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Suspicious minds? – users' perceptions of autonomous and connected driving

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ABSTRACT

In this article, the public perception and acceptance of novel vehicle technologies – autonomous driving (AD) and connected driving (CD) – is investigated. Following a multistep empirical procedure, we explore participants' cognitions towards AD and CD. Therefore, a questionnaire study was run in which the perceived benefits and barriers of the technologies were evaluated by 443 participants in a wide age range (18–76 years). In addition, we took a closer look at the impact of user diversity (gender, age, need for privacy, control, risk taking tolerance and technical self-efficacy) on the evaluation of both driving technologies. Finally, cluster analyses were used out to identify evaluation profiles in both benefits and barriers, respectively. Overall, CD is seen significantly more positive compared to AD. With increasing risk taking tolerance and technical self-efficacy, the perception of the benefits was higher. In contrast, the perception of barriers in novel vehicle technologies was independent of personality factors and attitudes. Here, privacy and data protection issues were seen as key disadvantages. The findings can be used to develop timely and individually tailored public information and communication strategies for automated and connected vehicle technologies.

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need; technology
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1. Introduction

Mobility and communication are two key issues for our society. A steadily growing and aging population (United Nations 2012) in line with sustainable energy claims in cities foreshadows the need for novel mobility infrastructure concepts that consider not only reliable and energy-aware traffic infrastructure but also regards diverse population needs in mobility. Therefore, a socially relevant and participant-related view on mobility is necessary. Also aiming at a sustainable, safe and efficient way to do so, the technological developments of driving autonomously and connected are promising approaches to these challenges.

Today, driver assistance systems connect infrastructure and traffic participants, thereby opening new possibilities to observe and intervene during critical situations (Breuer et al. 2007; Flannagan et al. 2016; Picone et al. 2016). The communication between vehicles among themselves and elements of the infrastructure is called vehicle-to-everything

(V2X). Numerous technological features (e.g. radar, ultrasonic and sensor cameras) have been already installed to reduce the risk of accidents and aid the driver with time critical decisions.

Nevertheless, several concerns have been raised in the context of autonomous driving (AD) and connected driving (CD). Cottam (2017) identifies the primary challenges raised against the new technology as safety and enjoyment, while increasing safety is not only a European must with the number of traffic accidents counting over 30,000 caused by human error in Germany (European Commission 2017). The 30,000 fatalities reported by the National Highway Traffic Safety Administration (NHTSA) in the United States stress the eminent importance of safety as a key criterion of vehicle technologies (Cottam 2017, 35). This indicates also the economic burden of today's mobility with a cost of \$300 billion for car crashes (Cambridge Systematics 2011). As about 90% of the crashes result from driver errors NHTSA 2008, V2X technologies represent essential opportunities to reduce the number of car accidents. 'Taking the biggest technological advance in personal transport that the world has seen in over a century', the European Commission adopted a programme in 2010 with the goal of halving the amount of road traffic on Europe's roads by 2020 (Bansal, Kockelman, and Singh 2016). Here, not only an increased enforcement of road traffic regulations is addressed, but also the programme provides the promotion of intelligent technologies.

With technological possibilities of connecting not only cars and infrastructure but also smart mobile devices, vulnerable road users (e.g. wheelchair users or pedestrians) also can be integrated into the technological development (Narla 2013; Sun, Liu, and Zhang 2017). Utilising the benefits of intelligent vehicle technology (e.g. flexibility, efficiency and safety) necessitates the exchange of information and data between different road users and elements of the infrastructure. This, however, represents a huge challenge in adequate privacy protection and careful data handling and is often the biggest obstacle for public acceptance. With AD and CD, two important parts of mobility behaviour are addressed: the (lack of) driving experience and the connectivity of the cars and drivers, both of which include a wide range of privacy and data security issues. The emotional value of driving – high flexibility and independence as well as being in control – needs to be also addressed. At least in the Western world, driving (in particular cars) is perceived as a deeply ingrained part of social life and contributes to the perceived social esteem (Sheller 2004; Fraedrich and Lenz 2014). Novel car technologies might be regarded as breaking with tradition – the car and the infrastructure technology is in control rather than the driver (Banks and Stanton 2017) often raising feelings of loss of control and the fear of being controlled by technology (Schmidt, Philipsen, and Ziefle 2015; Josten et al. 2017).

In view of these facts, a comprehensive approach is needed that offers an understanding of how people look upon the novel technologies. To increase the possibility of game-changing technology integration into daily life, critical issues like innovation culture and diffusion as well as technology adoption need to be not only addressed, but more importantly understood and integrated into the development and the public communication (Rogers 1995). For the successful integration of AD and CD, it needs to be explored if the public differentiates between the two intertwining technologies, which benefits and barriers are prevailing in both technologies, and how the perceptions are connected to the diversity of users of autonomous cars and drivers of connected vehicles, respectively.

1.1. Acceptance of technological innovations

The technological innovation of CD and AD is not only a European but rather a worldwide research duty. Aiming at a safe, comfortable and trustworthy way to travel, the novel technologies are not only surrounded by a high amount of uncertainty (Geenhuizen and Nijkamp 2003) but also the possibility of being rejected by the public. To understand the likelihood of adoption, all stakeholders need an understanding of the public's perceptions of benefits and barriers of the technology (Ward et al. 2017). Hence, the research area of mobility technology acceptance is based on results of general acceptance research of technical innovations (Davis 1985; Venkatesh and Davis 2000). Main representatives of technical acceptance research are the technology acceptance model (TAM) by Davis (1985) as well as its advancement, the unified theory of acceptance and use of technology (UTAUT) by Venkatesh and Davis (2000). Both theories centre around the influence of perceived usefulness and perceived ease of use on the actual system use and the attitude towards using technology. A high level of prediction for the acceptance of ICT was revealed with both models. Nevertheless, there is a challenge in the transferability of these existing acceptance models: TAM-based acceptance models are devoted to technologies already used by the consumers, which are thereby more tangible compared to the subject of research at hand. Currently, AD is still a theoretical construct for consumers as only a small portion of persons do have real experience with autonomous vehicles. In addition, most of the TAM-based technology acceptance studies deal with technologies with lower assistance and automation levels (Beier 1999). They also do not cover the large diversity of technology users (e.g. their cognitive and affective needs) with focus on novel vehicle technologies. In line with technology diffusion theories, novel technologies are not necessarily adopted. Rather, consumers show diverse adoption reactions to innovations, including 'early adopters', persons that are much more willing to adopt a novelty to 'laggards', who refuse the adoption of the innovation as long as possible (Rogers 1995). It has been shown that users' cognitive and affective beliefs of perceived attributes of a novel technology are – even when not technically correct – strong drivers for or against a novel technology development (Lavine et al. 1998; Joffe 2003). It is thus essential to address the (diversity) factors that promote and impede the adoption of innovations and to explore how consumers differ within both poles of innovation openness.

1.2. Technology acceptance and public perception of automated driving

Users' perception and acceptance of autonomous technologies is a highly researched field in the mobility context. Recent studies revealed important results and help to identify which parts of understanding are still missing (Abraham et al. 2016; König and Neumayr 2017; Lee et al. 2017; Ward et al. 2017).

A diverging picture has emerged, hinting that user-centred research on CD and/or AD is still not fully explored: Son et al. (2015) found that women and younger drivers show lower acceptance towards advanced driver assistance systems (e.g. forward collision warning), while a slightly more positive picture for younger adults was laid out by a large-scale study focusing on acceptance of varying levels of possible automation (Abraham et al. 2016). Regarding fully autonomous (i.e. driverless) technology, younger adults were more comfortable than older ones. Hence, different assessments of this technology may also come from varying domain knowledge and experience with technology in the past. Here, a

generation comparison study from Lee et al. (2017) showed that age negatively affects perception of driverless technology and the interest to use it. Beyond effects of knowledge and experience, age and gender are found to be potentially influencing factors in mobility technology acceptance.

Previous experience with driver assistance systems¹ was found to have a positive relation with the acceptance of AD whereas driving experience (measured by kilometres per week on average and the duration participants hold a driving licence) has a negative one (Böhm et al. 2017).

