Privacy Pirates - The Key Role of User Diversity in V2X-Technology

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Abstract. Success of novel products and services depends on a profound understanding and integration of the consumers wants and needs. Privacy is one major contributor that influences the acceptance, use, and efficiency of novel technologies. To understand, if the usage-context of technologies shapes the privacy perception, we conducted an empirical user study with n = 157 participants and two different considered domains: First, internet usage as a generalized topic. Second, autonomous driving as a more specialized field of interest. One key finding of the presented study is that privacy perception depends on the specific usage-context of a technology. Furthermore, several user diversity factors, such as technical self-efficacy and gender were identified as significant and profound levers on privacy perception.

Keywords: Autonomous driving · Privacy · User-Diversity

1 Acceptance of Novel Technological Development and Privacy Concerns in a Connected World

The steadily increasing technological developments in the mobility sector are key factors in todays society. Promising research approaches such as Volvos Vision 2020 [20] aim for zero traffic accidents due to autonomous driving functions or smartening the infrastructure to secure traffic situations like the CSIC [6]. By implementing smart communication systems into vehicles (V2X; Vehicle-to-everything), problems like the increasing number of traffic fatalities or heavy pollution are addressed. Currently, technical issues are mainly focused in research, e.g. development of specialized network technology [18, 21], whereas an awareness that novel technology is not always capable being seamlessly integrated into customers' and public perception should be raised.

Out of a pragmatic perspective, it could be assumed that novel technologies naturally evoke concerns and criticism in the launching phase. Due to adjusting the technology, these concerns decrease over time. Also, persuasive marketing is in fact a powerful tool, that might solve or camouflage most of public concerns, even after the technological devices or products are already positioned in the market. Both assumptions seem to be not far-reaching enough, out of a social science perspective. Especially large-scale technologies are critically viewed or at least ambivalently perceived by the public [13]. In contrast to technical artefacts (e.g. mobile devices), people have difficulties to

V. G. Duffy (Ed.): DHM 2018, LNCS 10917, pp. 255–267, 2018.
https://doi.org/10.1007/978-3-319-91397-1_22

comprehend or control large scale technologies, which leads to feelings of insecurity, aloofness and ultimately in rejection of the technology [16]. It has been shown that the users' perceived risk of a novel technology and the rejection probability are negatively correlated with the familiarity, the knowledge and the information depth [3]. It was also found that personal factors as age or gender do considerably impact risk perceptions towards large scale technologies [24]. Thus, public perception and users' acceptance should be implemented as early as possible within the technology development in order to adapt technology decisions in line with the fears and wishes of the customers.

The research field of automated vehicles requires more personal data of both active (e.g. driver) and passive traffic participants (e.g. pedestrian passenger), bringing privacy as crucial factor to the topic [7, 12]. Concluding, a profound understanding of the users' acceptance or reluctance towards the technology is essential for future research. The constant increase of privacy concerns can be seen in various research fields for developing technologies as the internet itself [2, 11], social media [5, 17] or medical technology [22, 25]. However, there is a lack of research on privacy issues on autonomous driving out of a social science perspective. Seen from a legal point of view, sharing personal information like position, medical status or type of vehicle to others makes all entities with access automatically co-owners of that information [1]. This underlines that benefits of data sharing and the guarantee of protecting (and not imposing) personal data is an important and fragile part that needs to be transparently communicated to potential users – especially in automated technology. Otherwise, future scenarios like fully automated driving are hardly to be realized without public protest. Previous and current experience as well as domain knowledge can be important drivers for trust; as was displayed in internet research [4] or information technology [19].

