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Design of (Semi-)Autonomous Vehicles: Perceptions of the People in Sweden

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Abstract

The field of autonomous vehicles is gaining wide recognition in the industry, academia as well as social media. However, there is a lack of knowledge on expectations of people regarding this topic. To this end, this paper analyses extant research on perceptions of people in various countries about semi-autonomous and autonomous vehicles. Secondly, based on the findings of this analysis, we developed a questionnaire to gauge the perceptions of the people in Sweden regarding such vehicles. The findings have important implications for the design of AVs in Sweden, and possibly other countries.

Keywords: autonomous vehicles, artificial intelligence (AI), ethics, user-centred design

1. Introduction

Artificial intelligence (AI) is the intelligence demonstrated by the artificial systems, such as machines. Its conceptualization started not long after the programmable digital computer was invented in the 1950s (Mijwil, 2015). The field is evolving to develop general intelligence which also includes human intelligence. However, due to factors like limited data and computational power, this technology was put on the side-line, and it took over half a century before finally achieving some of its oldest goals. Today AI is believed to eventually become the most powerful technology in the human history. AI can be divided into two categories (Waser, 2009), namely narrow AI (weak AI) and general AI (strong AI). Strong AI is classified as when a computer program can experience feelings, self-awareness, consciousness, and self-learning (Ng and Leung, 2020). Today's AI is speculated to be decades away from being developed to strong AI. The AI that is used today is weak AI and is designed to perform narrow tasks such as facial recognition and self-driving cars. This type of AI has the potential to benefit society by automating time-consuming tasks or analysing data which is overwhelming for humans (Rajna, 2015).

The field of autonomous robots is gaining wide recognition in academia as well as social media. The manufacturing, automotive as well information technology (IT) industries are among those that are increasingly adopting this technology (Alessandra and Brilli, 2018). There is a difference between the concepts of 'automation' and 'autonomous' in context of AI. Whereas automation is meant to control a system to perform a task, autonomy includes the ability to perform a task while adapting to any unexpected obstacles (Xu, 2021). Tesla, Toyota, Volvo, and many other car manufacturing companies are developing either fully or semi-autonomous systems for their vehicles (Talpes et al., 2020; Morales-Alvarezal et al., 2020).

In Sweden, the regulatory framework for the transport sector have been defined for manually driven vehicles (Bjelfvenstam, 2018) and are therefore, not adapted for fully- or semi-autonomous vehicles (AVs). This new technology shows great promise but can perhaps also raise concerns amongst people. Companies and governments have created a ranking system to classify the different types of autonomy

levels of a vehicle (Anderson et al., 2016; Arrias et al., 2014). Each type of autonomy explains the involvement of the vehicle and the human. This way the distinction between an AV and a semi-AV is clarified. In an AV, the technology fully controls the vehicle without any human operator, whereas a semi-AV requires some level of intervention from the driver. According to the Swedish transport agency 'Transportstyrelsen', the law does not allow autonomous cars in Sweden because those vehicles do not fulfil the requirements to be classified as safe vehicles. The lack of regulations around this topic complicates the introduction of any AV according to the Swedish transport agency (Arrias et al., 2014). Nevertheless, there are regulations in the European Union (EU) and Transportstyrelsen that allow exemptions for testing of these types of systems. However, this testing is allowed only under certain conditions, such as if it can be done without endangering road safety, etc.

The technology of semi-AVs and AVs may change the interaction between the society and its transportation system. Given that fact, it is important to develop these technologies in a way that aligns them with the public and political views on these systems. Recent studies have identified what views on the subject exist today and what people find most concerning about AVs (Howard and Dai, 2014; Schoettle and Sivak, 2014). They have been able to identify these categories such as cost, security, and safety, etc. Within these categories, different uncertainties create some concern among people. New technologies can have different impacts on people depending on a society's structure, ethics, morals, and economy. This study focusses on the views of people in Sweden regarding AVs. Although similar studies have been conducted elsewhere in the world, our study has been carried out in Sweden. The findings of this study will help companies in this industry to adapt and design products using this technology. Furthermore, the study aids them to fit their products within expectations and the moral structure of the society it operates in. Henceforth, we jointly refer to the combined terminology of semi-AVs and AVs as simply AVs for brevity.