The fact that infrastructure, vehicles and vulnerable road users will be connected with each other via V2X technology necessitates an exchange of various data. This highlights privacy and data security as key factors for the acceptance of this technology. Regulations need to be implemented to determine, for example the data recipient, the data type to transmit as well as where and for how long data may be stored. Here, first research results show that people do not want to share their personal data (the more personal the data, the less willing to share) or store it for a longer period of time (Schmidt, Philipsen, and Ziefle 2016).

Although at this time the potential technology is partly still a theoretical construct, it is now essential to investigate the technology acceptance during the development phase to enable a successful implementation in the future. With a three-tiered research approach, we focused on user-diverse requirements in the context of V2X technology.

2. Questions addressed and logic of empirical procedure

An essential step in reaching a high adoption willingness of novel vehicle technologies is the identification of influential user acceptance factors. To provide an overview of perceived major advantages and disadvantages of AD technology from a user perspective, we followed a two-tiered research concept (i.e. combining qualitative and quantitative empirical procedures).

First, qualitative interview studies were run to gain deeper insights into public acceptance of novel car technologies, the role of prevailing experience with driver assistance technology, needs of control and perceived advantages and disadvantages of AD/CD. From the findings, major benefits and barriers were extracted that served as an item base for the subsequent questionnaire study in which the level of agreement to benefits and barriers but also their relation to each other were explored. To receive a fair evaluation, we selected only participants with prior experience with driver assistance systems but included a larger sample, nearly gender-balanced and within a wide age range. To understand the impact of individual factors on evaluations, we surveyed participants regarding topic relevant user characteristics (age and gender, individual extent of privacy need, need for control, risk tolerance as well as technical self-efficacy).

The following research questions guided our approach:

1. Which are the prevailing perceived benefits and barriers in AD and CD?
2. Do autonomous and connected vehicles differ within cognitive models of participants?
3. To what degree are the perceived benefits and barriers impacted by user diversity factors?
4. Are there identifiable benefit or barrier perception patterns (i.e. user profiles)?

3. Qualitative approach: understanding lines of argumentation

The qualitative interview studies were carried out in early 2017 in western Germany to identify and discuss relevant insights about AD and/or CD out of a user perspective. All interviews were voice-recorded with the consent of the participants and transcribed for a content analysis (Quelle). The result categories were derived from the transcribed interview material in an iterative process. The studies were developed as semi-structured interviews and contained questions in dialogue form, a short survey to fill out and discuss, as well as a definition for the level of automation (see Figure 1, according to definitions of VDA, BAST, NHTSA 2017). For this work, we consider a level 5 automation based on Gasser et al. (2012), in which the vehicle may drive itself in all use cases (i.e. driverless). This way, considerations about needed information, functionality, trust and control were based on common base knowledge of all participants.

The qualitative approach was structured in two parallel conducted interview studies (see Figure 2). Both consisted of (a) general questions (e.g. demographics), (b) informative questions (e.g. about previous experience with driver assistance systems), (c) an informational part (presenting the level of automation as well as a classification of which level is discussed) and (d) specific questions (e.g. influence of technology type on likelihood of use or privacy focused questions). In order to identify influencing user factors, the studies focus on understanding of argumentation lines towards perceived benefits and barriers of future mobility technologies. The result categories are translated for the presentation in this article.

The next sections will introduce the procedure and measurements (see also Figure 2):

3.1. Interview study: sample

The sample consists of two independent participant groups who partook in one interview study either focused on AD or CD. A closer sample description for each study is given now:

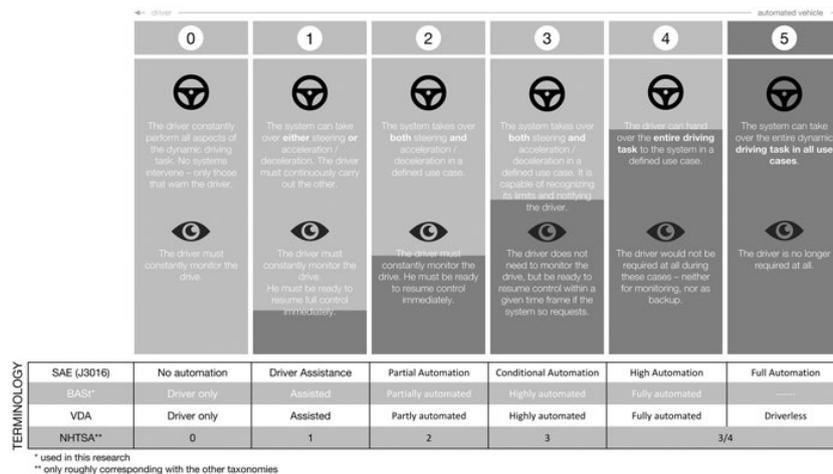


Figure 1. Automation levels definition according to VDA, BAST and NHTSA.

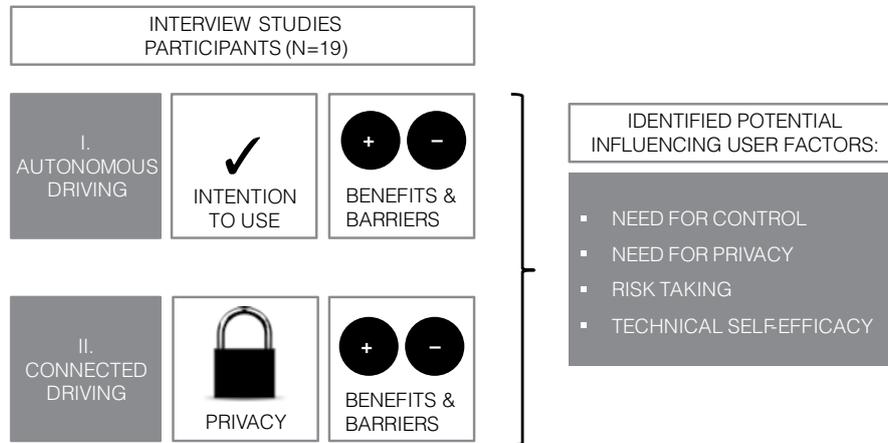


Figure 2. Qualitative research approach.

1 – AD: Five men (m) and five women (w) aged between 23 and 64 years completed the first interview study, which took about 60 minutes. Each interview was led by a trained interviewer and focused on autonomous car usage and possible perceived situational differences, benefits and barriers. All participants hold a driving licence since for at least five up to 47 years. Two participants drive less than 5000 km per year, four participants drive 5000 to 10,000 km per year, and the remaining drive even more.

2 – CD: A total of $N=9$ participants (eight men and one woman, in an age range of 25–59 years) took part in the second interview study, which lasted approx. 40 minutes. Again, each interview was led by a trained interviewer and focused on connected car technology (V2X technology), privacy and data security aspects as well as overall benefits and barriers. All except one participant hold a driving licence. In this sample, the technical self-efficacy was rather high with 5.5 (out of 6 points max.).

Before the interviews started, we informed interviewees that participation was voluntary and not gratified. Also, detailed information was given about the purpose and the aim of the studies. We also stressed that participants should feel free to comment on the topic and to openly share their opinions. In addition, conforming with privacy standards of empirical studies, the participants were informed that all answers are anonymised.

3.2. Interview study: autonomous driving

Overall, the participants were well aware of the technology, nurtured by the media discourse and the local daily press reporting from municipal activities in driving technology and local policy, which is very open-minded to recent developments in vehicle technology development. Accordingly, nine out of ten respondents reported to knowing and understanding what AD and/or CD is. The terminology descriptions of the participants are consistent with the definition subsequently provided later in the interview. Further, they see their future role in the vehicle as passengers. The reduction of (perceived) stress and the possibility to use travel time for other things are highly approved. Only one of the participants disagreed with that shared beneficial view and wanted to be able to gain back control at all times,

believing that focus needs to be on the street all the time. In total, six of the ten interview participants (four male, two female) would not use an autonomous vehicle today whereas four would at least try it or 'always in favor of using it but not alone' (w, 26 years). Here, an overall feeling of caution was communicated. On the one hand, positive reasons mentioned for usage were drive support, more safety in traffic, curiosity and enthusiasm for technology. On the other hand, negative reasons mentioned were loss of control, giving away responsibility, distrust in technology and technological development. Further, based on the brought up reasons for or against the use of autonomous vehicles, the following result categories are identified (and here representative for the sample) as most important to the participants and analysed for a quantitative validation of perceived barriers and benefits:

3.2.1. Technical experience and self-efficacy

The majority of the participants reported only theoretical knowledge about most of the driver assistance systems. In addition to cruise control, which all participants are familiar with, other systems have not been regularly used.

