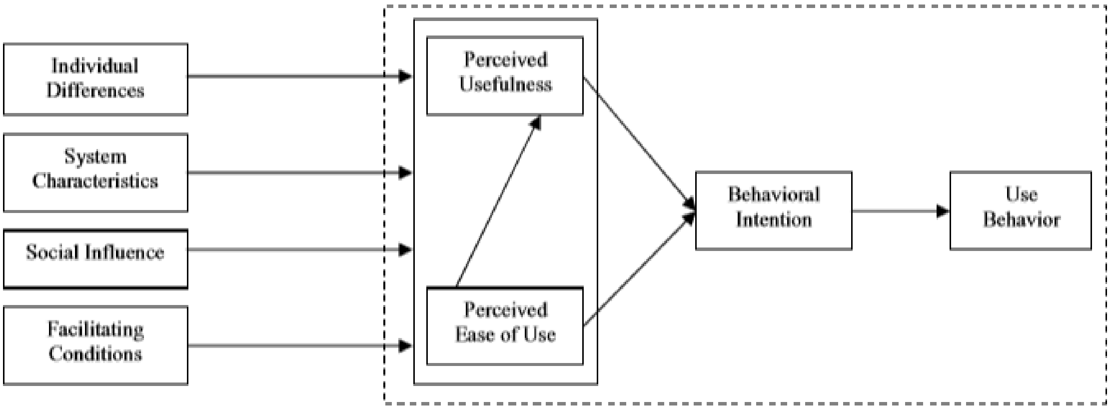


Figure 1. Technology Acceptance Model (adapted from Venkatesh and Bala, 2008)

Differing from TPB, according to the Technology Acceptance Model (TAM; Davies, 1993; Venkatesh & Bala, 2008) intention to use the technology is directly predicted by cognitive beliefs regarding i) perceived usefulness of technology and ii) perceived ease to use the technology. The belief that the technology is high on usefulness would lead to high intention to adopt technology, while the belief that the technology is not so useful would lead to low intention to adopt technology. The concept of "perceived ease" in TAM partly corresponds to the concept of perceived behavioural control, and therefore incorporates both one's ability to use a technology and the perception of external barriers. A high perceived ease to use the technology would lead to high intentions. When the perceived ease is rather low - meaning the technology is perceived to be difficult to use due to external barriers for instance-, then intention to use the technology would decrease. In addition, perceived ease is expected to have a direct influence on perceived usefulness of technology. This is not surprising given that when a technology is difficult to use, its usefulness would decrease.

One could see that perceived usefulness and perceived ease of use are key determinants in the model as when these are not at desirable levels, both intention and therefore the actual adoption likelihood would decrease. The TAM is later modified (see Venkatesh & Davis, 2000; Verkatesh & Bala, 2008) to include other predictors in the model in an attempt to finetune what kind of characteristics or aspects are more related to perceived usefulness and ease of use. For instance factors such as whether adopting the new technology will improve one's status or whether it would help him to get social approval of important others (i.e., subjective norm) are included to predict perceived usefulness.

In addition, several additional factors were depicted to predict perceived ease of use in the modified TAM (Venkatesh & Bala, 2008). One of these factors is self-efficacy, which is defined as whether the person feels able to use the technology. A second factor is perceptions of external control; that is whether there is external support to use the technology. Notably, emotional factors are also included as predictors of perceived ease. For instance, when the person feels anxious or is scared to use the technology, then this is expected to negatively influence perceived ease. In contrast, if the person perceives using the new technology as enjoyable, then this would have a positive impact on perceived ease.

The modified version of TAM also includes the variable of experience with technology. Experience is regarded as a moderating factor between perceived ease and perceived usability of the new technology: when someone is more experienced in using the technology, then it is more likely that perceptions regarding the ease of using the system will actually affect perceptions regarding usability. Mirroring this to the case of CAV, when people are not experienced with fully-automated vehicles, they might have some implicit and perhaps unrealistic assumptions regarding how easy or difficult to use such vehicles, which might impair beliefs on whether it is useful to adopt this technology. However, after some exposure to fully-automated vehicles, and if the experience is positive, then perceived ease could affect usability judgments more strongly.

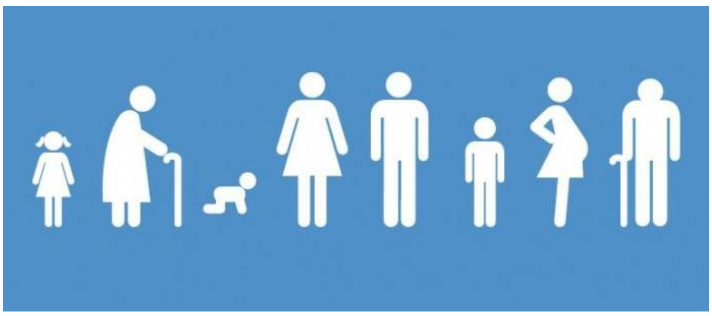
A modified version of TAM has been used to measure behaviour intentions for a shared AV that drove around in France and Switzerland (Madigan et al., 2016). Respondents' enjoyment had a large impact on the desire to use a shared AV again, although this may be partly due to the novelty associated with the vehicle. Aside from hedonic motivations, the AV's performance, the resources provided to support their use, and the social norms surrounding the AVs also influenced whether or not respondents wanted to use the AV again.

TAM posits that the cognitive beliefs about perceived usefulness and perceived ease of use are to be determined by four factors: 1) individual factors such as personality characteristics, gender and age, 2) system and design features of the technology, 3) social influence that is defined as the implicit influence of others in our decision-making, and 4) facilitating conditions such as legal and policy support around the new technology. Below we will discuss literature on the influence of these factors in the acceptance of CAV.

3. INDIVIDUAL DIFFERENCES

3.1. Gender and Age

Most studies included age and gender in their analyses in an attempt to see whether there are some innate demographic differences when it comes to acceptance of CAV. Findings reveal that female drivers were somewhat more concerned to be in a fully automated vehicle (Schoettle & Sivak, 2014). The literature review of Becker and Axhausen (2017) supports this finding: males were less concerned to be in a fully automated vehicle. Males were found to be more concerned with liability issues and females with low-control (Howard & Dai, 2014). Differences in willingness to use an automated vehicle between men and women can be partially explained with emotions. Men tend to assign positive emotions to automated driving, while women tend to assign negative emotions (Hohenberger, Spörrle, & Welpe, 2016). In addition, men anticipated both more pleasure and less anxiety than women towards using automated vehicles.



Gender and age[2]

[2] https://ec.europa.eu/echo/news/european-commission-launches-gender-age-marker-toolkit_en

Comparison between age groups revealed equivocal results. Some studies showed that young people were more positive about automated vehicles as compared to people in older ages (see review by Becker & Axhausen, 2017). Interestingly, there were also findings showing the opposite. For instance, older people were found to be more interested in using an automated vehicle (Gold, Korber, Hohenberger, Lechner, & Bengler, 2015; Rödel et al., 2014). This might be because of the anticipated cognitive decline that comes with age, which would make driving difficult, and thereby making fully-automated driving a good alternative. Older people also rate potential safety gains of automation as higher than younger people do (Gold et al., 2015). In a sample from Australia and New Zealand, older people had a higher level of trust in CAV, but they also had higher levels of concern about their safe performance. All in all, older people had more positive perceptions of potential benefits of CAV, and showed a greater willingness to use them (Regan et al., 2017). However, in a later wave of the same study, younger people had more positive perceptions of potential benefits of CAV (Ledger, Cunningham, & Regan, 2018).

Rahman and colleagues (2019) found that older adults (60+) have positive attitudes towards autonomous vehicles when they would be a passenger, but negative attitudes towards autonomous vehicles if they would be a pedestrian. They argue that a lack of information regarding how pedestrians can safely interact with automated vehicles may be the cause for this difference.