The presented paper has two aims. Firstly, it aims to identify what the previous research has concluded about people's perceptions and concerns about AVs, and to identify the subject categories of those concerns. Secondly, this identification forms the basis of our survey, the purpose of which is to get a more profound understanding of the perception of the people in Sweden regarding AVs. The survey was distributed among people of different ages and backgrounds. The survey was mostly quantitative and contained multiple choice questions, in addition to open-ended questions that required text-based answers. These responses were analysed in detail to address the second aim.

2. Related Work

User perceptions and expectations of AVs are important (e.g. Penmesta et al., 2019; Hulse et al., 2018). The topic of self-driving is not an untapped area of research but there is an absence of studies from various countries including Sweden. Since there is a shortage of relevant studies in Sweden on this topic, studies from other parts of the world were analysed. Schoettle and Sivak (2014) conducted an online survey in three English-speaking countries, namely the U.S., the U.K., and Australia. The purpose was to apprehend the public opinion regarding AVs. The online survey was carried out using the application SurveyMonkey (Waclawski, 2012). The goal of this study was to compare different responses from the chosen countries, and also to ascertain if there is a similar pattern in opinions among the participants. The study found that the majority of the participants had a positive attitude towards self-driving vehicles. Furthermore, whilst they had high expectations from the technology, they also had concerns about riding in an autonomous car. There was a concern that these vehicles might not perform as effectively as a manually driven vehicle. Having this technology was something that the majority would desire but not at a significantly additional cost. Another survey was carried out in California to investigate the public attitude towards self-driving cars. According to it, people appreciated the potential of AVs to increase the safety and convenience while allowing multitasking. On the contrary, liability, costs and control were considered as the most concerning areas. The study also revealed that people were worried that the price of this technology will only be appealing to the wealthy class. Lastly, losing control of the car to the AI while being able to always trust the system was a concern. This has a connection to the liability as to who would be responsible if the case of an accident.

The reviewed literature shows that there is absence of the qualitative research from the users' perspective in Sweden, insofar AVs are concerned. Most of the research is either quantitative or is carried out in

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other countries. This paper addresses the aforestated knowledge gaps by gaining insights into attitudes of people in Sweden regarding AVs.

3. Method

In order to address the two aims of our research, we carried out a literature review which formed basis for the design of the survey.

3.1. Literature Review

To get an understanding of what people think of AVs, it is necessary to first get a deeper understanding of the subject before creating and distributing a survey to the people. Therefore, a literature review was necessary, and it contributed to the understanding about the categories that people find most concerning, e.g., cost, safety, and privacy. The literature was scrutinized based on its relevance for addressing our research aims. Articles with results that presented relevant findings on how people viewed certain topics about AVs were perused. The categories encountered in those articles showing one or several concerning topics (e.g., cost, liability, etc.) were then added to a list of collected concerns. When analysing the results from the articles, the first focus was to identify how often a concerning topic (e.g., safety, and security) occurred in the articles. Any topics that showed strong responses from the participants of the previous empirical studies were also considered and were added in the survey questionnaire. An illustration of these categories represented as bubbles is shown in (Figure 1), where Qi refers to one of the questions in our questionnaire (not included in the paper due to space restrictions).

3.2. Survey

After the literature review was completed, a survey was distributed to explore the expectations and ethical perceptions of people in Sweden regarding AVs. The survey consisted of a combination of qualitative and quantitative (multiple-choice) questions. The qualitative part of the survey allowed them to express their open-ended opinions on the related topic. The broader categories (e.g., security, safety, etc.) provided a foundation upon which various relevant questions were added (see also Figure. 1). Each question was related to one or several categories. Besides survey questions that were relevant to the AVs, some general questions related to participants were also included (e.g., age, profession, and awareness of AI). The purpose of this was to better understand the answers and how they correlated with the background of the participants.