So, when I use driver assistance systems, I have to say, they are already very well-developed. (m, 26 years)

Although, the respondents are overall satisfied with the performance of the known assistance systems – describing them as reliable, pleasant and helpful – also inhibitions like loss of control or loss of driving pleasure were named, leading to the next category:

Because then I have no influence on things. That's why I think I do not like to give up control. (w, 26 years)

If I'm sitting at the steering wheel myself, I just like driving my own car, because I like that feeling. So it's less about losing control than that driving pleasure. (m, 23 years)

The technical experience with driver assistance systems and the technical self-efficacy can therefore be identified as crucial user factors, which need to be considered influential.

3.2.2. Control and trust

Concerning control, the general impression was that all the participants demand the possibility to interfere with an autonomous system at all times. It was difficult for most participants to envision a complete (i.e. all the time) relinquishment of control to the technology. It becomes clear that the participants continue to see themselves in charge and responsible for the vehicle's actions, as the repeated wish for a possible intervention was communicated:

At least I want to be informed. So, I want to be informed and I want to be able to regain control, if I think it's right. (m, 26 years)

One participant expressed the feeling that she needs to be familiar with the system, to build trust in order to 'take the risk' of giving up the control:

But, if I have already made a bit of experience with the system, then I find that, actually, driving autonomously could be even pleasant. So that's about trust, I would say. (w, 26 years)

Thus, need for control is another influencing user factor worth analysing further.

3.3. Interview study: connected driving

Overall, the participants were very aware of the technology, with all respondents having a concrete idea about CD and envisioning a development towards AD in the future. In total, eight of nine interview participants (all male) would definitely use connected vehicle technology, whereas the one hesitant answer specified:

I would use it. Of course, there is always a risk that you rely too much on the system. Then, you are easily distracted by looking at your smartphone or to see what the system suggests, without paying attention to the environment. So, in a supportive way, I would certainly use it, but to a limited extent. (w, 29 years)

Here, an overall positive perception that CD is a supportive technology was communicated. Positive reasons mentioned for usage were a higher safety level in traffic (mentioned by all participants), accident prevention, increase in efficiency and more comfort, whereas negative reasons mentioned were a high risk for the individual's privacy and data security as well as a feeling of being spied on. It was also mentioned that almost no disadvantages are perceived, except data-related ones. Further, based on the mentioned reasons for or against the use of CD technologies, the following categories are identified as important to the participants and analysed for a quantitative validation of perceived barriers and benefits:

3.3.1. Privacy and data security

The most mentioned topic and simultaneously concern about CD was privacy. Clearly, all participants attach great importance to it:

I see direct disadvantages only in privacy. The question is whether such a car drives itself, what data are collected, and how the car manufacturer gets the data, and where they are stored. (m, 27 years).

Here, an overall hesitation towards the technology regarding a sufficiently secure connection was communicated. One participant mentioned that he wanted to decide for himself if the vehicle (or smartphone) is connected or not. Also, the type of data storage (centralised vs. decentralised) was discussed. Further, the actual possibility of being hacked was mentioned:

Of course, there is the danger of hacking attacks, but of course also data loss. (m, 30 years)

Here, some of the participants were unsure about the technical process of being hacked, but they still listed it as a major concern. The majority agreed that privacy is an important factor for both technologies and is therefore focused as potential influencing factor.

3.3.2. Risk perceptions

Addressing the (perceived) risk to using CD technology in traffic, a diverse picture evolved. On the one hand, more, faster or more detailed information (as driver and passenger) and communication (between technology and/or traffic participants) were practical requirements for the technology. Here, one participant summed up the idea of decreasing severe situations through technology in traffic:

By communicating with each other's vehicles, certain situations can be detected earlier and responded to earlier, avoiding situations that are otherwise critical. An accident, for example, between a vehicle and a pedestrian. (w, 29 years)

On the other hand, all participants agreed that using a new technology in traffic can be risky, because the question of responsibility is not definitively determined. One participant also mentioned the difficult task of regaining trust, in case the technology did not work properly:

And there could be the danger that an accident happens at some point and that the trust in the automated or connected technology will sink extremely. The risk is too high, some kind of breach of trust may occur. (m, 25 years)

Another respondent also commented that *using the technology too early is too risky* (m, 64 years). Risk taking in traffic will therefore be addressed in the following quantitative approach of this work.

4. Questionnaire study: methodical approach

With the qualitative studies, insights of AD and/or CD from a user's perspective were gained. Based on the participants' answers, we developed a questionnaire to validate these results. Here, not only (a) benefits and barriers from a user-diverse perspective were addressed, but also (b) categorical rankings regarding their importance for both (connected and autonomous) driving technologies. Finally, (c) user profiles were generated out of all the results (see Figure 3). To do so, we used post hoc clustering procedures (exploratory identification of data structures) on the base of participants' answering patterns.

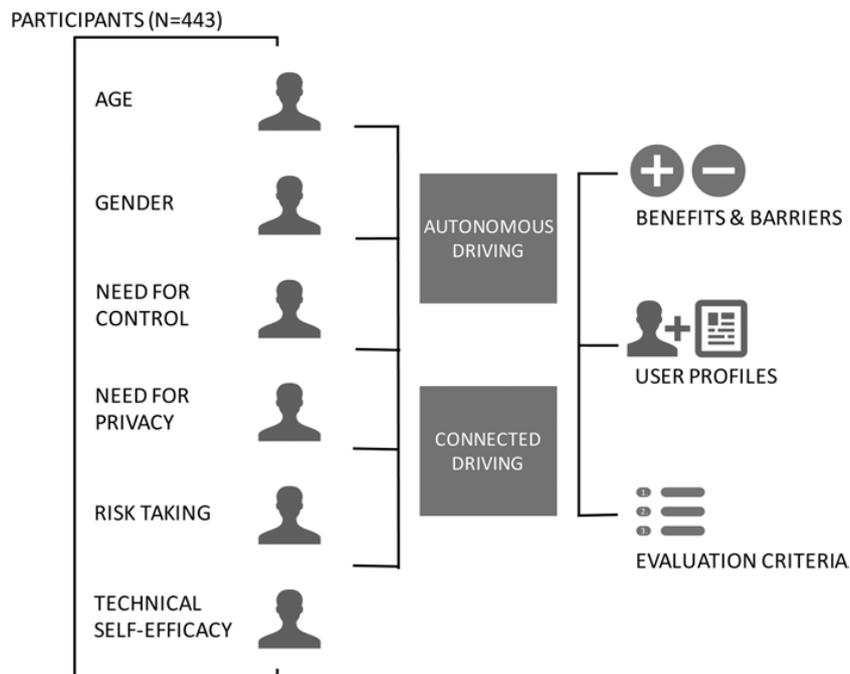


Figure 3. Methodological concept of the research model.

Beyond age and gender, we assessed several user characteristics that could be important for the evaluation of novel car technologies. As such, we measured the users' driving frequency and annual mileage, the willingness to take risks in road traffic, the individual need for privacy and control as well as the technical self-efficacy (Beier 1999).

4.1. Data collection

In order to cover a census representative sample with participants from all strata of society, an independent research marketing company was hired to collect a representative sample. Accordingly, participants were paid a financial expense allowance in accordance with German wage standards.

The possession of a driving licence and regular driving were screening criteria for the acquisition of participants. As we wanted to examine only persons who have at least rudimentary knowledge about automated cars, an additional screening criterion was 'at least theoretical knowledge' about adaptive cruise control (ACC). The latter was taken as a criterion as actual hands-on experience with fully automated vehicles is currently only available to technical expert users in development contexts. To be able to address a broader group of non-experts, the experience with ACC systems was used as a makeshift factor since this functionality is part of a fully autonomous vehicle and is also part of an advanced automation level (2).

For quality assurance of the data, multiple criteria were used to identify dropouts, speeders and contradictory, non-serious response behaviour. Corresponding data records were excluded from further analysis.

4.2. Data processing and analysis

To understand our data, descriptive statistics (reporting means (M) and standard deviations (SD)) were applied. For calculating differences between user groups, null-hypothesis significance testing was used. Generally, parametric testing was applied when applicable, but tested non-parametrically in addition due to the ordinal scales in questionnaires. However, since parametric tests were very robust, especially given our sample size, we report the parametric test results.