A meta-analysis of trust in automation showed that age had a moderate positive effect on trust in automation (Schaefer et al., 2014). In a survey among older persons living in Florida self-reported ease of new technology use had positive effects on willingness to use automated vehicles and expected benefits from using an automated vehicle. Moreover, greater ease of technology use reduced concerns relating to AVs (Souders & Charness, 2016).

In preliminary results of a study on older drivers' (65+) acceptance of CAV, a negative correlation was found between years of driving experience and acceptance. The authors argue that older adults' low acceptance of CAV may stem, in part, from a lifetime of driving experience that governs their expectations of vehicle control (Haghzare, Campos, Bak, & Mihailidis, 2019). However, this research is still a work in progress, with currently valid data of only 10 participants.

In a large-scale survey on CAV in Japan, where elderly drivers are involved in 40% of all traffic accidents, it was found that almost half of the respondents thought CAV would be useful in the mitigation of mobility problems and accidents related to elderly drivers (Shin, Tada, & Managi, 2019).

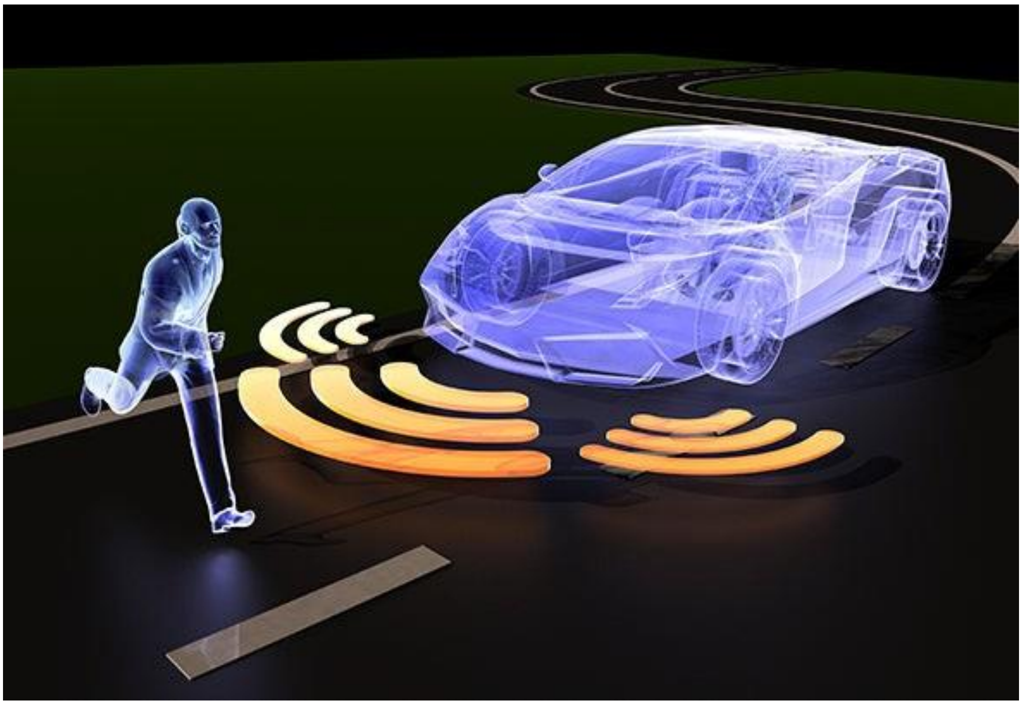
Overall these findings indicate that there are both positive and negative attitudes towards CAV among elderly drivers for instance, stemming from different reasons. It seems when accident involvement or unsafe driving practices are a concern, acceptability of CAV could be somewhat higher among elderly. However, for experienced elderly drivers, for whom accident involvement is perhaps not a concern yet, the fear of losing control of the vehicle could act as an inhibiting factor affecting acceptance. As such, demographic factors might not provide the best way of clustering the data, as not the age or gender but rather some other psychological factors (i.e., fear of accident involvement, fear of losing vehicle control) seem to be affecting acceptability ratings of respondents.

3.2. Type of road user

Most studies on the acceptability of automation comprised potential buyers of these vehicles who will switch to the status of a “passenger”. Yet, fully automated vehicles will also impact other road users, such as pedestrians and cyclists. How do other users evaluate fully-automated vehicles? And are there any differences in judgements of future passengers of CAV and other road users that will come across a CAV on the road?

In certain traffic situations (for example at low speeds and in ambiguous situations), pedestrians' decisions to cross a road and feelings of safety are affected by non-verbal cues given by the car's driver (for example eye contact, waving a hand, and posture). Pedestrians rate eye contact with a driver as promoting calm interaction, while a driver who appears distracted leads to stress for pedestrians (Habibovic et al., 2016). When pedestrians are faced with a CAV, they cannot rely on non-verbal cues. Deb, Rahman, Strawderman, and Garrison (2018) argue that because most pedestrians prefer to interact with drivers before crossing the road, a decline in comfort and trust may arise when CAV are implemented. Moreover, pedestrians may be confused about whether they should interact with the driver or the vehicle itself when a person is sitting in the driver's seat in a CAV. Lagström and Lundgren (2015) found that pedestrians want some indication if a vehicle is in automated driving mode.

Habibovic and colleagues (2018) tested if they could make pedestrians feel safer when interacting with a CAV that was able to convey its intentions visually. Participants were trained to recognize the visual signals the CAV could send. After this training, participants (pedestrians) felt calmer, more in control of the traffic situation, safer, and more positive towards the CAV than when they interacted with a CAV that could not send out visual cues. This indicates other road users will be more accepting of automated vehicles when they can understand the behaviour and intentions of the vehicles, and when the vehicles can communicate with other road users. Especially females and adult populations (30+) rate the inclusion of external interfaces that can communicate with pedestrians on a CAV as positive, perhaps because this increased their perceptions of safety (Deb, Strawderman, & Carruth, 2018).



Pedestrian interacting with automated vehicle[3]

Deb and colleagues (2017) developed a scale to measure pedestrian receptivity towards CAVs. They found three major components that determined receptivity: safety (perceived

[3] https://www.scientificamerican.com/article/how-pedestrians-will-defeat-autonomous-vehicles/

safety for pedestrians), interaction (willingness to interact with CAV as a pedestrian), and compatibility (belief that CAV can be successfully implemented within the existing traffic system). Safety had the largest impact on acceptance, while interaction had the largest impact when looking at behavioural intention to cross the road in front of a CAV. Aside from that, they also looked at the effect of demographics on acceptance. Male pedestrians were more inclined to accept CAVs than female pedestrians. The youngest age group (between 18 and 30 years old) had significantly higher receptivity towards CAVs than the other age groups. People from urban regions were more receptive toward CAVs than people living in rural regions.

In a comparison between drivers' and non-drivers' opinions on automated vehicles, it was found that non-drivers (1) assumed that automated vehicles would be less useful and less likely to enhance performance, (2) were more enthusiastic about automated vehicles being applied for people who are not allowed or unable to drive regular manual vehicles, and (3) had greater concerns about the automated driving system itself, compared to drivers (Qu et al., 2019).

Lastly, potential users seem to dislike the idea of transporting their children in a fully automated vehicle (see Regan et al., 2017). Both pedestrians and cyclists who had interacted with an automated vehicle were more positive towards automated vehicles than those who had not interacted with an automated vehicle (Penmetsa et al., 2019). Moreover, both pedestrians and cyclist who had an interactive experience with automated vehicles were more likely to think that automated vehicles have the potential to reduce injuries and fatalities than those who had not interacted with an automated vehicle.

3.3. Vulnerabilities

One aspect of CAV that is being promoted is that it would be a remedy for vulnerable road users such as handicapped people or elderly who are not fit to drive. But would vulnerable people find CAV acceptable to use?

In an analysis of text comments on fully automated driving, people with physical disabilities and/or bad eyesight seemed to be more positive towards CAV (Bazilinskyy, Kyriakidis, & de Winter, 2015). In two waves of a study conducted in Australia and New Zealand, a high proportion of respondents agreed they would like to use a fully automated vehicle when they are physically and/or mentally unable to drive themselves (Regan et al., 2017; Ledger, Cunningham, & Regan, 2018), indicating that an anticipation of decline in health might be associated with higher acceptance.