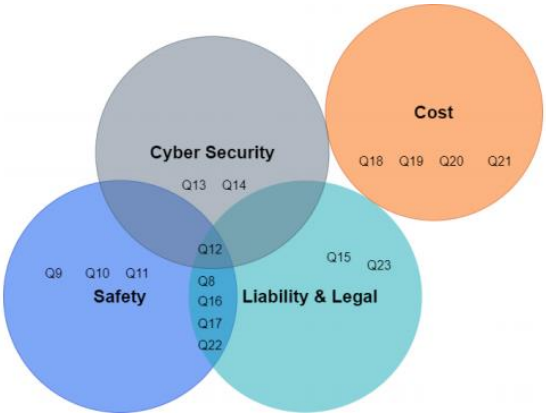

Figure 1. The bubbles represent the categories identified in the literature survey and each question (Qi) belongs to one or more of these categories.

To get responses from a diverse range of the participants (e.g., age, gender, profession, etc.), the survey was distributed using several sources to people born and raised in Sweden. This ensured that all concerned groups were adequately represented in the received responses. The survey included questions covering topics related to AI, ethics, etc. This could potentially make the survey too intricate for anyone who is not exposed to these topics (Julie Ponto, 2015). Therefore, before distributing the survey, it was tested to ensure that the participants could comprehend the questions as intended. To this end, a pilot

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study was conducted with 8 participants. This further ensured that the respondents' working effort and the time to complete the survey was within reasonable bounds.

3.2.1. Survey Analysis

Analysing the text-based (qualitative) answers can be done by sorting the respondents' opinions and their comments in a matrix (Male, 2016). The answers were categorized based on the meaning of the received responses (e.g., yes, no, positive or negative). Their comments were analysed to see motivations to their answers or how they have interpreted a question. Keywords were then placed in the matrix based on the subject's response. The result was then put into a final matrix where the respondents' comments and opinions are summarized. As the sample size is relatively small, the findings are presented using descriptive statistics.

4. Results and Analysis

4.1. Literature Review

The literature review was necessary to understand extant research on this topic. It also helped us to understand as to how people perceived AVs in different parts of the world, the differences, and commonalities in their perceptions. The literature review showed the different types of questions that have been asked in previous empirical studies.

4.1.1. Results

Based on the analysis of the relevant studies, the following four categories about perceptions of people on AVs were identified (Figure 1):

- Safety
- Liability & legal aspects
- Cost
- Security

These four categories are put together as the main categories of discussion while formulating the survey questionnaire. Some subtopics were merged in these concluded categories, such as trust and bias.

4.2. Survey Findings

The survey had a total of 46 respondents and the questions that have been asked were formed as if they would have been asked during an interview. (Figure 2) shows the background of the participants, such as their age, gender, level of education and awareness of AI. Out of the 46 respondents, 17 identified themselves as having a technical background, whereas the remaining 29 as non-technical people.
There were 23 questions in total and by analysing the responses from the participants, patterns can be detected. Whilst a few respondents had concerns about AVs, most of them suggested a positive attitude towards this technology (see Table 1). Those neutral did show a positive attitude towards the technology but were mostly concerned about its safety. A few respondents who expressed a negative attitude mostly did not trust the technology or did not believe it will work in practice. People also have high expectations that a self-driving car would be released on the roads only after fulfilment of thorough safety standards.

Table 1. Respondents' attitude towards autonomous cars

Responses	Nr	Comments	Uncertainties
Positive	35	Safer, time saving, less traffic, better for the environment.	Safety, cannot handle the Nordic climate.
Divided	7	Positive towards the technology, neutral opinion, likes to drive manually.	Not sure about the safety.
Negative	4	Don't think it will work, don't trust the technology, more trust towards human drivers.	-