The following statistical analysing procedures were applied. (a) For significance testing, the data were analysed by *t*-tests and multivariate procedures with repeated measurements (determining main and interacting effects). Within the MANOVA procedures, we used the individual factors (age, gender, need for control, risk taking and need for privacy) as independent variables, and the scores for perceived benefits and barriers (sum scores) as dependent variables. (b) In order to determine relations between variables, Spearman rank correlation analyses were used. (c) Regarding the analysis of user profiles and the identification of groups of individuals with a similar response pattern, a two-step cluster analysis was applied. The level of significance was set at $\alpha = 0.05$. Outcomes within the less restrictive significance level of $\alpha = 0.1$ are referred to as tentatively significant.

5. Questionnaire study: sample

Overall, the responses of $N = 443$ participants were included in the analysis. In total, 52.8% of the participants were male ($n = 234$) and 47.2% were female ($n = 209$). The average age

was 46.0 years (SD =15.6) and varied between 18 and 76 years. Therefore, the sample was only marginally older than the German society, which is 44.3 years on average.

As can be seen in Table 1, the sample was rather diverse in terms of educational attainment and employment: university degree, high-school diploma and secondary school certificate were represented in the sample.

In terms of employment and vocational training, more than 70% of the sample was employed. The second largest group was made up of pensioners, while only a small part of the sample was still in training. Free-text responses on employment showed that all strata of German society were represented, from incapacitated participants to participants in leading positions.

5.1. User characteristics

Looking at the user factors, the participants' average technical self-efficacy, their need for control and their need for privacy were slightly above the centre of the scale (see Table 1).

Regarding the individual levels of the dimension 'need for control', six items were used (item example: 'I like to have situations under control'. Items were developed on the base of the findings of the preceding interviews). Items had to be answered on a 6-point Likert scale (0 = completely disagree, 5 = completely agree). The full item list is provided in the Appendix.

With respect to the dimension 'need for privacy', nine items were given (item example: 'I think that it is important to know what happens with my data'. Items were developed on the base of the findings of the preceding interviews). The full item list is given in the Appendix. Items were to be evaluated on a 6-point Likert scale (0 = completely disagree, 5 = completely agree).

For 'technical self-efficacy', we used four items based on Beier (Beier 1999) (item example: 'I can solve quite a lot of the technical problems I am confronted with on my own'). The full item list can be found in the Appendix. Items had to be answered on a 6-point Likert scale (0 = completely disagree, 5 = completely agree).

Finally, individual 'openness to take risks' in the context of driving was assessed (item example: 'Without some sort of thrill driving a car is boring'. The ten items were developed on the base of the findings of the preceding interviews). Items had to be answered on a

Table 1. User characteristics.

		Quota/mean
Education	University degree	29.6%
	High school diploma	23.9%
	Secondary school certificate	33.9%
	Elementary school certificate	12.3%
	No school diploma	0.2%
Profession	Employed	63.4%
	Self-employed	8.5%
	Retired	20.1%
	In education	5.4%
	Job-seeking	2.6%
Personality traits	Need for control (max =5)	M = 3.8 (SD =0.8)
	Need for privacy (max =5)	M = 3.3 (SD =0.9)
	Technical self-efficacy (max =5)	M = 3.4 (SD =1.2)

6-point Likert scale (0 = completely disagree, 5 = completely agree). The item list can be taken from the Appendix.

The single items in each of the user characteristics – need for control, technical self-efficacy, risk taking behaviour and need for privacy – were summed up to an overall score, each. The internal consistency for all scales was high, with Cronbach values of $\alpha = .809$ for *need for privacy*, $\alpha = .679$ for *need for control*, $\alpha = .850$ for *technical self-efficacy* and $\alpha = .835$ for *risk taking in road traffic*.

In order to use the user factors as independent variables, we formed two groups by median split for each of the user factors, resulting in a group with lower ($M = 3.1$; $SD = 0.52$) or higher ($M = 4.5$; $SD = 0.4$) need for control, a group with lower ($M = 2.6$; $SD = 0.49$) and higher ($M = 4.1$; $SD = 0.5$) need for privacy, a group with lower ($M = 0.8$; $SD = 0.3$) and higher ($M = 2.2$; $SD = 0.6$) levels of risk taking and, finally, a group with lower ($M = 2.4$; $SD = 0.9$) and higher ($M = 4.4$; $SD = 0.5$) levels of technical self-efficacy.

5.2. Mobility behaviour

In accordance with the screening criteria, all participants had a driving licence for passenger cars. Car ownership was very high: 98.0% of the participants owned a private car. On a scale of 0 = never to 4 = daily, the average usage frequency of these cars was $M = 3.4$ ($SD = 0.8$), which is why we can speak of a frequently driving sample. The annual mileage, on the other hand, tended to be normally distributed (see Table 2) with a peak at 10,000 kilometres: most drivers stated that they drive between 5000 and 10,000 kilometres per year, followed by mileage between 10,000 and 15,000 kilometres. This corresponds to current data on annual mileage in Germany (VuMA 2016).

With regard to the use of ACC, 75.6% of the participants had at least theoretical knowledge of the functionality while 24.4% were already actively using this type of automated driver assistance system. The average willingness to take risks in road traffic (min = 0, max = 5) was rather low with $M = 1.5$ ($SD = 0.9$).

5.3. Interrelationships of user characteristics

The following section describes relationships between user characteristics to identify possible interactions between factors and distortions in the sample. As can be seen in Figure 4, there were numerous significant correlations between the user factors. However, most of the relations were only weak to moderate.

In terms of demography, neither age, nor gender, nor level of education was correlated. In contrast, factors affecting mobility behaviour showed intercorrelations: A high driving frequency accompanies high annual mileages and vice versa. Furthermore, the annual

Table 2. Annual mileage.

Less than 5000 km	12.5%
Between 5000 and 10,000 km	28.3%
Between 10,000 and 15,000 km	25.4%
Between 15,000 and 20,000 km	16.1%
Between 20,000 and 25,000 km	9.8%
Between 25,000 and 30,000 km	6.8%
Not known	1.1%

mileage was also negatively correlated with age, which means that older participants tended to drive fewer kilometres per year.

Understanding the interrelation of user factors, we carried out correlation analyses with and between the four user factors in focus: While *need for control*, *need for privacy* and *risk taking in road traffic*, were intercorrelated, *technical self-efficacy* showed no significant relation to the other three factors. Both the *need for control* and the *need for privacy* were negatively correlated with *risk taking*, which means that high needs for privacy and control go along with a low willingness to take risk in road traffic.

Furthermore, *risk taking* is positively correlated with the driving frequency and the annual mileage and negatively with age. Therefore, drivers who drive a lot and frequently behave more risky, while increasing age has the opposite effect. The older the driver, the less willing they are to take risks. In addition, increasing age accompanies a higher *need for control*. This need is correlated with the level of education, too: The higher the level of education, the lower the need for control.

It is noteworthy that relevant correlations to one of the other user factors were neither found for gender nor for *technical self-efficacy*. Although some significant effects ($p < .05$) existed, the effect sizes, respectively degrees of correlation, were marginal (≈ 0.0 – 0.1) and are not listed here in detail.

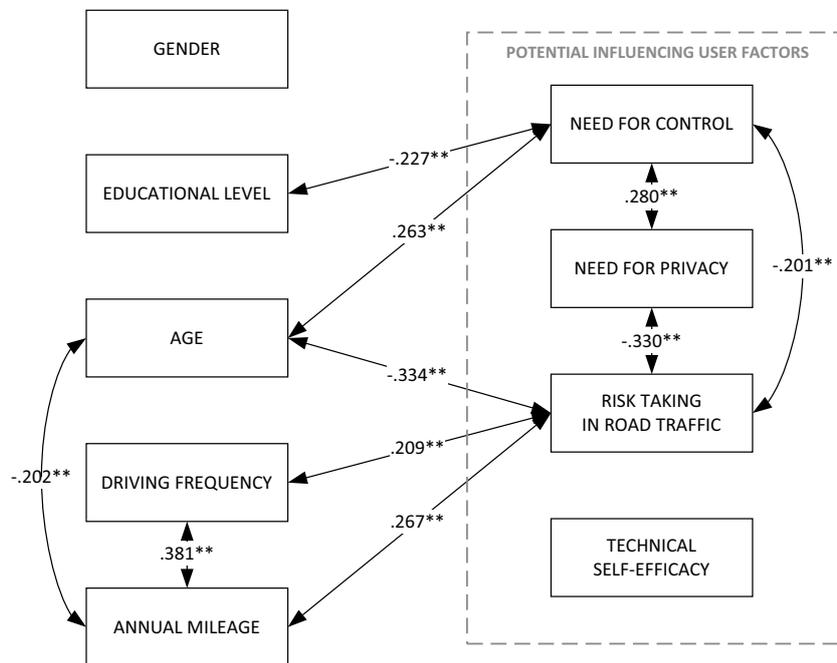


Figure 4. Spearman's rho for significant correlations between user factors (** correspond to $p < .01$). Minor correlations with are not reported.