2 Questions Addressed and Experimental Design

From the presented development level, it becomes clear that the user has only been involved in a few studies, especially regarding the codetermination, which data transmission is approvable and what happens with the data. To investigate relevant user factors for a wide-spread dissemination of autonomous vehicle technology, the attitude towards privacy as influential factor will be focused, to determine whether there is a difference between privacy perception with data embedded in the internet context versus privacy perception with data embedded in autonomous driving context. Also, a closer look on the user diverse requirements on privacy context-bound to autonomous driving will be given following these main research questions:

1. **Which user-specific factors have an influence on privacy perception?**
2. **Does (technical) context play a crucial role in the perception of privacy?**

Based on a profound literature review and prior qualitative studies (expert interviews), the experimental design for answering the questions mentioned above will be laid out. As can be seen in Fig. 1, the methodological concept shows that user factors (age, gender, technical self-efficacy and prior experience) are examined further. First, they are analyzed towards a general privacy disposition. Further, a contextual embedded

question-block about internet and autonomous driving privacy perception gives insights of the contextual dependence. The increase or decrease of the participants' intention to use autonomous driving technology is also identified.

3 Methodological Approach and Survey

Building on the results of former acceptance-centered V2X-technology research [14], we identified relevant user factors in order to test their influence on the perception of privacy. Further, we divided the empirical approach of the privacy perception assessment in two context based question blocks to test a possible influence on the intention to use autonomous driving features. A brief overview of the study design will be reported:

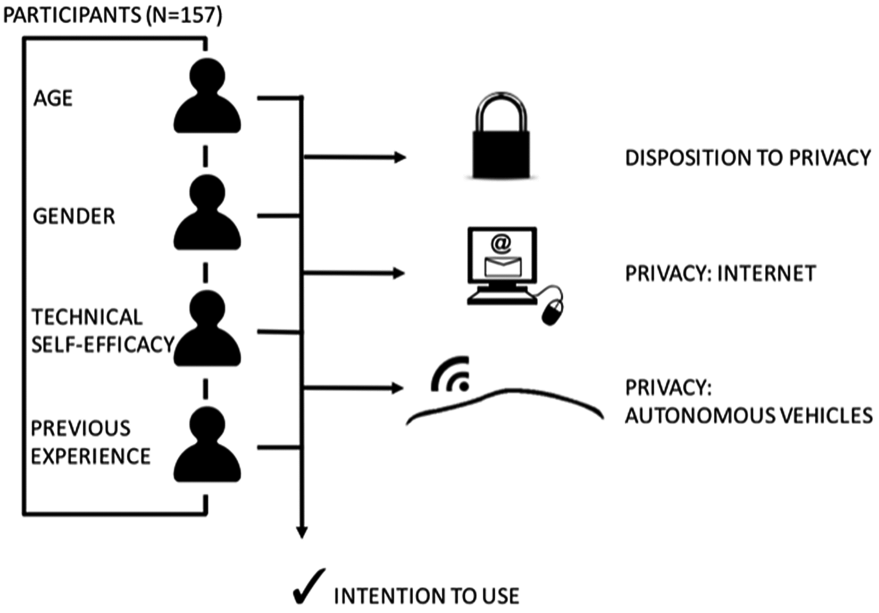

Fig. 1. Methodological concept of experimental design.

3.1 Survey

Demographical Questions. Demographical details (age, gender, etc.) and previous mobility experience as driver (professions such as public transport, cab or ambulance driver etc.) were questioned first.

Mobility Profile. Further, the participants were questioned about their drivers' license and their willingness to use autonomous driving. As a next part, the frequency of different means of transport and the experience with driver assistance systems was questioned (e.g. park assistant, lane assistant etc.).

Privacy and Technical Profile. The next part measured the technical self-efficacy (KUT) [8], the individual confidence in one's capability to use technical devices. Also, the general disposition towards privacy was questioned (see Table 1). The participants also rated privacy perception statements in the context of internet usage (compare [10, 9]).

Table 1. Item example of participants' general disposition of privacy.