In a sample from the UK differences in attitudes towards automated vehicles between people with physical disabilities that interfered with their ability to walk and people with no such disabilities was examined (Bennett, Vijaygopal, & Kottasz, 2019). Two-thirds of the sample of people with disabilities held either negative or ambivalent views of automated vehicles. People with disabilities were especially likely to make negative comments about automated vehicles when (1) they had high levels of generalized anxiety, and (2) when they had a low internal focus of control, meaning they felt they do not have control over events. Participants with disabilities were more positive towards automated vehicles when (1) they were more action oriented, and (2) they were interested in new technologies. The researchers believe that public information messages targeted at people with disabilities should emphasize the safety features of automated vehicles, the ease of use for people with disabilities, and automated vehicles' reliability and dependability. A main difference found between people with physical disabilities and people with no disabilities was that those with disabilities were more concerned with safety issues with automated vehicles themselves, while those without disabilities were more concerned with adequate road traffic conditions and bad behaviour of drivers of manual vehicles.

In a large-scale survey in Japan, approximately 19% of all respondents who did not have a driver's license chose being able to drive in a CAV without a license as one of the top three merits of CAV (Shin, Tada, & Managi, 2019). This finding indicates that for people for whom driving manually is not an option, CAV could indeed be a good alternative to overcome vulnerabilities.

3.4. Driving style

Another individual differences factor that could have an impact on acceptability of CAV is one's driving style and whether the automated vehicle is somewhat mimicking this style. A simulation study assessed what type of driving style potential users would like in an automated vehicle (Griesche et al., 2016). Most participants preferred an automation of their own driving style. Being in an automated vehicle that used a driving style with smaller safety margins was disliked by all participants. In a simulation study by Hartwich, Beggiato, and Krems (2018) it was found that younger drivers preferred a familiar (their own) driving style for an automated vehicle, while older drivers preferred an AV-driving style that is not impaired by age (i.e. faster than their manual driving style). This means that depending on individual needs, expectations from the driving style of the vehicle might also differ.

Acceptability of CAV might be high among people who do not like to drive long-distances. Notably, in a sample from Switzerland, respondents especially preferred driving an automated vehicle on longer trips (Becker & Axhausen, 2018). This was also found by Shin, Tada, and Managi (2019), who found that potential users of fully automated vehicles have higher purchase intentions and greater willingness to pay when they regularly drive long-distances.

3.5. Experience with the innovation

Acceptability of CAV could also depend on whether it is a complete unknown or whether people have some experience with it. After all, CAV is a technological innovation. Having no experience with an innovation can trigger negative responses, particularly among people who are not open to new technology. In line with this reasoning, a large-scale survey in the United States revealed that most respondents were concerned to be in a fully automated vehicle (AAA, 2016). Interestingly, respondents indicated they would be more likely to use driver assistance systems such as Adaptive Cruise Control, which are in the market for a long period of time now, and therefore are not considered to be an innovation where people have no experience with. As such, having experienced the innovation could make a difference in people's willingness to use it. Indeed, with lower levels of automation in simulation studies, it was found that perceived trust or intention to use an automated vehicle increased after exposure to automation than before (Gold et al., 2015). Particularly positive experiences are important to have a positive influence on attitudes and evaluations, meaning that pilots with CAV or initial trials should ensure that the experience could be a satisfying and positive one.

Experiencing a self driving car[4]

In a study by Hartwich, Witzlack, Beggiato, and Krems (2018) participants' initial perceptions of highly automated driving (HAD) were measured, followed by experiences of HAD in a driving simulator, and finally system experience on a test track. The development of trust and acceptance towards HAD was assessed at several time points. Trust, acceptance, perceived usefulness, and satisfaction of HAD increased significantly after experiencing the driving simulator, compared to the a priori measurements. Moreover, positive ratings remained stable over time. Differences between age groups were also investigated. Although older drivers had a more positive attitude towards using HAD compared to younger drivers, they had less self-efficacy (i.e., the belief that one can handle a situation; Bandura, 1982) when handling HAD.

An online survey found that self-reported familiarity with automated vehicles was positively correlated with expected benefits (both in usefulness and in situations) of automated vehicles, and negatively correlated with concerns regarding automated vehicles (Qu et al., 2019). Intent to use automated vehicles was greater among those that own a vehicle with highly automated features (for example automatic lane keeping, adaptive cruise control, or automated parking) than those who own vehicles with no such features (Sener, Zmud, & Williams, 2019). These results indicate that letting people experience innovation leads to more acceptance.

3.6. Motives

Generally, when people are asked why they drive a car, they will come up with all kinds of practical arguments, such as my car gives me flexibility to go to work at any time; the car enables me to bring my kids to school. This illustrates that car use is generally regarded as mostly utilitarian and practical. In promoting the use of CAV, indeed innovators generally also stress the convenience, safety and other instrumental advantages of CAV. However, a car is more for people than just a means of transporting from A to B. For example, individuals can express that they have high status by owning an expensive car, or show that they care for the environment by driving an electric vehicle, meaning that besides the often first mentioned instrumental motives for car use, there are also symbolic motives that influence car ownership. Also, for many people driving is in itself a positive and enjoyable activity

[4] https://www.pbs.org/newshour/science/in-a-crash-should-self-driving-cars-save-passengers-or-pedest rians-2-million-people-weigh-in

(Gatersleben, 2007; Mokhtarian, 2005; Steg, Vlek & Slotegraaf 2001; Steg, 2005). In other words, people have several motivations for driving a car.

Steg and Tertoolen (1999) proposed a theoretical model in which they illustrated how these motivations influence each other and car use (see Figure 2). As shown, the instrumental and symbolic motives influence the affective motives, meaning that that if one regards driving a car as convenient, low cost and safe, for example, and one also feels one can express who they are with the car, they are likely to appraise driving it as giving them a good feeling, which in turn makes using the car more likely.

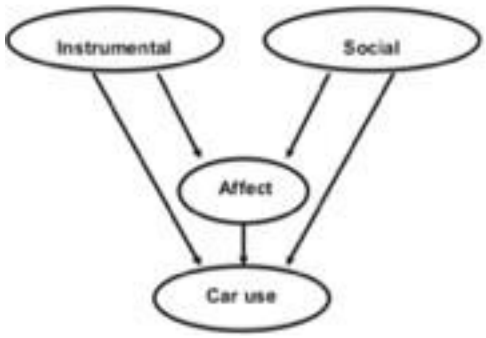


Figure 2. Motivational model for private car use (Steg and Tertoolen, 1999).

There is to date no research extrapolating these motivations for normal car use to intentions to use CAV. But in a recent study, researchers replicated the study of Steg (2005) by applying it to the purchase of electric vehicles (Noppers, et al., 2014). The findings revealed a similar pattern as described above for fossil fueled cars. Participants indicated that instrumental aspects of electric vehicles were more important to them in their decision to buy an electric vehicle, but purchasing intentions were actually better predicted by the evaluation of the symbolic aspects of the electric vehicle. More specifically, the intention to purchase an electric vehicle was mostly associated with gaining status.

This finding is in line with Egbue and Long (2012), who proposed that early adoption of innovations is associated with high-status amongst people. Hence, people might prefer certain transport modes, including relatively environmentally friendly modes, if they are associated with high-status and prestige (Noppers et al., 2014). In other words, mobility choices might have a signalling function that is used to convey one's identity and status. One could hypothesise that these motivations that play a role in normal car use and new innovations in car use such as electric vehicle use could also important in the adoption of CAV.

For instance, people that highly enjoy the feeling of power that comes with driving or the thrill of engaging in risk behaviours like speeding may be less thrilled to use CAV (Rothengatter, 1988; Lawton et al., 1997). Highly automated driving could pose a threat to driving pleasure, particularly for those for whom driving is associated with fun. On the other hand, seeing as CAV is a new innovation the motivation to display status by driving CAV could motivate people to adopt CAV in the same way it has been shown to motivate people to adopt an electric vehicle.