6. Questionnaire study: results

In the following, we report the outcomes of perceived benefits and barriers for both technology types (AD and CD). To understand user diversity, we analysed the impact of age and gender but also the impact of need for control, need for privacy, risk taking tolerance and technical self-efficacy on the evaluations. Those user characteristics could be relevant for the perception of benefits and barriers in novel vehicle technologies. In a second step, cluster analyses were carried out to determine possible user profiles for the perception of benefits and barriers, respectively. Last, we report the ranking outcomes in which participants weighted the importance of six criteria to be considered for the respective vehicle type.

6.1. Evaluation of the perceived benefits of novel vehicle technologies

In the following, we concentrate on the perceptions of benefits of connected and autonomous vehicles. For a deeper understanding of the impact of user diversity, we report the effects of age and gender on the evaluations, followed by effects of individual privacy needs, control needs, the risk taking while driving as well as the technical self-efficacy. For all analyses, we carried out MANOVAs with repeated measurements, using the cumulated benefits score as dependent variable and the user diversity factors as independent variable.

Overall, a main effect of the type of novel vehicle technology was found ($F(1,437) = 5.25$; $p < .05$). The perception of the benefits for both vehicle technologies differs significantly, with a higher benefit seen for CD ($M = 3.1/5$ points) in contrast to AD ($M = 2.8/5$ points). Regarding the impact of user diversity, we first take a look on age and gender. Neither impacted the perception of benefits significantly. Regarding the users' need for control and need for privacy, the MANOVA revealed a marginally significant interacting effect of vehicle type \times privacy need ($F(1,439) = 3.01$; $p < 0.1$). Generally, the connected technology is perceived as more beneficial than to AD, but the difference between both vehicle technologies is more pronounced in persons with a higher privacy need. The higher the privacy need, the lower is the benefit perception in AD. In contrast, persons with lower privacy needs see both vehicle types more positively. The descriptive outcomes are depicted in Figure 5.

When looking at different levels of need for control, no significant effect was found for the evaluation of benefits for either vehicle technologies. Finally, the impact of risk taking and the level of technical self-efficacy are analysed. A significant three-way interaction of *car technology* \times *technical self-efficacy* \times *risk taking* was found ($F(1,439) = 4.68$; $p < 0.05$), as depicted in Figure 6: persons with a low technical self-efficacy in combination with a lower willingness to take risks perceive the benefits of novel vehicle technologies lower compared to persons with higher levels of technical self-efficacy and risk taking. This is significantly more the case with AD which is seen as less beneficial by respondents.

6.2. Evaluation of the perceived barriers of novel vehicle technologies

In this section, we report on the evaluation of barriers. Again, the cumulated barriers' score was input as dependent variable in the MANOVA procedures. Both vehicle technologies were used as independent variable, with the user diversity factors, in close correspondence to the analyses of the benefits, as between-variables. Overall, the scores for the barriers

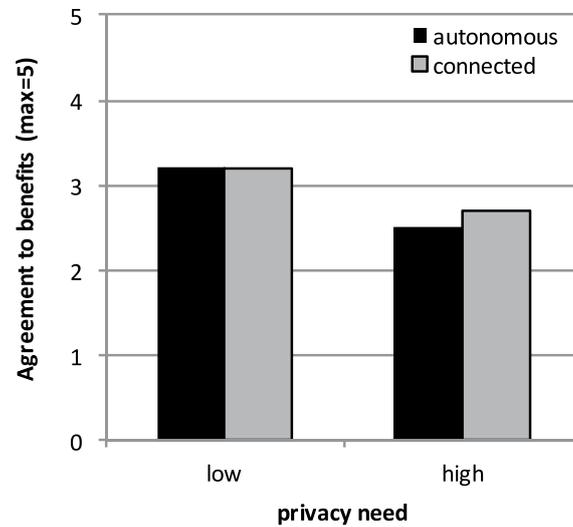


Figure 5. Privacy needs.

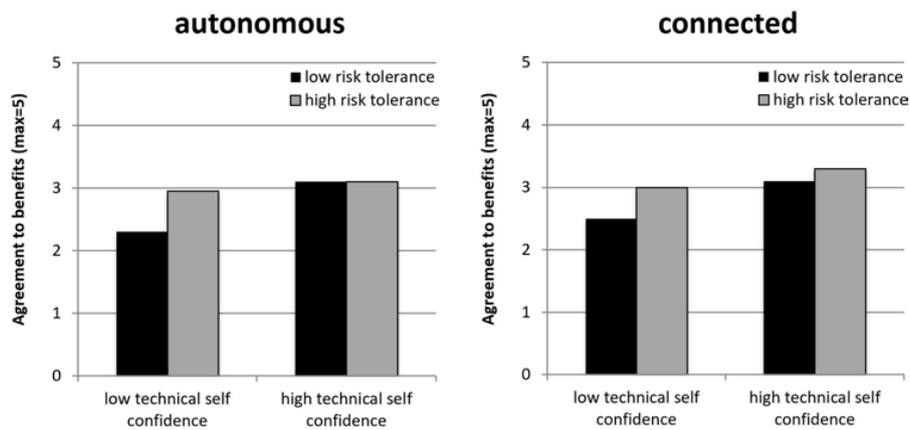


Figure 6. Average agreement to benefits of autonomous and connected driving depending on risk taking tolerance and technical self-efficacy.

range between $M=3.3$ – 3.7 points on the 5-point scale, indicating a considerable barrier perception. However, the perception of barriers is comparable for both vehicle technologies. In addition, none of the user factors did impact the respondents' evaluation of the barriers. Thus, the sample was quite homogeneous in seeing the risks without a modulation by individual levels of *privacy needs*, *control needs*, *risk taking* or *technical self-efficacy*.

6.3. User profiles and the perception of benefits and barriers

In order to identify segments or groups of individuals according to their similarities in response patterns, a two-step cluster analysis was used. Referring to the agglomeration

coefficients, two clusters each for perceived benefits and barriers were identified. In a next step, the clusters were interpreted as to their content and user characteristics of the subsamples and assigned with a descriptive label.

Looking at the benefits, we distinguish between the *traditionalists* ($n = 225$), who do not see the advantages of CD and AD and even show slight rejection (see Figure 7), and the *trailblazers* ($n = 218$), whose average agreement to the questioned benefits is almost always 4 out of 5 points maximum. *Trailblazers* are only a little more sceptical about the possibility of controlling private information. As can be seen in Figure 7, neither *traditionalists* nor *trailblazers* differentiate significantly between CD and AD. The latter group in particular showed an almost identical response behaviour with regard to the benefits of both technologies.

A closer look into the user characteristics shows that *trailblazers* are characterised by a slightly lower age ($t(1,441) = -2.226$; $p = .027$) (44.4 years for trailblazer/47.7 years for traditionalist), a lower need for privacy ($t(1,441) = -5.051$; $p < .001$), a higher willingness to take risks in road traffic ($t(1,441) = 2.447$; $p = .015$) and a higher technical self-efficacy ($t(1,441) = 5.083$; $p < .001$). In addition, *trailblazers* are characterised by a higher proportion of men than women (56.4% for trailblazer/43.6% for traditionalist).