How do you evaluate the following statements? (1 = do not agree, 6 = totally agree)
– I am comfortable telling other people, including strangers, personal information about myself
– I am comfortable sharing information about myself with other people unless they give me a reason not to
– I have nothing to hide, so I am comfortable with people knowing personal information about me
– Compared to others, I am more sensitive about the way other people or organizations handle my personal information
– Compared to others, I see more importance in keeping personal information private
– Compared to others, I am less concerned about potential threats to my personal privacy

Privacy in Autonomous Driving. The last part included the rating of privacy perception statements in the context of autonomous driving (see Table 2; compare [23, 15]). Further the participants were invited to think of certain traffic situations in which autonomous driving could be used. At last, the participants had the possibility to give feedback about the topic in general.

Table 2. Item example of participants' privacy perception of autonomous driving.

How do you evaluate the following statements? (1 = do not agree, 6 = totally agree)
– As a result of my usage of autonomous vehicles, others know more about me than I am comfortable with
– As a result of my usage of autonomous vehicles, information about me, that I consider private will be more easily available to others than I would like to
– As a result of my usage of autonomous vehicles, information about me is out there that, if used, will invade my privacy
– As a result of my usage of autonomous vehicles, my privacy will be invaded by others, who collect all data about me
– I feel I will have enough privacy when using autonomous vehicles
– I am comfortable with the amount of privacy I will have when using autonomous vehicles in the future
– I think my privacy is preserved when I use autonomous vehicles
– The above use of personal information for autonomous driving is an invasion of privacy

3.2 Sample/Participants

In total 157 participants took part with an age range of 16 to 67 years (**M**ean = 31.7; **S**tandard **D**eviation = 12.3). The gender distribution is slightly asymmetrical with 106 men (67.5%) and 51 women (32.5%). Most participants hold a driving license (97.5%). The sample contains 48.1% with a university degree or higher (n = 76), 33.1% with a technical college degree (n = 52) and 12.1% did vocational training (n = 19). All participants reported a rather high technical self-confidence with 4.43/6 (SD = 0.79). Cronbachs alpha for the 12 self-efficacy items were .85 respectively.

Here, men are significantly more technical affine (M = 4.59; SD = 0.75) than women (M = 4.11; SD = 0.80) ($t(155) = 3.61$, $p < .001$). For further research, users had to classify if they used technical support systems (lane assistant, distance control, automatic parking, cruise control and brake assistant) in vehicles before. Here, the overall sample has rather little experience M = 2.10 (scale form 0 = no experience to 5 = experience with all systems). Participants, who use(d) none or one of the questioned driver assistance systems before, were classified as *laypeople* (n = 69, 43,9%), whereas participants, who have experience with two or more driver assistance systems were classified as *experienced* (n = 88, 56,1%). The distance control was used/is used by 40,8% (n = 64) participants, the lane assistant by 33,8% (n = 53) and the automatic parking by 26,8% (n = 42).

4 Results and Data Analysis

First, the findings for both privacy contexts on the complete sample will be reported. Afterwards, the effects of age, gender, previous experience with assistance systems and technical self-efficacy will be introduced extensively. The resulting data were analyzed by descriptive analysis and, with respect to the effects of user diversity, by uni- and multivariate analyses of variance ((M)ANOVA) as well as non-parametric counterparts. The level of significance was set to $\alpha = 0.05$. We report the perception of privacy related to the internet and autonomous driving.

4.1 Overall Findings

We report that the overall sample would in fact drive autonomous vehicles (75,2%; n = 118), while a smaller part would not drive such a vehicle (24,8%; n = 39). A closer look into the reasons against autonomous driving shows that out of the 39 non-drivers, 53,8% (n = 21) like driving themselves too much. Also the distrust in the technology was a highly anticipated reason (25,6%, n = 10). The sample's general disposition on privacy was rather indifferent (M = 3.60; center of scale at 3.50, SD = 0.07), while the privacy perceptions in the two technology contexts were just slightly higher (see Fig. 2.), with higher values indicating greater concerns about the preservation of privacy aspects.