Next generation Tesla, a high status car[5]

3.7. Personality factors

Besides the motives that drivers might have regarding fully automated vehicles, scholars also investigated whether personality factors such as sensation seeking and neuroticism affect the evaluations about fully automated vehicles. Findings on this line of research largely proved inconsistent or showed weak relationships.

For instance, Kryriakidis and colleagues (2015) investigated how personality factors might influence safety issues drivers may have with fully automated vehicles. They showed a weak link between neuroticism and worry about data transmission in automated vehicles (i.e. people scoring higher on this trait showed more worry about data transmission). In addition, people who score high on sensation seeking, which is related to a willingness to be open to new and risky experiences (Zuckerman, 1994), were found to report higher intention to use fully automated vehicles (Payre et al., 2014). This latter finding indicates that fully automated driving as a new and novel technology could particularly be appealing for those who are interested in new experiences. As sensation-seeking is higher among young people and males, the acceptability of fully automated vehicles might also be higher among this group (see Becker & Axhausen, 2017 for a review).

3.8. Personal values

People's worldviews (i.e., their key values and what they deem important in life; Schwartz, 1992) and motives could also affect their acceptability judgments for CAV. In an exploratory qualitative research in Germany, the underlying motives and values for potential users of automated vehicles were examined (Merfeld, Wilhelms & Henkel, 2019). Three overarching motives were found along with underlying values for each motive. The first motive was self-fulfillment: utilitarian and hedonic values; wanting to enrich one's life by using the freed up time from using an automated vehicle. This motive was strong among those who valued career success, social connections, and quality of life. The second motivation was security. This motivation was strong for those who valued personal integrity (improved security of the

[5] https://www.teslarati.com/tesla-model-s-model-x-refresh-details-leaked/

driver and fewer accidents) and weak for those who valued safety (not being in control when needed, proneness to hacking, and concerns about malfunctions). The final motive was responsibility. This motive was strong for those who valued social responsibility (enhancing third party road safety, sustainability of automated vehicles), and weak for those who valued accountability (being only an observer while wanting to take personal responsibility).

In terms of worldview, individualism has been found to be negatively associated with the support of automated vehicles (Dixon et al., 2018). The authors argue that individualists may perceive some aspects of self-driving cars as threatening to their worldview, such as a perceived loss of freedom, additional government intrusion via new regulations, or privacy concerns. Aside from individualism, the same study found that egalitarianism was also negatively associated with the support of automated vehicles. The authors argue that egalitarian values, such as greater transportation access for disadvantaged persons and greater energy efficiency, have not been visible enough in public and news media discourse. The research by Dixon and colleagues (2018) compared worldviews between subjects within the United States. However, it is possible that differences between cultures (national level) also have an effect on the support of automated vehicles.

4. SOCIAL INFLUENCE

Acceptability and acceptance of CAV are not only influenced by individual characteristics, but also by the perception of what others do (descriptive social norms) or what we think that others expect us to do (injunctive social norms) (Cialdini, Reno & Kallgren, 1990). For instance, if a person thinks that the majority of the people in their neighbourhood use CAV instead of a conventional car, then using the CAV becomes a descriptive norm in that environment. Descriptive norms can influence individual actions as they reflect what is the appropriate and sensible thing to do, and we tend to think that the majority will make the most sensible choice. That is, if the majority behaves in a certain way, that must be the right way to behave.

Communicating the descriptive norm can be effective in influencing one's behaviour by, for instance, emphasising the extent to which others engage in the desired behaviour in information campaigns, and providing information to people about what others do when it comes to this particular behaviour. For example, if a municipality of a city wants to motivate CAV-use they could inform their citizens that the majority of people living in their city travels to work by CAV. However, in some instances the undesired behaviour can be the descriptive norm. As such, a descriptive norm can influence behaviour in both directions: it not only reinforces the desired behaviour but also the undesired behaviour. In that respect, information regarding the descriptive norm should be credible to be effective.

Injunctive norms, on the other hand, reflect unwritten rules about what a person thinks others expect him or her to do in a given situation (Cialdini, Reno & Kallgren, 1990). People follow injunctive norms to gain social approval, or to avoid social disapproval. Different than descriptive norms, injunctive norms do not only tell what is the right thing to do at a certain moment, but they also signal that norm violations would be associated with social sanctions while normative behaviour would be associated with social rewards (Cialdini, Reno, & Kallgren, 1990). Hence, when an injunctive norm is violated, this could have social consequences for the individual, such as being negatively judged by one's immediate community. As such, communicating the injunctive norms can also be used to change behaviour. But what happens when there is a mismatch between descriptive and injunctive norms? How would an individual behave when the rule is not to drive your kids to school and no cars are allowed in front of the school but almost everyone is driving their kids to school and parking in front of the school?

In such situations where there is a conflict between the injunctive and descriptive norm, the most salient norm becomes most influential (Cialdini, Reno, & Kallgren, 1990). Following from the example above, an injunctive norm, such as a no-parking sign in front of the school, might make it more salient that other drivers are not obeying the rules (descriptive norm), increasing the likelihood that one follows the descriptive norm of disregarding the no parking sign. Situational cues (e.g. signs) are crucial in that respect in underlining whether other people are following the norm or not; thereby increasing the chances of norm-abiding or norm-violating behaviour.

They reason that for such behaviours it would be more effective to inform people about the so-called dynamic norm, which would emphasize that there is a change in the behaviour of a large group of minority. Following their reasoning, it would be an effective strategy to tell that “30% of the people switched to CAV last year”, because such information would make it salient that there is a trend of using this new innovation in the society, which will increase even further in the future. Indeed, anticipation of future behaviour (referred to as pre-conformity by the authors) seems to explain how dynamic norms could affect behavioural intentions, as well as real behaviour in the desired direction. When the idea of “changing norms” is salient in people’s minds, they seem to be more open to considering changing individual behaviour.

5. PERCEIVED CHARACTERISTICS OF CAV

According to the TAM, individual factors, system and design features of the technology, social influence and facilitating conditions such as legal and policy support around the new technology influence the perception of the new technology. This means that perceptions that people have of CAV influence their attitude and behaviour towards CAV. But whereas TAM only distinguishes between two factors influencing acceptability and acceptance (i.e. perceived usefulness and perceived ease of use) we see that the acceptance of (C)AV is influenced by at least five different kinds of perceptions. The first perception is perceived control one has while being a passenger in CAV. Secondly and thirdly, the perceived safety of and trust in the vehicle as both passengers of CAV, but also as traffic participants engaging with CAV are influential. Fourth and fifth, perceived convenience and perceived pleasure in using CAV both play a role. Although these factors at points relate and overlap, they should be regarded as separate factors, since they have different ways of influencing acceptance and acceptability of CAV, but also because we expect they have distinguishable relationships with the individual differences described above.

5.1. Perceived control

The feeling of being in control is an integral part of driving. One barrier towards the acceptability of CAV is therefore low feelings of control associated with fully automated vehicles. This is supported by findings which show that preference for an automated vehicle tends to get higher for lower automation levels (38.7%) as compared to full automation (15.5%) (Schoettle & Sivak, 2016). Notably, the majority of the drivers indicate that they still would like to have some control over the pedals and the steering wheel. Moreover, almost all people in survey conducted in Finland said to prefer that all automated vehicles could also be driven manually (Liljamo, Liimatainen, & Pöllänen, 2018). This indicates that full automation could indeed pose a threat to the basic need of feelings of control. Indeed, lack of control is rated as the least attractive feature of fully automated vehicles (Howard & Dai, 2014). Interestingly, in Howard’s & Dai’s, (2014) study this was particularly the case among those who enjoy driving as a single driver, who enjoy car-use and associate it to be a luxury possession. This indicates that when a car is seen as a status item, the lack of control that would come with full automation becomes concerning.