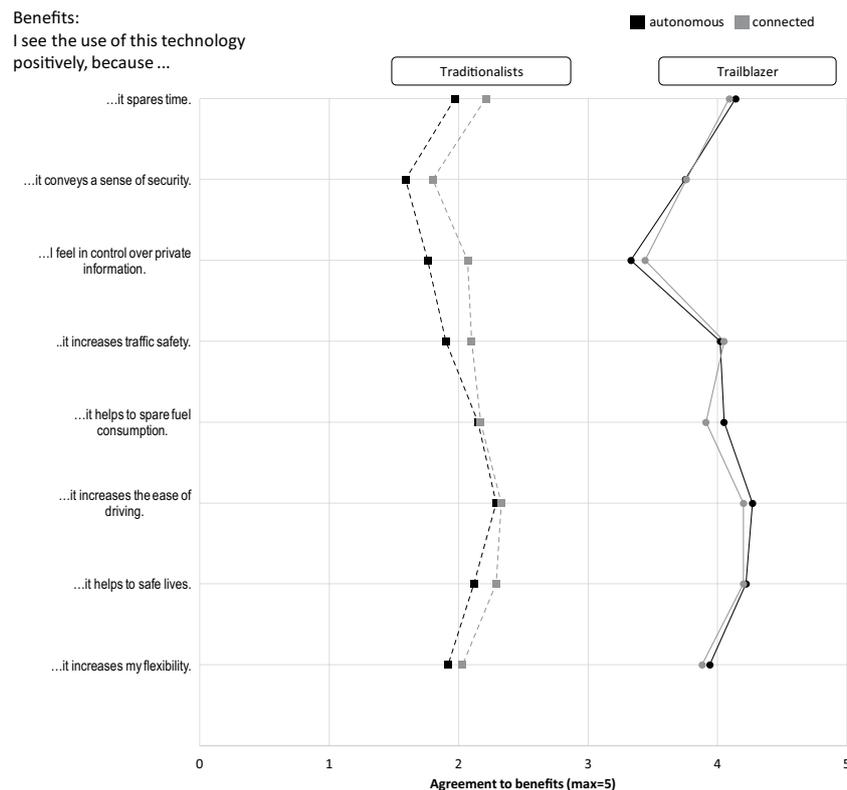


Figure 7. Average agreement to benefits of autonomous and connected driving technology after cluster analysis.

In contrast, the *traditionalists* group has a balanced gender distribution. Both groups do not differ in terms of their level of education, their vehicle use or their need for control.

Similarly, the approval of barriers allowed us to identify two groups that were not congruent with the benefit clusters. The first group is the *dauntless* ($n=206$), who are not deterred by potential risks and disadvantages of a novel technology. They show a slight rejection to all of the presented barriers and face the *guardians* ($n=237$), who want to play it safe and who especially want to protect their data. As illustrated in Figure 8, the *guardians* show a very high average agreement to all mentioned barriers (close to the scale maximum for almost all barriers).

Similar to the benefits, both groups make only marginal differences between vehicle technologies and show a very homogeneous response behaviour across all barriers. Interestingly, the *dauntless* see fewer barriers to AD while the *guardians* see fewer to CD.

A closer look at the user characteristics of both groups shows that, analogous to the previous groups determined on the basis of benefit perception, there was also a difference in the need for privacy between these groups: the *guardians* are characterised by a higher need for privacy ($M=3.4$, $SD=0.8$) than the *dauntless* ($M=3.0$, $SD=0.8$), with $t(1,441)=-8.086$, $p<.001$. In addition, the groups differ only in terms of gender distribution. While the *guardians* show an approximately balanced gender ratio, the men in the *dauntless* group were outnumbered (58.3% for guardians/41.7% for dauntless). There is no significant

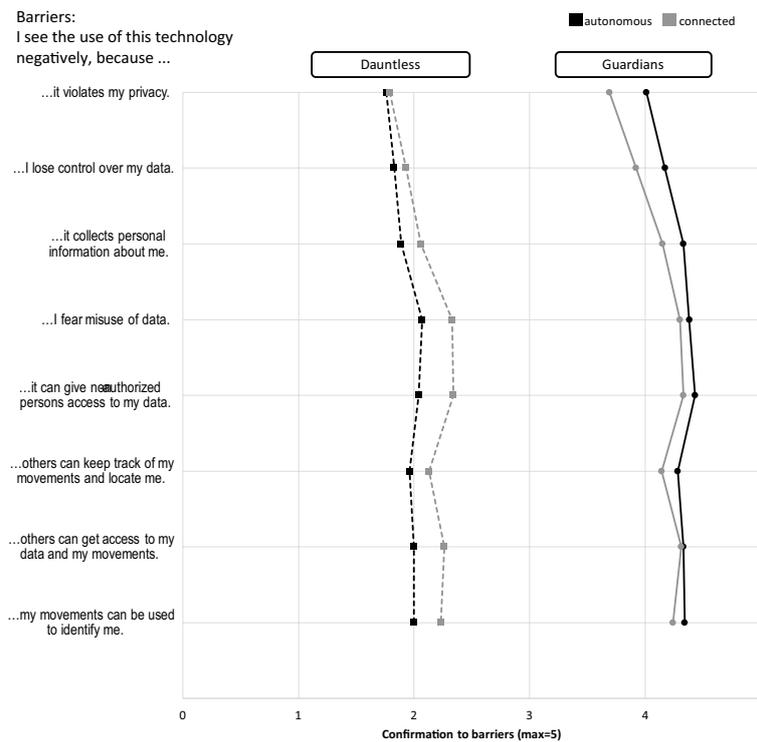


Figure 8. Average confirmation to barriers of autonomous and connected driving technology after cluster analysis.

difference between the two groups in terms of *age, level of education, vehicle use, willingness to take risks in road traffic, need for control or technical self-efficacy.*

6.4. Users' evaluation criteria for driving technologies

Finally, participants had to sort several evaluation criteria for automotive technologies by importance. A non-parametric Friedman test revealed significant main effects of criteria for AD ($\chi^2 = 154$; $p < .001$) and CD ($\chi^2 = 115$; $p < .001$). However, pairwise comparisons based on Durbin–Conover tests disclosed that not all criteria were significantly different from each other in terms of the assigned ranks.

As can be seen in Figure 9, *safety* was the most important criterion for both AD and CD and was ranked as significantly more important in comparison with all other criteria ($p < .001$). The second most important criterion was *control*. Again, the assigned rank for *control* differed significantly from those of the other criteria ($p < .001$). For the following four criteria, the distinction in the evaluation is not that clear: in the case of AD, there are no significant differences in the ranking of *cost, privacy, time saving* and *comfort*. However, purely descriptively based on the distribution, the order of importance is given, as shown in Figure 9, with *comfort* as the least important attribute.

When it comes to CD, the four criteria mentioned above differ significantly. While *privacy* does not differ from the lower-rated criteria, there is a significant difference between *costs*, on the one hand, and *comfort* ($p = .002$) and *time saving* ($p = .005$) on the other. Descriptively, there is a sequence of importance starting with *privacy*, decreasing over *cost* and *comfort* to *time saving* as the least important criterion.

7. Discussion

The present study aimed at an assessment of public perceptions and acceptance of novel vehicle technologies, namely, AD and CD. The overall goal was to identify and understand influencing user factors to provide a potential set-up for the development of individually tailored public information and communication strategies.

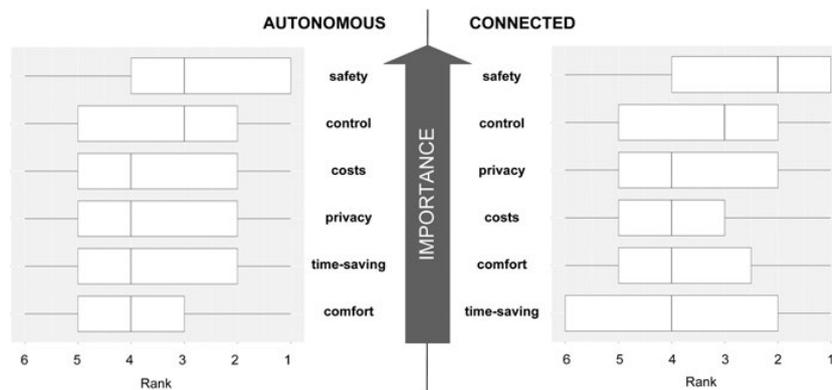


Figure 9. Evaluation criteria for automotive technologies in order of importance (median rank, upper and lower quartile) distinguished between autonomous and connected driving.