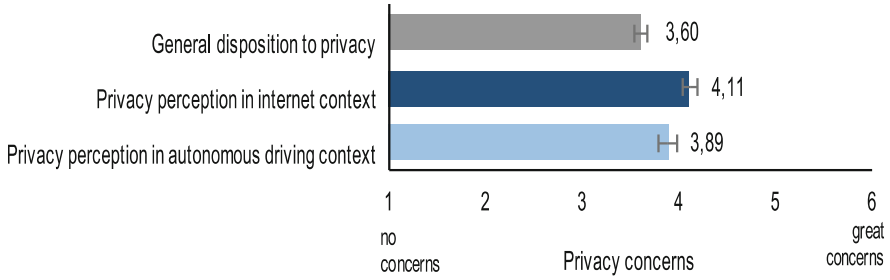

Fig. 2. Means and standard deviations of privacy concerns regarding general disposition and technology usage contexts (min = 1, max = 6).

Looking at the relations between the personal disposition and the perception of privacy in both the internet and the autonomous driving context, it becomes clear that all factors were significantly positively intercorrelated (see Table 3).

Table 3. Pearson correlation coefficients and p-values of the general disposition on privacy and privacy perception in technology contexts.

		General disposition on privacy	Privacy perception in internet context	Privacy perception in autonomous driving context
General disposition on privacy	r	1	.239	.204
	p		.003*	.011*
Privacy perception in internet context	r		1	.603
	p			<.001*
Privacy perception in autonomous driving context	r			1
	p			

There was only a small correlation between the personal, general attitude towards privacy and the privacy perception in the different technology contexts. In contrast, the privacy perception of internet usage was highly correlated with the one of autonomous driving. Figure 3 gives a more detailed insight into the differences between the contexts regarding the agreement to privacy perception statements. Following, we report a general evaluation about which attitude towards privacy the user has in both, the context of internet usage and the theoretical context of driving autonomously (see Fig. 3).

There are several caveats in both context-based privacy perception results. The feeling of having "enough privacy when using internet/autonomous driving" results in a small agreement (M = 2.52, SD = 1.13/M = 2.73, SD = 1.28) whereas the fear, that the usage of either the internet or autonomous vehicles is an invasion in one's privacy results in a stronger agreement (M = 4.18, SD = 1.32/M = 4.03, SD = 1.53). Overall, the internet privacy concerns (Fig. 3 light blue bars) have a higher approval rate compared to the autonomous driving privacy concerns (Fig. 3 dark blue bars), except for the possible "invasion by others", who collect all the data about the user (internet: M = 3.78, SD = 1.40/autonomous driving: M = 3.85, SD = 1.54). Also, some approval

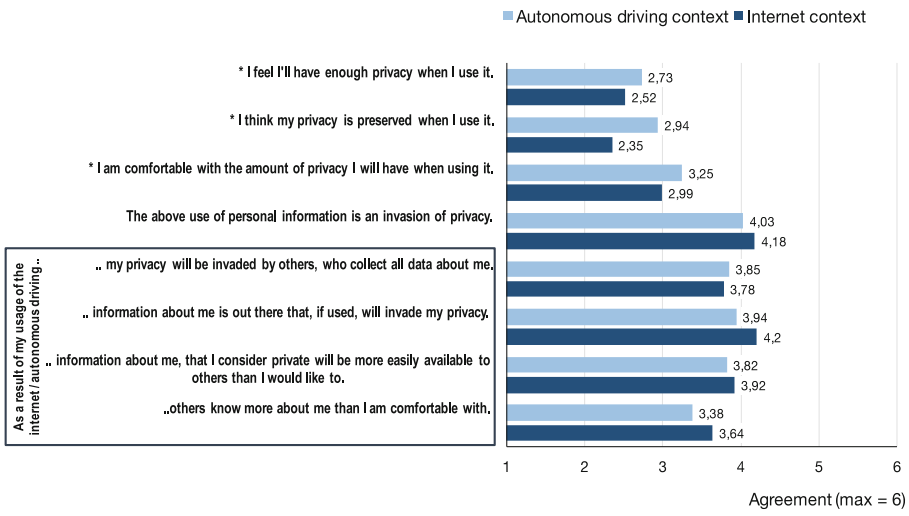

Fig. 3. Average agreement to privacy perception statements in both internet and autonomous driving context (min = 1, max = 6). (Color figure online)