In one study participants were asked when they would let an automated vehicle take full control of the vehicles. Responses indicate that people are more comfortable with giving away control on highways and rural and scenic roads, whereas they are less comfortable to do so on roads with higher traffic complexity (Bansal & Kockelman, 2016). This finding indicates that when the complexity of the road environment increases, people have a need to have control over the manoeuvres of the vehicle, perhaps resulting from low trust in automation in hectic road environments.

Menon (2015) found that the concerns which lowered adoption intentions of automated vehicles were related to control: respondents did not like giving up control of the steering wheel, were concerned that using automated vehicles would lead to a decrease in their own driving skills, and were concerned that the system could fail. However, a different study found that those who already use adaptive cruise control (ACC) would be more comfortable about driving without a steering wheel than those who do not currently use ACC (Kyriakidis, Happee, & de Winter, 2015). The latter finding indicates that experience with similar technology could make a difference in acceptability judgments.

Interestingly, when people feel that automated vehicles are able to drive safely by being in control of the road situation at all times, they are also more likely to support CAV. For instance, Dixon and colleagues (2018) found that greater perception of external control (perceiving that an automated vehicle itself has control over and can avoid possible hazardous situations) was related to greater support of automated vehicles in a survey in the United States. But the question of where these positive or negative beliefs stem from needs to be answered to fully understand what kind of strategies are needed to increase acceptability.

5.2. Perceived safety

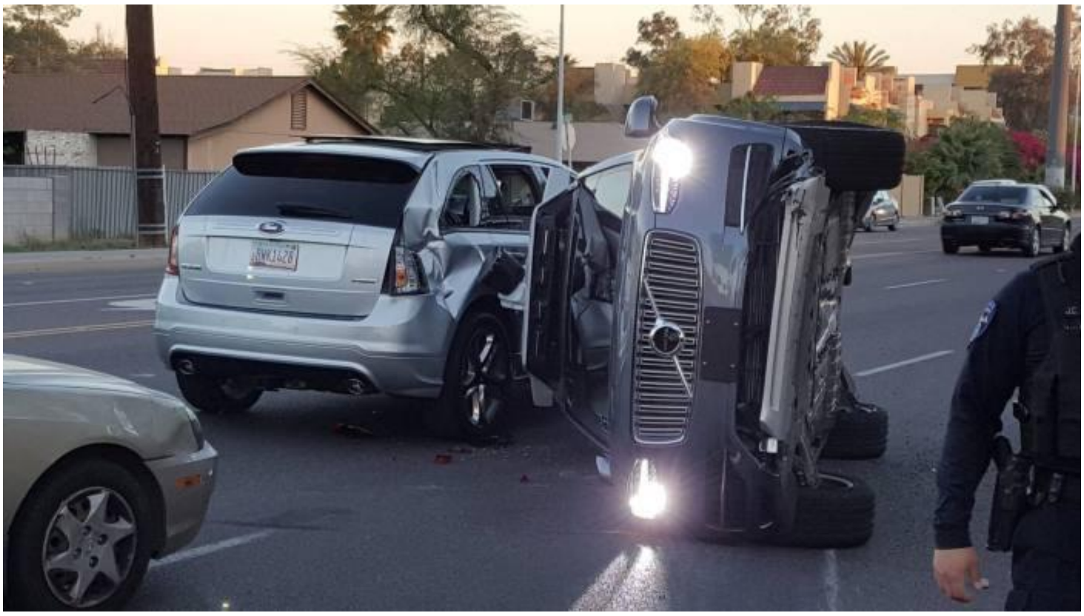
Another factor that influences the acceptance of fully automated vehicles is the personal expectations drivers have of the new technology. For example, Sommer (2013) found that 59% of respondents considered automated driving as a useful advancement but 31% stated that they were rather scared of driving one. Also, Schoettle and Sivak (2014) found that 57% of their respondents had a positive opinion about fully automated vehicles but 25% was very concerned about safety issues. When asked about whether they would like to use an automated vehicle on a daily basis, 40 to 50% of the respondents were found to be willing to have a private automated vehicle to be used on a regular basis, meaning that around half of the respondents were skeptical about using a fully automated vehicle (Bansal & Kockelman, 2016; Zmud et al., 2016). The most concern was raised about equipment failure, vehicle performance in unexpected situations, software hacking and data misuse (Kryriakidis et al., 2015; Schoetle & Sivak, 2014).

Interestingly, some respondents seem to believe that fully automated vehicles will be threatening to safety and some believe these vehicles will improve road safety (Zmud et al., 2016). This means that personal expectations regarding trustworthiness and perceived safety might differ. As particularly low perceived safety and trustworthiness could be detrimental for the acceptance of fully automated vehicles, it is crucial to find out those potential user groups or people that associate fully automated vehicles with low safety, and to find out what drives their negative perceptions. To date, there is no research on evidence-based interventions to improve perceived safety and trust for fully automated vehicles. This research aims to fill this gap by addressing how perceived safety and trustworthiness of fully automated vehicles can be increased, particularly among user groups who have negative expectations and evaluations of fully automated vehicles.

Previous studies indicate that there is a lot of individual variation when it comes to perceived safety of automated vehicles. For instance, while some people associate full-automation with high safety (Zmud, Sener, & Wagner, 2016; Howard & Dai, 2014), some associate it with low safety (Zmud et al., 2016). A large scale survey with over 1500 participants revealed that a large body of respondents believe that fewer accidents will happen in the future thanks to automated vehicles, meaning that the expected safety increase was high (Schoettle & Sivak, 2014). In a study examining people's prioritization of benefits from automated cars, 51% chose 'highest possible level of safety' as their greatest priority (Lustgarten & Le Vine, 2018).

In a study where potential users experienced an automated vehicle with level 4 automation, it was found that perceived safety, trust, and acceptance were strongly correlated, and that they were all solid predictors of intention to use automated vehicles (Zoellick et al., 2019). In a Spanish sample a link between demographics, perceived safety, and intention of using automated vehicles was found (Montoro et al., 2019). The more driving experience respondents had, the more often they drove, and the more often they had been involved in conventional car-based traffic crashes, the more likely they were to perceive automated vehicles as a safer alternative for their daily transportation. Those with a higher education level were also more likely to perceive automated vehicles as more positive, as well as safer than conventional vehicles (both for themselves, as well as for other traffic).

Lack of trust in the technology was the main reason why respondents of a survey, conducted in major cities in Texas, had indicated that they were not likely to use self-driving vehicles (Sener, Zmud, & Williams, 2019). Other (less frequent) reasons were liking to drive, a desire for control over the vehicle, or seeing no need to use a self-driving car as long as they have the ability to drive themselves. Greater perceived safety was related to a greater intent to use an automated vehicle.



Uber SUV on its side following an accident in Tempe, Arizona, United States[6]

5.3. Perceived Trust

Another factor that plays a key role in acceptability of automated vehicles is perceived trust, which can be defined as whether the person believes that the automated vehicle will function

[6] https://www.ft.com/content/89692fee-1181-11e7-80f4-13e067d5072c

as intended and without posing any danger to its occupants as well as other road users. Indeed, in an international survey 47% of all participants indicated that trust is the biggest barrier for automated vehicles (Jeon et al., 2018). There were some differences between countries: Americans believed trust to be the biggest issue more often than Austrians, Germans, and Koreans.

Low trust could even lead to intense physiological responses among users. For example, a simulation study with a high fidelity driving simulator showed that those who have less trust in automated vehicles, experience an additional increase in psychophysiological stress when the vehicle drives autonomously, than when the user is in control (Morris, Erno, & Philcher, 2017). 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 finding indicates that perceived capabilities or overreliance on one's driving skills, for instance, could appear as a factor impairing perceived trust.