Methodologically, we focused, in a first step, on understanding the cognitive argumentation lines of future technology users for and against the technology usage (via interviews). In a second step, we assessed perceived benefits and barriers of both driving technologies in a large western European, heterogeneous sample (via questionnaire). Additionally, we analysed user profiles with respect to user diversity factors regarding their influence on the evaluation of the technologies (via cluster analyses). Also, users' evaluation criteria for the technology usage have been researched (via ranking).

In the following, we thoroughly discuss the results in context of the current state of the art, but also the used methodological procedure to assess the impact of the outcomes for future information and communication strategies. Finally, some limitations of the approach are outlined, in conjunction with future research duties.

7.1. Evaluation of the empirical procedure

Any empirical procedure that aims at capturing public perceptions towards novel technologies depends considerably on the validity and reliability of the methodology, the selected sample and the items, which formed the basis of the evaluation. The methodological rationale adopted in this research was based on a user-centred multistep procedure. The identification of perceived benefits and barriers was accomplished through beforehand assessed interview studies, in which participants discussed potential benefits and barriers of novel vehicle technologies. The argumentation lines and the criteria raised in these extensive interviews were taken as basis for the items used in the subsequent questionnaire. Internal consistency for all scales showed sufficiently high Cronbach values assuring a high item quality. However, it should be critically noted that the benefit items showed a much higher diversity, including aspects of safety, sustainability, efficiency, comfort and flexibility. In contrast, the items for barriers cover exclusively privacy and data protection issues. On the one hand, this can be justified by these issues being of predominant interest in the interviews. Also, recent research confirms the strong focus of public concerns in this respect (Schmidt et al. 2015), thus vindicating assessments of data disclosure, general concerns about protection of data and the fear of losing privacy. On the other hand, one could critically argue that the scope of the barriers should be more diverse.

Moreover, one could critique that it might be redundant to assess both perceived benefits and barriers of a novel technology, as barriers are, by definition, the antonyms of benefits. From a social science perspective, however, this is not the case. Barriers and benefits can prevail at the same time. One might be completely enthusiastic about the technology (high benefit perception) and still have some concerns about potential risks (data security and privacy issues). Therefore, it is mandatory to assess both benefits and barriers as standalone constructs.

Furthermore, we aimed at including a large gender-balanced sample of a wide age and education range to get a realistic picture of public perceptions. However, we included only those participants with prior experience with driver assistance systems to exclude pseudo-opinions (de Best-Waldhober et al. 2012). While this procedure was reasonable for the aim of the study, the findings were a kind of best-case evaluation (as all participants have at least rudimentary experience with assistance systems and automated car functionalities). Thus, we could not exclude that the evaluation of the benefits was lower and the evaluation of barriers was more pronounced for laypersons who could overestimate

the negative consequences of innovations undervalue the benefits (Renn 1989; Joffe 2003; Slovic et al. 2002).

7.2. Differences in mental models of both vehicle technologies

Regarding the second research question, if the cognitive models of participants differ for AD and CD technologies, the results uncover an interesting picture. The first differences in the perception of the vehicle technologies were already revealed in the qualitative interview studies. Here, the majority stated their readiness to test CD whereas testing AD received only a rather moderate appreciation. Hinting at a cognitive discrepancy, the reasons for hesitation concerning AD were mostly loss of control, transmitted responsibility and a distrust in the technology development. User resistance towards technology has been found in other contexts to be a topic of importance (Jiang, Muhanna, and Klein 2000), too. This shows the understanding and challenge to adapt from being a driver towards being a passenger. The main reasons for hesitation in CD, on the other hand, were mostly focused on privacy and data security, which goes in line with findings by Kyriakidis (2015) and Schoettle and Sivak (2014). In the present study, people have been most concerned about being hacked, but also safety and privacy were considered, making data-related concerns the most important for the people. Overall, CD was considered to be a supportive technology, whereas AD received a rather cautious assessment. This begs the question why the AD technology is perceived in such a different way. The quantitative follow-up study offered a more detailed view on the perceptual differences. Especially the benefits of the technologies were assessed differently strong – but not the barriers. Here, a confirmation that the participants know exactly what they are evaluating, can be suggested. The barriers (focused on privacy and data-security) were equally perceived, because they are very similar in their outcome on a technological level. The assessment of the barriers was rather high for both technologies, revealing a need to integrate people's perceptions and requirements into technology development from an early stage on. Taking the participants' characteristics into account, the need for control and privacy was quite high; almost all participants possessed a driving licence, but their risk taking tolerance was rather low. Nevertheless, the sample did not contain any drivers who had hands-on experience with automated cars, which softens the critical point of differing evaluation of the technologies.

7.3. Impact of user diversity on the evaluation of innovations in vehicle technologies

The third and fourth research questions covered issues of user diversity. To what extent are the evaluations of AD and CD technologies impacted by individual variables and, are there answering patterns which can be aggregated to user profiles? Generally, both questions can be confirmed and declined at the same time. Thus, a differentiated view is needed. Overall, the impact of user diversity on evaluation is comparably small, in contrast to technological innovations in the medical technology context (Ziefle, Rucker, and Holzinger 2011), the energy technology context (Zaunbrecher et al. 2016; van Heek, Arning, and Ziefle 2017), the mobile technology context (Arning and Ziefle 2009; Arning, Kowalewski, and Ziefle 2014) and electromobile technologies (Philipsen et al. 2016). In all these technology

contexts, novel products or systems show that age and gender but also individual cognitive and affective responses do considerably impact the innovation openness of respondents and the willingness to use novel products (Rogers 1995). It is noteworthy, in the context of AD and CD, that user diversity effects show up only when evaluating the benefits of both vehicle technologies. The lower the individual level of privacy needs and the lower the technological self-efficacy (Beier 1999; Arning and Ziefle 2009), the smaller is the perception of the benefits. In contrast, there is no user diversity impact on the evaluation of the barriers. Here, all participants, independent from individual requirements, see privacy protection and possible violations thereof as well as a risk in data handling as a considerable stumbling block for novel vehicle technologies. This negative evaluation is not unreasonable, however. All participants – this was clearly demonstrated in the interviews – are well aware that benefits and barriers cannot be reached and avoided at the same time. They see the benefit of having a higher traffic safety by means of connected technology, but they are not willing to sacrifice their privacy. As revealed by the user profiles that were formed through cluster analysis, we found a group that is inclined to see the benefits more strongly (i.e. the trailblazers) and a group which is more reserved (i.e. traditionalists). We learn from psychometrics that the trailblazers are persons with a lower need for privacy and a lower need for control but also with a higher technical self-efficacy and an openness to tolerate risky situations while driving. This pattern allows them to value benefits from novel technologies higher in comparison with traditionalists who are much more suspicious, cautious and reluctant to see benefits of novel vehicle technologies. Conversely, we also identified two clusters in the barriers perception, the dauntless and the guardians, who show opposing patterns. The dauntless are not deterred by potential privacy and data leakages in contrast to the guardians who are very concerned and see privacy issues as the central barrier of novel technologies (Westin 1967). Future work will have to compare the user profiles identified in this research with existing user profiles in different application contexts (e.g. Roger's innovation types (Rogers 1995)) or the Internet privacy typologies reported by Sheehan (2002) and Baruh et al. (2017). Here, future studies will have to explore the relationship of innovation willingness across different usage contexts. Another research duty is the question of the cultural impact. The willingness of persons to share data is indeed cultured (Krasnova, Veltri, and Günther 2012) as is the sociocultural handling of personal rights and the individual freedom. So far, we only have a German-centric perspective and it should be complemented by insights of other countries and cultures.

7.4. Consequences for future information and communication concepts

How can the results of this study contribute to future information and communication concepts? First of all, it should be noted that there was – overall – a high openness to AD and CD, also a willingness to test the technology. People acknowledge the undisputed advantages of novel developments, but, on the other hand, there was a considerable amount of caution based on privacy and data issues (Schmidt et al. 2015) as well as discomfort and aloofness as to the idea of handing over the control to autonomous vehicles. Cars without a driver evoke sincere concerns, feelings of uncanny, risky, and uncontrollable technology. Persons' long experience of driving cars and the perceived control over the car is not easy to overcome or compensate. Here, public information and communication concepts should

address this gap and inform the public about the factually higher safety of autonomous vehicles. However, from a social science point of view, it is important that the concerns should not be met with an increase in information and knowledge alone (Achterberg et al. 2010). It is known from other technology contexts that risk perceptions of novel technologies are often affective and not necessarily based on facts (Slovic et al. 2002; Renn 1989). Accordingly, public concerns can only be adequately met when people learn to trust the technology and the reliability of public information and communication (Zaunbrecher et al. 2016; Zaunbrecher and Ziefle 2016). Thus, it is, as mentioned earlier, mandatory to integrate future consumers into early phases of technology development to benefit from the consumers' experience, their requirements as well as the reported concerns in an open innovation process. In addition, consumers should have the opportunity to get hands-on experience with autonomous cars to develop a more realistic evaluation basis for the novel technology (Banks and Stanton 2016). Finally, it should be a collective educative duty to provide a transparent, honest and non-agitating media information strategy, fostered by science, policy and public relations.