rate differences between the contexts were statistically significant, namely the disparities regarding the belief that privacy will be preserved ($F(1,156) = 28.844$, $p < .001$), the satisfaction with the amount of privacy during use ($F(1,156) = 5.088$, $p = .025$), and the feeling to have enough privacy ($F(1,156) = 4.007$, $p = .047$), indicating an influence of context in the privacy perception of technology.

4.2 Effects of Age

In the following section, age is the first examined user factor considered in detail. First, no connection between age and the intention to drive autonomous vehicle was found. Although, age is a critical factor for experience with driver assistance systems ($r = .318$, $p < .001$, $n = 157$). Age had no influence on the disposition of privacy in general. There were also no significant differences/results in the agreement to the privacy perception statements in both contexts compared to the overall sample.

4.3 Effects of Gender

Gender appeared to be more formative influential. Although, an influence on the intention to drive autonomously could not be identified and the disposition of privacy in general was not significantly different between both sexes. Gender showed several significant effects on the privacy perception in the internet context (see Fig. 4).

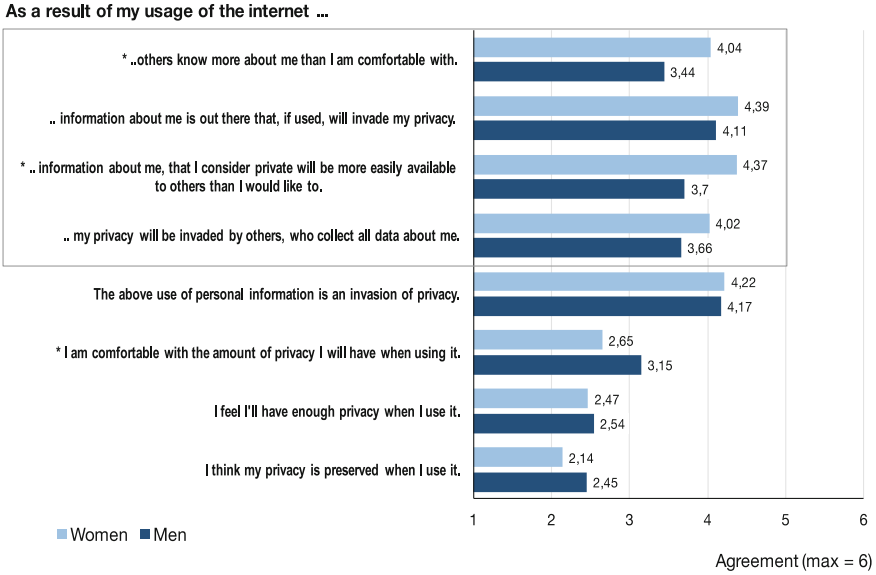

Fig. 4. Arithmetic means of statement agreements for internet-based perceived privacy differentiated by gender (N = 155), significant differences marked with * (min = 1, max = 6).

Women agree (M = 4.04, SD = 1.43) significantly more on the statement, that due to their usage of the internet, others know more about them, than they are comfortable with ($t(155) = -2{,}374$, $p = .019$) compared to men (M = 3.44, SD = 1.49). They also agree (M = 4.37, SD = 1.50) significantly more on the possibility that the information, which is considered as private, is more easily available to others due to their usage of the internet ($t(155) = -2{,}663$, $p = .009$) than men (M = 3.70, SD = 1.50). At last, a significantly lower agreement towards the comfort of the amount of privacy when using the internet ($t(155) = 2{,}243$, $p = .026$) could be identified for women (M = 2.65, SD = 1.32) compared to men (M = 3.15, SD = 1.32). Further, no significant differences could be identified concerning the perceived privacy statements in the autonomous driving context.