Experience with automation might also have an influence on perceived trust (Gold et al., 2015). Yet, the direction of the influence depends on whether negative or positive experiences are accumulated. The finding comes from a simulator study with Level 3 automation, where participants were exposed to several take-over scenarios in environments with different traffic complexity. Participants' evaluations regarding Level 3 automation were measured before and after the simulated driving. It was found that self-reported trust increased after the simulated driving as compared to before. In addition, participants, particularly elderly ones, had decreased horizontal gaze patterns during the course of automated driving, meaning that they trusted the automated vehicle to manage road situations. The authors reasoned that trust might have increased due to the fact that there were no malfunctioning of the equipment during automated driving. However, there were a couple of instances where participants experienced crashes during take-over scenarios, and such a crash experience was correlated with decrease in trust. Interestingly, some people were observed to fall asleep, meaning that there might be individual differences when it comes to trust in technology: some people might be more inclined to trust technology than others. This might also lead to the so-called over-reliance on automation (Parasuraman & Riley, 1997) and might be particularly dangerous in situations where the interference of human controllers is needed, despite the level of automation.

Choi & Ji (2015) found that system transparency (the degree to which users can predict and understand the operating of the vehicle), technical competence (perception of the vehicle's performance), and situation management (belief that the user can recover control when desired) all had positive effects on trust in AV. Moreover, they found that greater trust decreased perceived risk of an automated vehicle, and that greater trust was associated with greater intention to use automated vehicles.

It should be noted that one key factor that influences trust is whether the automated vehicle behaves in the expected direction, or whether it engages in unexpected actions. For instance, false alarms and errors might decrease trust in the automated system (Schaefer, Chen, Szalma, & Hancock, 2016). This means that it is crucial to have automated vehicles that operate error-free as much as possible, as even the smallest error could alarm the user that automation could fail. Also, trust in the vehicle seems to be related to perceived intelligence of the vehicle, which may play a role in acceptance. In two simulated road navigation tasks, those who rated the vehicle as more intelligent spent more time gazing at the surrounding traffic than those who rated the vehicle as low in intelligence (Thill, Nilsson, & Riveiro, 2015). Although not directly tested, this may indicate that a higher perceived intelligence of the vehicle is related to greater trust and acceptance. The question remains: how to increase perceived intelligence of these vehicles?

5.4. Perceived Convenience

Convenience appears to be an important factor associated with fully automated driving (Howard & Dai, 2014). Notably, potential users seem to favour the idea that they would be able to multitask, such as reading and replying to their emails on the road. Aside from that, potential users think automated vehicles could improve traffic safety, and may increase the mobility of people who are unable to drive (Jeon et al., 2018). There might be cultural differences in what people prioritize as a characteristics of an automated vehicle: Korean respondents were less interested in improved safety, and more interested in multitasking than Austrian, German, and American respondents.

In a study examining prioritization of benefits from automated vehicles, a majority (51%) expressed willingness to pay more, as well as a willingness to accept slower travel (54%) in exchange for greater comfort while traveling (Lustgarten & Le Vine, 2018). The perceived benefits of automated vehicles that had significantly improved adoption intentions of automated vehicles were (1) fewer traffic crashes and increased roadway safety, (2) a less stressful driving experience, (3) a more productive use of travel time, (4) less traffic congestion, and (5) lower car insurance rates (Menon, 2005). All of these factors are related to comfort and convenience, indicating the importance of this aspect for people. In line with this, in a German sample, 21% of the respondents said they could imagine buying a car with high automation if the vehicle provides more opportunities and extended comfort (than a manual car) (Pfleging, Rang, & Broy, 2016).

But does perceived convenience change depending on the level of automation? Potential users seem to believe fully automated driving would be easier than manual driving, while partially or highly automated driving is seen as more difficult than manual driving (Kyriakidis, Happee, & de Winter, 2015). This is also displayed in the secondary tasks they would be inclined to engage in while riding the vehicle: the higher the level of automation, the more potential users would intend to rest, watch movies, or read.

Finally, Lee, Chang, & Park (2018) found in a Korean sample that acceptance of autonomous vehicles in general was determined by perceived usefulness, reliability, and legality. Acceptance of CAV specifically was determined by user convenience, perceived safety, costs, and compatibility with the existing environment (infrastructure). As such, perceived convenience is indeed among the key factors influencing acceptability judgements.

5.5. Perceived pleasure

As mentioned before, Steg (2005) already pointed out that a significant percentage of drivers do not view driving as just a means of transportation, but find the driving in itself thrilling, pleasurable and adventurous. Also, people regularly see their cars as a source of power and identify with it (Glancy, 2012). Given this, König and Neumayr (2017) point out that those who have attributions about driving in this way may not feel comfortable with driving a fully automated vehicle. Instrumental attributes (i.e. whether the new technology is easy to use, safe and affordable), affective attributes (i.e. whether the new technology is found pleasant), and symbolic attributes (i.e. whether the new technology will give people status and will tell others something about them) have all been found to be relevant attributions that influence acceptance of new technology (König & Neumayr, 2017). There is, however, to our knowledge no research devoted to linking them to the acceptance of fully automated vehicles specifically, let alone connected automated vehicles.

One argument that is widely used to advertise automated vehicles is that these would have various instrumental benefits for the user, such as being able to go from A to B in one's own car without any effort, by engaging in other unrelated tasks or not having the need to keep an eye on the road. Interestingly, rather than such instrumental motives, affective motives could play a more important in people's decisions to own or use a car (Steg, 2005). For instance, one might enjoy the freedom or power that comes with driving or the thrill of engaging in risk-behaviours like speeding (Rothengatter, 1988; Lawton et al., 1997). Highly automated driving could therefore pose a threat to driving pleasure, particularly for those for whom driving is associated with fun. In one study, researchers compared evaluations for five different automated driving scenarios that differ based on levels of automation (Rödel et al., 2014). It was found that expected fun of driving was lower for scenarios involving higher automation, indicating that full-automation could indeed be viewed as a threat to driving pleasure.

However, certain aspects of highly automated driving could also increase driving pleasure. For instance, engaging in certain manoeuvers, such as reverse parking, could kill the pleasure obtained from driving. Automated vehicles would particularly increase enjoyment when the user does not need to deal with such hassles. Supporting this reasoning, Bjørner (2017) found that people expect to experience the highest pleasure with automated vehicles in situations of a traffic jam or parallel parking. In a traffic jam, people expect high pleasure in an automated vehicle resulting from the possibility of being able to work or just relax despite the traffic jam. Pleasure of driving/trip could also decrease when the automated mode needs to be shared with other people.

6. LIMITATIONS

Findings that are discussed above are mostly from questionnaire studies and self-reports. As CAV is still a new technology, we can assume that the majority of the respondents do not have any real-life experience with these vehicles, but they rather respond based on their intuitions and interpretations. Needless to say, negative news in the media, such as a fully automated car being involved in a crash, could have a negative influence on people's perceptions and evaluations. In a similar vein, positive news can also bias people's perception. We therefore need other studies where participants could experience automation in a realistic setting, and measure their acceptance before and after experiencing driving in an automated vehicle.

CONCLUSION

In D1.1. we aimed at providing a literature review of the psychological factors that are studied in relation to the acceptability of CAV. We first discussed the Technology Acceptance Model, which has been used as a general framework to study acceptance of technological innovations such as CAV. Next, we elaborated on some key factors, such as individual difference factors and perceived characteristics of CAV. Notably, we provided an account of the current literature that focused on these factors.

Our main conclusion is that the acceptability of CAV is a complex process involving several individual, social, cognitive and perceptual factors. Aspects such as perceived trust in CAV, perceived safety of the vehicle, perceived control and perceived pleasure and convenience seem to play a crucial role in defining acceptability judgments. Interestingly, there seem to be many individual differences in people's perceptions and evaluations of CAV. For instance, while some elderly people hold favourable attitudes towards CAV, some hold unfavourable attitudes. Therefore, rather than relying on demographic factors, more psychological individual difference factors, such as values or personality differences, could be more informative to study the acceptance of CAV. In other words, not the age of the person, but whether he or she is open to innovations could play a more important role. We propose that a revised model of acceptance of CAV is needed which is more holistic in terms of factors covered. We aim at developing such a model in SUaaVE as part of WP1.

REFERENCES

AAA (2016, March 1). Three-Quarters of Americans “Afraid” to Ride in a Self-Driving Vehicle. Retrieved from: http://newsroom.aaa.com/2016/03/three-quarters-of-americans -afraid-to-ride-in-a-self-driving-vehicle/ in December 2016.