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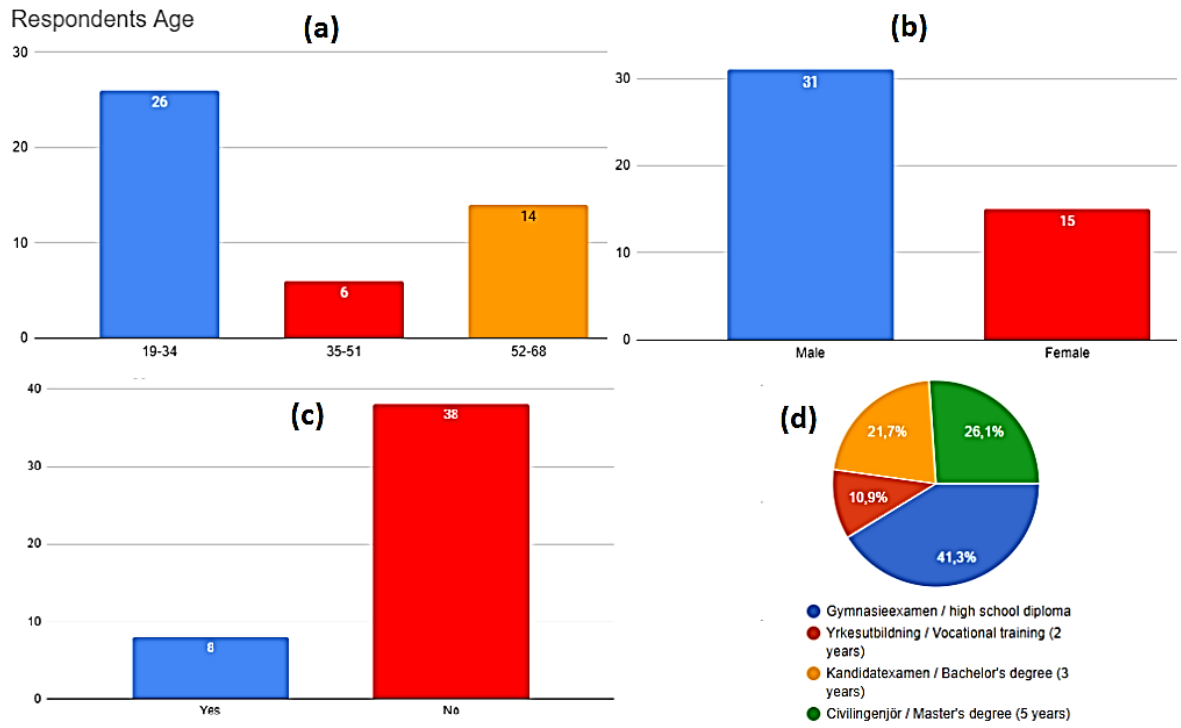

Figure 2. The charts show the background of the subjects that participated in this survey (a) age, (b) gender, (c) awareness of AI, and (d) educational level.

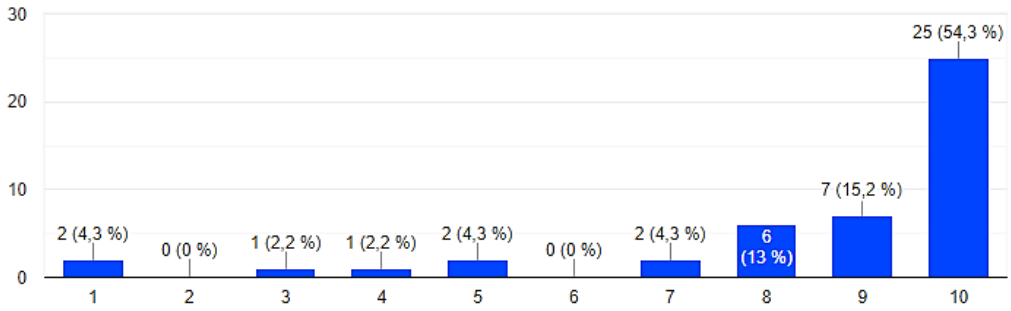

Figure 3. The subjects rated their expectation regarding companies' ability to produce safe vehicles before releasing them (10 is highly expected and 1 is not expected at all).

The respondents rated their expectations that any company that releases an AV has made sure that it is safe enough to drive on the roads (Figure 3). In another question, the subjects were asked if it mattered which country the autonomous technology was developed in (Figure 4a). Many participants also believed that the company in which AVs are developed have a role in deciding the trust factor connected to the technology.