4.4 Effects of Technical Self-Efficacy

A close evaluation of the results shows a positive correlation between the technical self-efficacy and the intention to use autonomous driving ($r = -.366$, $N = 157$, $p < .001$). The higher the technical self-efficacy scores, the more likely is the intention to use autonomous vehicles. In contrast, it had no influence on the disposition of privacy in general. As to the significant differences of the privacy perception in internet contexts, see Table 4 (only significant results are shown):

Table 4. Overview of significant results in internet-based privacy perception and KUT.

As a result of my usage of the internet…	N	M (SD)	Result	Sig.
.. others know more about me than I am comfortable with	[157]		t(155) = 2,180, p = .031	*
Low KUT	83	3.88 (1.52)		
High KUT	74	3.36 (1.43)		
.. information about me, that I consider private will be more easily available to others than I would like to	[157]		t(155) = 2,677, p = .008	*
Low KUT	83	4.22 (1.53)		
High KUT	74	3.58 (1.43)		
I am comfortable with the amount of privacy I will have when using it	[157]		t(155) = −3,067, p = .003	*
Low KUT	83	2.69 (1.36)		
High KUT	74	3.32 (1.23)		
I think my privacy is preserved when I use it	[157]		t(155) = −2,710, p = .007	*
Low KUT	83	2.11 (1.12)		
High KUT	74	2.62 (1.26)		

The technical self-efficacy has also a significant influence on the privacy perception in autonomous driving contexts, see Table 5:

Table 5. Overview of significant results in automated driving-based privacy perception and KUT.

As a result of my usage of autonomous driving…	N	M (SD)	Result	Sig.
.. information about me, that I consider private will be more easily available to others than I would like to	[157]		t(155) = 2,646, p = .009	*
Low KUT	83	4.12 (1.53)		
High KUT	74	3.47 (1.53)		
I feel I'll have enough privacy when I use it	[157]		t(155) = −3,179, p = .002	*
Low KUT	83	2.43 (1.22)		
High KUT	74	3.07 (1.28)		
I am comfortable with the amount of privacy I will have when using it	[157]		t(155) = −2,199, p = .029	*
Low KUT	83	3.01 (1.49)		
High KUT	74	3.51 (1.35)		
I think my privacy is preserved when I use it	[157]		t(155) = −2,668, p = .008	*
Low KUT	83	2.66 (1.41)		
High KUT	74	3.26 (1.38)		

4.5 Effects of Previous Experience

With regard to previous experience, the intention to use autonomous vehicles did not show any significant differences compared to the overall sample. Further, no influence of previous experience on the disposition of privacy in general could be identified. There was also no significant difference/result in the agreement to the privacy perception statements in the internet context. Moreover, there were a few significant effects in the autonomous driving context, namely, the experienced group agreed stronger ($t(155) = -1{,}897$, $p = .060$) on the statement "As a result of my usage of autonomous driving, information about me, that I consider private, will be more easily available to others than I would like to." ($M = 4.02$, $SD = 1.47$) than the laypeople ($M = 3.55$, $SD = 1.64$). Also the experienced group agreed stronger ($t(155) = -2{,}597$, $p = .010$) on the statement "…information about me is out there, if used, will invade my privacy." ($M = 4.24$, $SD = 1.59$) than the laypeople ($M = 3.57$, $SD = 1.64$).