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In Action Control (pp. 11-39). Springer, Berlin, Heidelberg.

Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50 (2), 179-211.

Bandura, A. (1982). Self-efficacy mechanism in human agency. American Psychologist, 37(2), 122.

Bansal, P., & Kockelman, K. M. (2016). Are Americans ready to embrace connected and self-driving vehicles? A case study of Texans. In 95th Annual Meeting of the Transportation Research Board. Washington DC: TRB.

Bazilinskyy, P., Kyriakidis, M., & de Winter, J. (2015). An international crowdsourcing study into people's statements on fully automated driving. Procedia Manufacturing, 3, 2534-2542.

Becker, F., & Axhausen, K. W. (2017). Literature review on surveys investigating the acceptance of automated vehicles. Transportation, 44(6), 1293-1306.

Bennett, R., Vijaygopal, R., & Kottasz, R. (2019). Attitudes towards autonomous vehicles among people with physical disabilities. Transportation Research Part A: Policy and Practice, 127, 1-17.

Bjørner, T. (2017). Driving pleasure and perceptions of the transition from no automation to full self-driving automation. Applied Mobilities, 4(3), 1-16.

Choi, J. K., & Ji, Y. G. (2015). Investigating the importance of trust on adopting an autonomous vehicle. International Journal of Human-Computer Interaction, 31(10), 692-702.

Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. Journal of Personality and Social Psychology, 58(6), 1015-1026.

Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioral impacts. International Journal of Man-Machine Studies, 38(3), 475-487.

Deb, S., Strawderman, L., Carruth, D. W., DuBien, J., Smith, B., & Garrison, T. M. (2017). Development and validation of a questionnaire to assess pedestrian receptivity toward fully autonomous vehicles. Transportation Research Part C: Emerging Technologies, 84, 178-195.

Deb, S., Rahman, M. M., Strawderman, L. J., & Garrison, T. M. (2018). Pedestrians’ receptivity toward fully automated vehicles: Research review and roadmap for future research. IEEE Transactions on Human-Machine Systems, 48(3), 279-290.

Deb, S., Strawderman, L. J., & Carruth, D. W. (2018). Investigating pedestrian suggestions for external features on fully autonomous vehicles: A virtual reality experiment. Transportation Research Part F: Traffic Psychology and Behaviour, 59, 135-149.

Distler, V., Lallemand, C., & Bellet, T. (2018). Acceptability and acceptance of autonomous mobility on demand: The impact of an immersive experience. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (p. 612). ACM, New York, USA.

Dixon, G., Hart, P. S., Clarke, C., O'Donnell, N. H., & Hmielowski, J. (2018). What drives support for self-driving car technology in the United States? Journal of Risk Research, 1-13.

Egbue, O., & Long, S. (2012). Barriers to widespread adoption of electric vehicles: An analysis of consumer atti tudes and perceptions. Energy Policy, 48, 717-729.

Fishbein, M., & Ajzen, I. (1975). Belief, Atti tude, Intention and Behavior: An Introduction to Theory and Research. Reading, MA: Addison-Wesley Publishing Co.

Gatersleben, B. (2007). Affective and symbolic aspects of car use. In Threats from car traffic to the quality of urban life: Problems, causes and solutions (pp. 219-233). Emerald Group Publishing Limited, United Kingdom.

Glancy, D. J. (2012). Privacy in autonomous vehicles. Santa Clara Law Review, 52(4), 1171-1240.

Gold, C., Körber, M., Hohenberger, C., Lechner, D., & Bengler, K. (2015). Trust in automation–Before and after the experience of take-over scenarios in a highly automated vehicle. Procedia Manufacturing, 3, 3025-3032.

Griesche, S., Nicolay, E., Assmann, D., Dotzauer, M., & Käthner, D. (2016). Should my car drive as Ido? What kind of driving style do drivers prefer for the design of automated driving functions. In Proc. 17th Braunschweiger Symp. Automatisierungssysteme Assistenzsysteme Eingebettete Syst. Transportmittel (pp. 185-204).

Habibovic, A., Lundgren, V. M., Andersson, J., Klingegård, M., Lagström, T., Sirkka, A., Fagerlönn, J., Edgren, C., Fredriksson, R., Krupenia, S., Saluäär, D., and Larsson, P. (2018). Communicating intent of automated vehicles to pedestrians. Frontiers in Psychology, 9, 1336.

Habibovic, A., Andersson, J., Nilsson, M., Lundgren, V. M., & Nilsson, J. (2016).

Evaluating interactions with non-existing automated vehicles: Three Wizard of Oz approaches. In 2016 IEEE Intelligent Vehicles Symposium (IV) (pp. 32-37). IEEE, New York, USA.

Haghzare, S., Bak, K., Campos, J., & Mihailidis, A. (2019). Factors influencing

older adults' acceptance of fully automated vehicles. In Proceedings of the 11th International Conference on Automotive User Interfaces and Interactive Vehicular Applications: Adjunct Proceedings (pp. 135-139). ACM, New York, USA.

Hartwich, F., Beggiato, M., & Krems, J. F. (2018). Driving comfort, enjoyment and acceptance of automated driving–effects of drivers' age and driving style familiarity. Ergonomics, 61(8), 1017-1032.

Hartwich, F., Witzlack, C., Beggiato, M., & Krems, J. F. (2018). The first impression counts; A combined driving simulator and test track study on the development of trust and acceptance of highly automated driving. Transportation Research Part F: Traffic Psychology and Behaviour, 65, 522-535.

Hohenberger, C., Spörrle, M., & Welpe, I. M. (2016). How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups. Transportation Research Part A: Policy and Practice, 94, 374-385.

Howard, D., & Dai, D. (2014). Public perceptions of self-driving cars: The case of Berkeley, California. In Transportation Research Board 93rd Annual Meeting 14, (4502) 1-16.

Jeon, M., Riener, A., Sterkenburg, J., Lee, J. H., Walker, B. N., & Alvarez, I. (2018). An international survey on automated and electric vehicles: Austria, Germany, South Korea, and USA. In International Conference on Digital Human Modeling and Applications in Health, Safety, Ergonomics and Risk Management (pp. 579-587). Springer, Cham, Switzerland.

König, M., & Neumayr, L. (2017). Users' resistance towards radical innovations: The case of the self-driving car. Transportation Research Part F: Traffic Psychology and Behaviour, 44, 42-52.

Kyriakidis, M., Happee, R., & de Winter, J. C. (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. Transportation Research Part F: Traffic Psychology and Behaviour, 32, 127-140.

Lagström, T., & Lundgren, V. M. (2015). AVIP-Autonomous vehicles interaction with pedestrians. Master of Science Thesis, Chalmers University of Technology, Gothenburg, Sweden.

Lawton, R., Parker, D., Manstead, A.S.R., Stradling, S.G. (1997). The role of affect in predicting social behaviors: the case of road traffic violations. Journal of Applied Social Psychology, 27(14), 1258–1276.

Ledger, S. A., Cunningham, M. L., & Regan, M. A. (2018, October). Public awareness, understanding and acceptance of automated vehicles: an international survey of Australian and New Zealand respondents. In Australasian Road Safety Conference Proceedings. Sydney, New South Wales, Australia.

Lee, J. D., & Moray, N. (1994). Trust, self-confidence, and operators' adaptation to automation. International Journal of Human-Computer Studies, 40, 153-184.

Lee, J., Chang, H., & Park, Y. I. (2018). Influencing factors on social acceptance of autonomous vehicles and policy implications. In Portland International Conference proceedings on Management of Engineering and Technology (PICMET) (pp. 1-6). IEEE, New York, USA.

Liljamo, T., Liimatainen, H., & Pöllänen, M. (2018). Atti tudes and concerns on automated vehicles. Transportation Research Part F: Traffic Psychology and Behaviour, 59, 24-44.

Lustgarten, P., & Le Vine, S. (2018). Public priorities and consumer preferences for selected attributes of automated vehicles. Journal of Modern Transportation, 26(1), 72-79.