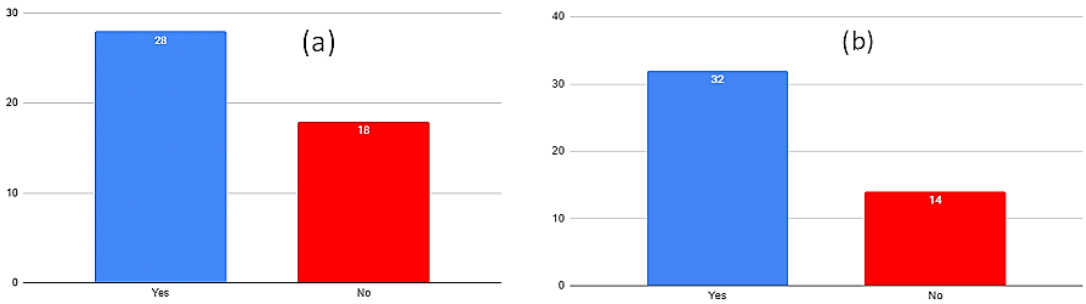

Figure 4. Of the 46 participants, (a) 28 subjects believe that it did matter which country develops the AV (b) 32 subjects would allow the AI to make a sacrificing decision in AVs.

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4.2.1. Liability

The participants were first asked whether an AV should be able to make a sacrificing decision, for example in the standard Trolly problem (Graham, 2017). 32 respondents (against 14) believed that AVs can be allowed to make such a decision (Figure 4b). This scenario being hypothetical drew mixed opinions from the respondents. The next question in the liability category sought to inquire if lives can be prioritised (e.g., old person vs. young person, kid vs. young adult). When the respondents answered this question, their attitude was different from that of the Trolly problem. Whilst the answers to the Trolley question reflected on the logical thinking of the participants, the answers to this question suggested that the respondents preferred to prioritize certain people over some other people (Table 2). Those who answered yes to the question on prioritizing lives, argued that age can be a factor that should be considered if AI would make such a decision.

Table 2. Respondents' thoughts on AI being able to prioritize lives in an accident

Responses	Nr	Comments summarizing
Yes	17	-Based on age, based on pregnancy or child which should be prioritized. -Based on the least amount of damage caused in people not on any features, yes but no on features which are discriminating. -Based on a collective decision on how to make these prioritizes.
No	24	-It is not possible for an AI to make those decisions, people do have different values, but this cannot be calculated in these scenarios -A computer should not be able to make these types of decisions, ethically wrong, dangerous, make it random.
Don't know	5	Cannot decide.

Most respondents thought there should be dedicated roads for AVs (Table 3). They suggested that AVs should not be allowed in areas close to schools or parks. Many of the respondents were also concerned about densely populated areas or where there is a heavy traffic such as the centre of a city. Some respondents showed concerns about situations where AVs might find it hard to operate, e.g., gravel or dusty roads, or icy/snowy conditions, which can disrupt the sensors.

Table 3. Respondents' thoughts on AV road restrictions

Responses	Nr	Comments
Yes	28	-Not in cities or closely populated areas, not near places where there are kids (schools or parks), roads that need human interaction such as one lane roads and smaller country roads -Divide the rods into manual driving roads and AI driven, any place where there might be bad reception, icy and snowy roads -Only on highway roads, not on highway roads, roads that can disrupt the sensors (dusty roads).
No	9	-Should be the same as for a manual driver, should be roads that are better optimized for self-driving.
Not sure or N/A	9	

4.2.2. Cost

The findings suggest that a majority of the participants did not express any concerns about the cost of the self-driving technology in Sweden (Figure 5a).

In response to another question on if the participants were seeking to acquire a self-driving car anytime soon, the answers between yes, maybe and no were almost equally divided between the respondents (Figure 5b). It appears that the respondents who do not plan to purchase an AV anytime soon (within the next 15 years) are likely to be correlated with the ones who did not show much concern for the cost of this technology. (Figure 5c) shows how much different participants were willing to pay in a one-time payment for self-driving technology. None of the respondents think that the technology should cost more than 500K SEK.