5 Discussion

Aiming a first impression of how context influences the perception of privacy in different technology contexts, we worked with a well-educated, highly technical affine, but diverse sample in terms of previous experience with driver assistance systems. A solid age range, but slightly asymmetrical gender distribution made a close look on the user specific factors possible. Further, the participants were analysed due to their general disposition to privacy. All questioned characteristics could be relevant corner stones for privacy perception in technological contexts. Also, the intention to use automated driving (in future) was questioned to identify two of the main groups (according to Rogers 2003): possible deniers or early adopters – which was not the case due to the overall high approval of using automated driving functions. Context-dependency was a former key factor of the willingness to share (private) data with V2X-technology [14], also the FIA (Federation Internationale de l'Automobile) reported similar outcomes in their report 2016 [26]. Therefore, one of the research questions addressed context as possible influential factor of privacy perception. Addressing the first research question, which user specific factors have influence on privacy perception, it can be stated that several results can be highlighted. Whereas age had almost no effect at all on the privacy perception or the intention to use autonomous vehicles, the consequence arises that privacy is a crucial factor of all age (timeless). This fact could be explained by a closer look on the age-range of the sample. Here, all participants could have been involved with either internet based applications or web-enabled devices. A general sensitivity for privacy (concerns) can be identified throughout the age of a user.

The intention to drive autonomous vehicles – which is overall present – is in general not influenced by any of the user factors, except the technical self-efficacy. A higher technical confidence relates to the agreement to use automated vehicles. Generally speaking, ones' capability to use technology is identified as the main key factor for privacy perception. Therefore, technology – especially data sensitive technology like connected or autonomous vehicles – should have the opportunity to train ones' capability, by different automation modi for example. The analysis revealed, that the less

affine to technology a user is, significantly more concerns arise – in both the internet and the autonomous driving context. This could lead to the conclusion, that a profound understanding of how the technology works, overall experience and self-confidence with technology results in less concerns about the own privacy. Here, a transparent communication and information model could help educating people about their privacy options.

Speaking of previous experience, contrastingly, participants who used driver assistance systems in the past, have significantly stronger privacy concerns, but only in the autonomous driving context. Experience as such is according to that an intensifying factor in both directions.

Another influencing factor seems to be gender. Women have significantly stronger concerns about their privacy in the internet context – also in the automated driving context, but not significantly – especially when it comes to what others may be able know about them.

Here, a more frequent use of different services could lead to a higher experience level or a higher frustration about the terms and conditions provided. Therefore, a questioning about general (previous) experience with internet-based services should be focused in future studies, to help identify, if this discrepancy is connected to usage and experience with the technology or gender.

Addressing the second research question, context can be characterized as driving factor for privacy perception. Here, several significant differences in privacy perception of the two domains were displayed. An overall scepsis towards both context-based privacy scenarios could be revealed, opening questions about privacy terms and conditions in general. Interestingly, the concerns of the autonomous context were not as strong as the concerns of the internet context, leading to the consideration that the more generalized topic (internet) is known for years and the use of autonomous vehicles is mostly a theoretical scenario. The disposition of privacy intercorrelated strongly with both context-based perceptions, indicating that concerned people do not put their attitudes aside, but the manifestation varies context-wise. The identified privacy concerns are also an indicator for a possible overall distrust in technology and the data handling of todays services and applications.

6 Conclusion and Outlook

The findings revealed interesting insights into effects of user diversity and even more the effects of context dependent technology perception. Although, the results show only a small part of the diversity of user types and only two different technology contexts, the identification of technical self-efficacy as one of the key factors, which influence the privacy perception of technology was possible. A replication of the study with a larger and more diverse sample should be a next step. Another limitation was the online-based study method, due to a difficult accessibility of e.g. hands on experience with the technology. Context is a crucial factor for a users' perception of privacy. Further research with technology-involving topics like medical care, communication tools confirm the users' need of a transparent communication model about privacy handling.

Acknowledgment. Many thanks go to Sarah Völkel, Florian Groh and Philipp Brauner for research assistance. This project was supported by the Center of European Research on Mobility (CERM) – funded by both strategy funds at RWTH Aachen University, Germany and the Excellence Initiative of German State and Federal Government. Further, thanks go to the project I2EASE, funded by the German Federal ministry of Research and Education [under the reference number 16EMO0142K].

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