Madigan, R., Louw, T., Wilbrink, M., Schieben, A., & Merat, N. (2017). What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of automated road transport systems. Transportation Research Part F: Traffic Psychology and Behaviour, 50, 55-64.

Menon, N. (2015). Consumer perception and anticipated adoption of autonomous vehicle technology: Results from multi-population surveys. PhD Thesis. University of South Florida, Florida, USA.

Merfeld, K., Wilhelms, M. P., & Henkel, S. (2019). Being driven autonomously–A qualitative study to elicit consumers' overarching motivational structures. Transportation Research Part C: Emerging Technologies, 107, 229-247.

Mokhtarian, P. L. (2005). Travel as a desired end, not just a means. Transportation Research Part A: Policy and Practice, 39(2-3), 93-96.

Montoro, L., Useche, S. A., Alonso, F., Lijarcio, I., Bosó-Seguí, P., & Martf-Belda, A. (2019).

Perceived safety and attributed value as predictors of the intention to use autonomous vehicles: A national study with Spanish drivers. Safety Science, 120, 865-876.

Morris, D. M., Erno, J. M., & Pilcher, J. J. (2017, September). Electrodermal response and automation trust during simulated self-driving car use. In Proceedings of the Human Factors and Ergonomics Society Annual Meeting 61 (1) 1759-1762. Sage CA: Los Angeles, USA, CA: SAGE Publications.

Noppers, E. H., Keizer, K., Bolderdijk, J. W., & Steg, L. (2014). The adoption of sustainable innovations: Driven by symbolic and environmental motives. Global Environmental Change, 25, 52-62.

Parasuraman, R., & Riley, V. (1997). Humans and automation: Use, misuse, disuse, abuse. Human Factors, 39(2), 230-253.

Payre, W., Cestac, J., & Delhomme, P. (2014). Intention to use a fully automated car: Atti tudes and a priori acceptability. Transportation Research Part F: Traffic Psychology and Behaviour, 27, 252-263.

Penmetsa, P., Adanu, E. K., Wood, D., Wang, T., & Jones, S. L. (2019). Perceptions and expectations of autonomous vehicles–A snapshot of vulnerable road user opinion. Technological Forecasting and Social Change, 143, 9-13.

Pfleging, B., Rang, M., & Broy, N. (2016). Investigating user needs for non-driving-related activities during automated driving. In Proceedings of the 15th International Conference on Mobile and Ubiquitous Multimedia (91-99). ACM, New York, USA.

Qu, W., Xu, J., Ge, Y., Sun, X., & Zhang, K. (2019). Development and validation of a questionnaire to assess public receptivity toward autonomous vehicles and its relation with the traffic safety climate in China. Accident Analysis & Prevention, 128, 78-86.

Rahman, M. M., Deb, S., Strawderman, L., Burch, R., & Smith, B. (2019). How the older population perceives self-driving vehicles. Transportation Research Part F: Traffic Psychology and Behaviour, 65, 242-257.

Regan, M., Cunningham, M., Dixit, V., Horberry, T., Bender, A., Weeratunga, K., & Hassan, A. (2017). Preliminary findings from the first Australian national survey of public opinion about automated and driverless vehicles. Australia and New Zealand Driverless Vehicle Initiative online at https://s3-ap-southeast-2.

amazonaws.com/cdn-advi/wp-content/uploads/2017/08/ADVI-Public-Opinion-Survey_Final_ISBN. Retrieved October, 10, 2019.

Rödel, C., Stadler, S., Meschtscherjakov, A., & Tscheligi, M. (2014).

Towards autonomous cars: the effect of autonomy levels on acceptance and user experience. In Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications, pp. 1-8. ACM, New York, USA.

Rothengatter, T. (1988). Risk and the absence of pleasure: a motivational approach to modelling road user behaviour. Ergonomics, 31(4), 599-607.

SAE International (2018, November 11). SAE International releases updated visual chart for its "Levels of driving automation" standard for self-driving vehicles. Retrieved from https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-fo r-self-driving-vehicles.

Schade, J. & Schlag, B. (2003). Acceptability of urban transport pricing strategies. Transportation Research Part F: Traffic Psychology and Behaviour, 6(1), 45–61.

Schaefer, K. E., Billings, D. R., Szalma, J. L., Adams, J. K., Sanders, T. L., Chen, J. Y., & Hancock,

P. A. (2014). A meta-analysis of factors influencing the development of trust in automation: Implications for human-robot interaction (No. ARL-TR-6984). Army Research Lab Aberdeen.

Schaefer, K. E., Chen, J. Y., Szalma, J. L., & Hancock, P. A. (2016). A meta-analysis of factors influencing the development of trust in automation: Implications for understanding autonomy in future systems. Human Factors, 58(3), 377-400.

Schoettle, B., & Sivak, M. (2014). A survey of public opinion about autonomous and

self-driving vehicles in the US, the UK, and Australia. University of Michigan, Ann Arbor, Transportation Research Institute.

Schoettle, B. and Sivak, M. (2016). Motorists' preferences for different levels of vehicle automation: 2016 (Report No. SWT-2016-8). Ann Arbor: The University of Michigan Sustainable Worldwide Transportation.

Schwartz, S. H. (1992). Universals in the content and structures of values: Theoretical advances and empirical tests in 20 countries. In M. Zanna (Ed.), Advances in Experimental Psychology (Vol. 25, pp. 1-65). Orlando, FL: Academic Press.

Sener, I. N., Zmud, J., & Williams, T. (2019). Measures of baseline intent to use automated vehicles: A case study of Texas cities. Transportation Research Part F: Traffic Psychology and Behaviour, 62, 66-77.

Shin, K. J., Tada, N., & Managi, S. (2019). Consumer demand for fully automated driving technology. Economic Analysis and Policy, 61, 16-28.

Sommer, K. (2013). Continental mobility study 2011. Continental AG, Hanover, Germany.

Souders, D., & Charness, N. (2016). Challenges of older drivers' adoption of advanced driver assistance systems and autonomous vehicles. In International Conference on Human Aspects of IT for the Aged Population (pp. 428-440). Springer, Cham, Switzerland.

Steg, L. (2005). Car use: Lust and must. Instrumental, symbolic and affective motives for car use. Transportation Research Part A: Policy and Practice, 39(2-3), 147-162.

Steg, L., & Tertoolen, G. (1999). Sustainable transport policy: The contribution from behavioural scientists. Public Money and Management, 19(1), 63-69.

Steg, L., Vlek, C., & Slotegraaf, G. (2001). Instrumental-reasoned and symbolic-affective motives for using a motor car. Transportation Research Part F: Traffic Psychology and Behaviour, 4(3), 151-169.

Thill, S., Riveiro, M., & Nilsson, M. (2015). Perceived intelligence as a factor in (semi-) autonomous vehicle UX. In "Experiencing Autonomous Vehicles: Crossing the Boundaries between a Drive and a Ride" workshop in conjunction with CHI2015.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. Decision Sciences, 39(2), 273-315.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science, 46(2), 186-204.

Zmud, J., Wagner, J., Baker, R. T., Goodin, G., Moran, M., Kalra, N., & Fagnant, D. (2016).

Project NCHRP 20-102 (1) Policy and Planning Actions to Internalize Societal Impacts of CV and AV Systems in Market Decisions. University of Utah, USA.

Zmud, J., Sener, I. N., & Wagner, J. (2016). Consumer acceptance and travel behavior: impacts of automated vehicles (No. PRC 15-49 F). Texas A&M Transportation Institute, USA.

Zoellick, J. C., Kuhlmey, A., Schenk, L., Schindel, D., & Blüher, S. (2019). Amused, accepted, and used? Atti tudes and emotions towards automated vehicles, their relationships, and predictive value for usage intention. Transportation Research Part F: Traffic Psychology and Behaviour, 65, 68-78.

Zuckerman, M. (1994). Behavioral expressions and biosocial bases of sensation seeking. Cambridge University Press, Cambridge, UK.

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