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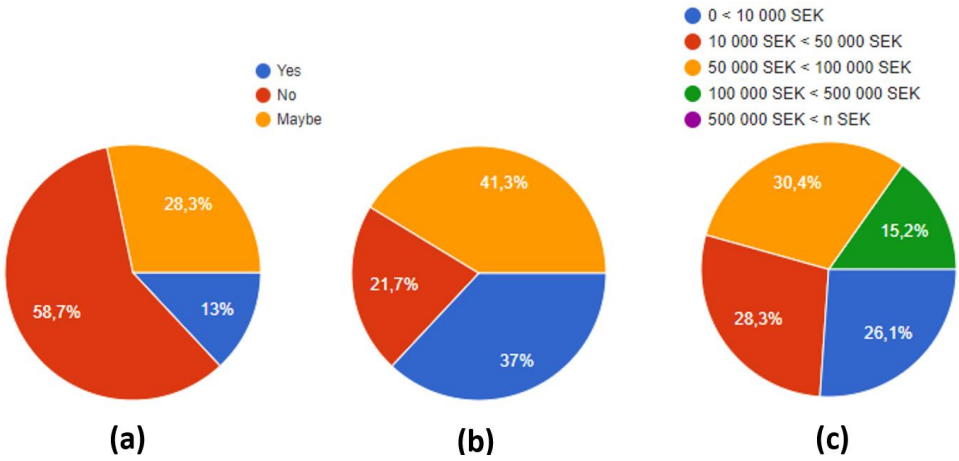

Figure 5. The participants in Sweden were asked (a) if the cost of AVs was a matter of concern to them, (b) if they were willing to buy a self-driving car in the future, (c) how much the respondents were willing to pay in a one-time payment in Swedish Kronas (SEK).

4.2.3. Security

(Figure 6) shows the expectations of people regarding security of an AV from a company that releases this technology. The threat of any type of cyber-attack is a possibility that some people were more worried about than others. It might also depend on what company has manufactured the car and also possibly on the observation that some people are more sceptical towards cyber-security than others.

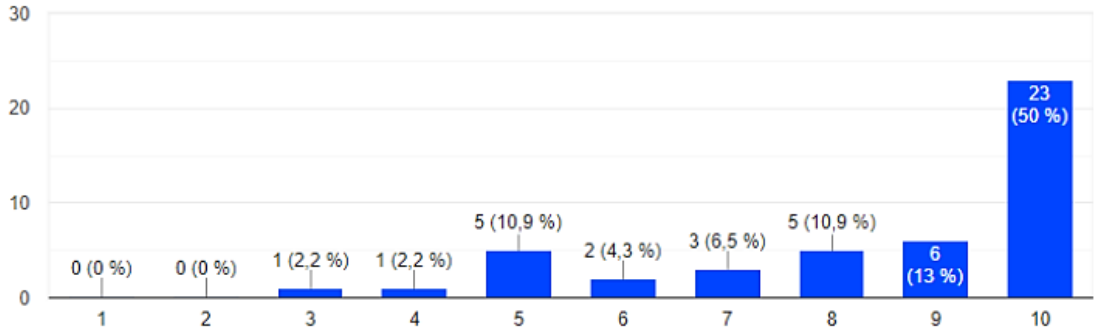

Figure 6. The participants' expectations about the companies' ability to provide a secure vehicle (1 is not expected and 10 is highly expected).

5. Conclusion

This study aimed at gaining insights into perception of the people in Sweden regarding (semi-) autonomous vehicles. To this end, the literature review provided an understanding of the ethics around AVs and provided a basis for the survey. The survey was also the instrument for answering the second part of the research, which was to understand the most important issues for the people in Sweden regarding AVs. Even though there were some differences in the results in the questions concerning safety, the comments in general revealed a common theme that safety is something that must be prioritized before any AVs can be released on the road. Safety is often correlated with the legal aspects and some of the respondents trusted the technology if a legal framework has been established for it in Sweden. Many of the respondents seem to trust the government and the legal system in Sweden and that possibly means that there would be a greater acceptance of AVs if the government had accepted it from a legal perspective. As previous research has found, there were some concerns about the cost of this technology and that AVs possibly will be reserved for those who have the means to pay for it. There are some limitations to this study. For example, the sample size consisted of 46 respondents. Future research can gain by conducting large-scale surveys covering a larger population in Sweden. Another limitation of this study is the possibility that some of the subjects' answers could be biased (Robson and McCartan, 2017),

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since they lacked any real-life experience of an AV. Overcoming this limitation could be another promising direction for future research.

Future research can gain by comparing results of our study with similar studies that might be conducted in future. Furthermore, future large-scale studies can be undertaken in close collaboration with companies developing AVs. In addition, further studies can gain by comparing perceptions of people with and without knowledge of technology that is used in AVs.

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