Note

1. Measured by frequent use of one out of five adaptive driver assistance systems (ADAS): cruise control, automatic parking, lane keeping assistant, emergency brake assistant and intelligent speed adaption.

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Disclosure statement

There was no conflict of interest in conducting the studies and preparing the manuscript and the authors have seen, read and understood the guidelines of copyright. The names of all co-authors have been included in the manuscript, all of them contributed to the final manuscript.

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Appendix Autonomous and Connected Driving

**Dear participant,
Many thanks for participating in this study!**

Not only in legislation development is “autonomous driving” an important topic at this moment, the research of self-driving cars is also being pursued. Efficient and secure mobility is thereby a fundamental concern and the role of the “driver” has to be defined anew. We would like to know what you – as potential user – think about these matters. The questionnaire therefore contains, among other items, questions about the perceived advantages and disadvantages of autonomous cars and a connected infrastructure.

We are interested in your personal opinion on the topic of connected and autonomous driving.

Demographic Data

First, we would like to know some things about you as a person. Please fill in what applies to you. All answers are anonymous.

What is your gender?

- female
- male

What is your age?

What is the highest level of education you have completed?

- no school diploma
- (German) Hauptschulabschluss
- (German) Realschulabschluss
- (German) (Fach-) Hochschulreife
- university degree
- promotion
- other: _____

What is your current job status?

- attending school/university
- seeking work
- employed
- self-employed
- retired
- other: _____

Do you own a driving license?

- no
- yes

Mobility

**How often do you use the following vehicles/forms of mobility?
(please select the answer that is most fitting to you)**

[5-point Likert scale: 0 = never & 4 = daily]

- car
- motorcycle, scooter
- public transport

How do you generally use the following vehicles/forms of mobility?

[3-point Likert scale: 0 = mainly as driver (active), 1 = mainly as passenger (passive), 2 = not at all]

- car
- motorcycle, scooter
- public transport

What is your annual mileage?

- less than 5,000 km
- between 5,000 and 10,000 km
- between 10,000 and 15,000 km
- between 15,000 and 20,000 km
- between 20,000 and 25,000 km
- between 25,000 and 30,000 km
- unknown

Do you own a car?

- yes
- no

What driving assistance systems does your car have?

- lane departure warning
- parking assistant
- cruise control
- traffic signs assistant
- lane change assistant
- adaptive cruise control

Which of the following driving assistance systems do you know or have you already used?

[5-point Likert scale: 0 = I do not know the system, 1 = I have heard of the system before, 2 = I have used the system once, 3 = I have used the system more often, 4 = I regularly use the system]

- lane departure warning
- parking assistant
- cruise control

- traffic signs assistant
- lane change assistant
- adaptive cruise control

Experience & Attitude Evaluation

To what extent do you agree with the following statements on your everyday life?

[6-point Likert Scale: 0 = completely disagree & 5 = completely agree]

- I like to have situations under control.
- I do not feel well when others make decisions for me.
- I like to give away responsibility and let others decide.
- I am glad when I can hand over control to others.
- I can estimate possible hazards very well in advance.
- For my behavior in dangerous situations I have to be able to assess possibilities and risks.

Data security and privacy become more and more important in a connected world. To what extent do you agree with the following statements on the use of your data.

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- I think that it is important to know what happens with my data.
- I do not oppose my data being shared with third parties.
- I do not mind providing information about my customs and preferences, because in that way products and services that really interest me can be developed.
- I would like to have an overview of what personal data has been saved at all times.
- The idea that detailed profiles of me exist scares me.
- To me it is important that politics prioritizes data security.
- There are situations in which it is important that there is data about me available on the Internet.
- I do not oppose revealing my data.
- I would reveal personal information if I would benefit from it financially.

How good are you in solving everyday technical problems?

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- I can solve many of the technical problems I am confronted with on my own.
- I think that it is fun to crack a technical problem.
- Because I managed technical problems well so far, I am optimistic concerning future technical problems.
- When dealing with technical devices I feel helpless, which is why I stay away from them.

To what extent do the following statements apply your driving behavior?

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- I would like to participate in a car race once.
- Sometimes I abstain from using the safety belt, or only fasten it during the drive.
- It fascinates me to test the technical limits of my car.
- I am able to tolerate driving behind a slowly driving vehicle for a longer time.
- After 2-3 glasses of beer, I basically drive as well as I do sober.

- Without some sort of thrill, driving a car is boring.
- I like to drive fast.
- When the traffic light switches to yellow, I see this as a sign to brake.
- Sometimes I use the highway's road shoulder to be faster.
- Routes I often drive and know well make me drive faster.
- In traffic situations that are not foreseeable for me, I rather act reserved.

Scenario 1: Connected Driving

The linkage of vehicles and infrastructure is labelled with the term V2X (Vehicle-to-X). This technology will enable vehicles (V) to interact with different communication partners (X), e.g., to make traffic more secure and efficient. V2X-technology uses wireless connections to exchange data and information. In this way vehicles can communicate with other road users (e.g., with other vehicles, pedestrians) or exchange information with the infrastructure (e.g., traffic lights, parking spots). Because of this, diverse possible applications can be put into practice: traffic optimization through controlled traffic lights, early warning when approaching hazard zones, or assistance via searching for available parking spots.

Imagine you are driving in a car that is able to exchange information with other road users and the infrastructure.

Pros and Cons of Connected Driving

For each statement, please indicate the answer that is correct for you:

I see the use of this technology positively,...

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- ... because it spares time.
- ... because it conveys a sense of security.
- ... because I feel in control over my private information.
- ... because it increases traffic safety.
- ... because it helps to spare fuel consumption.
- ... because it increases the ease of driving
- ... because it helps to save lives.
- ... because it increases my flexibility.

I see the use of technology negatively,...

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- ... because it violates my privacy.
- ... because I lose control over my data.
- ... because it collects personal information about me.
- ... because I fear misuse of data.
- ... because it can give non-authorized people access to my data.
- ... because other can keep track of my movements and locate me.
- ... because can get access to my data and my movements.
- ... because my movements can be used to identify me.

Rank the following” concepts” according to their importance for connect driving in a for you correct order:

[ranking question]

- control (over my vehicle)
- costs
- comfort
- safety
- privacy
- time-saving

Scenario 2: Connected and autonomous Driving

Autonomous driving enables the driver to take a new role, as passenger. For this level of automation no driver is necessary anymore and the system reacts on all situations automatically while driving.

Imagine, you are sitting in an autonomous car, which will bring you to your wished destination on its own. Your vehicle further enables you to exchange information with other road users and the surrounding infrastructure.

Pros and Cons of autonomous Driving

For each statement, please indicate the answer that is correct for you:

I see the use of technology positively,...

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- ... because it spares time.
- ... because it conveys a sense of security.
- ... because I feel in control over my private information.
- ... because it increases traffic safety.
- ... because it helps to spare fuel consumption.
- ... because it increases the ease of driving
- ... because it helps to save lives.
- ... because it increases my flexibility.

I see the use of technology negatively,...

[6-point Likert scale: 0 = completely disagree & 5 = completely agree]

- ... because it violates my privacy.
- ... because I lose control over my data.
- ... because it collects personal information about me.
- ... because I fear misuse of data.
- ... because it can give non-authorized people access to my data.
- ... because other can keep track of my movements and locate me.
- ... because can get access to my data and my movements.
- ... because my movements can be used to identify me.

Rank the following” concepts” according to their importance for connect driving in a for you correct order:

[ranking question]

- control (over my vehicle)
- costs
- comfort
- safety
- privacy
- time-saving