Interdisciplinary Description of Complex Systems 21(4), 399-411, 2023

AUTONOMOUS CARS – WHAT LIES BEHIND THE LACK OF READINESS

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DOI: 10.7906/indecs.21.4.9
Regular article

Received: 29 September 2022.
Accepted: 30 July 2023.

ABSTRACT

Autonomous systems are already available for public and private transport. The necessary hardware and software products have been created, and novel designs for (semi-) autonomous vehicles are launched every year, but their use is limited, and the penetration is not increasing rapidly. While this might be owing to their high price, their perception is also not universally positive. Many are afraid of not only using, but being around them. After introducing the relevant literature on trust in autonomous vehicles and the factors affecting it, the current article presents the data of an international quantitative research of 666 people. It highlights the biggest perceived threats and their prevalence, and also tries to uncover why more than half of the respondents are afraid of autonomous vehicles. In line with the data presented in the article, the topic is gendered – male respondents were more open towards autonomous vehicles. Furthermore, those who are not ready for autonomous vehicles have a generally higher level of fear of potential negative consequences, such as hacker attacks, system malfunctions, or lack of control. On the other hand, those in favour of automated vehicles believe that they have a positive effect on the occurrence of accidents, owing to their heightened reaction speed provided by the sensory system and the computing capacity which is far superior to that of humans, as well as on the society, on carbon emission, and, as a result, on our natural environment. Consequently, autonomous vehicles could form an important element of the transport systems of future smart cities.

KEYWORDS

autonomous cars, self-driving cars, covid-19

CLASSIFICATION

JEL: O14, O18, R49

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LEGAL REGULATION

The technology of self-driving cars has long been developed, but their mass introduction is still a long way off, since there are plenty of concerns regarding the technology and its trustworthiness. While autonomous vehicles are supposed to be means of transportation where human supervision is not necessary to perform predefined tasks, full autonomy is barely provided to vehicles, or any other systems. Since the term of self-driving vehicles is used as a synonym for autonomous vehicles, the term self-driving better describes the situation we are advancing towards. While autonomous systems do not need any intervention from humans, hence humans are not present or in interaction with the system, self-driving vehicles are able to perform their duties on their own, but a human driver shall be present at all times.

According to SAE International (2016) 6 different levels of autonomy can be defined, where level 0 stands for no autonomy, that is the human driver does everything on his/her own, and level 5 is the topmost level, where a "driver" is not needed any more, since the vehicle does all the driving-related tasks on its own. This top level would be considered the level of autonomous cars, while level 4, where the vehicle performs all necessary tasks related to driving, but a human supervision is necessary when out-of-the-box decisions are needed, and at level 3, the human driver provides constant surveillance and is able to engage in the act of driving when necessary [1].

Figure 1. Levels of driving automation [2].

But why is there a need for all these levels and different terminologies if the technology of autonomous vehicles is already available? The problem is multifaceted. First, there are still multiple legal and ethical issues related to responsibilities regarding autonomous systems. Second, only very few are willing to give up complete control over a vehicle and with it over their or their family's life to an autonomous system.

It is a well-known fact that technological development is far ahead of the relevant legislative environment regarding autonomous vehicles in the European Union. However, there are encouraging signs that the distance between them will slowly but surely shrink in the near future. We encounter vehicles with autonomous decision-making functions every day. The biggest obstacle to the spread of driverless cars in the EU is the 1968 Vienna Convention [3] on Road Transport, which states that the vehicle must have a driver and that the driver must be in control of the vehicle. On 23 March 2016, Articles 8 and 39 of the Convention were amended at the proposal of Austria, Belgium, France, Germany and Italy [3]. According to these amendments, technical systems affecting the control of the vehicle are considered acceptable if they comply with the relevant regulations of the UN Economic Commission for Europe, and the same applies to systems that can be overridden by the driver of the vehicle at any time. This means that the driver can switch them off or take back manual control at any time. As a result of the amendments, vehicles equipped with acceptable systems can practically be licensed up to high level (level 4) automation i.e., the stage before fully autonomous control.

On the other hand, in the USA, the age of self-driving cars is almost here. The US National Highway Traffic Safety Administration (NHTSA) has issued new regulations for self-driving

vehicles. Every car manufacturer knows exactly that these special and modern cars must be extremely safe. Even though they do not have a steering wheel, pedals or even a driver's seat, it is equally important to guarantee the safety of both passengers and other cars driving around them. Certain regulations in the Federal Motor Vehicle Safety Standards (FMVSS) define the characteristics, performance, and testing procedures that, with very few exceptions, all vehicles produced in the United States must pass. Hence, they managed to clarify and update exactly what rules apply to the third, fourth and fifth generation of self-driving vehicles [4].

FEARS

Self-driving cars, like any new technologies, arouse many fears in people. Industrial revolutions and the machines that appeared have always been terrifying for people primarily because of the potential loss of jobs. In addition, people fear new technology for many other reasons. While self-driving cars may be the future of transportation, it is still not proven if they are safer than non-autonomous vehicles. Unexpected events can happen while driving, which may force one to make sudden decisions, often they are just small decisions, such as going through or stopping at the yellow light, but sometimes there are situations where one has to make decisions about other people's or their own lives.

Only few people feel comfortable using a new and not yet well-known transportation technology. This phenomenon is also reflected in the history of flying. Although the Wright brothers flew the Kitty Hawk as early as 1903, the United States did not have a major passenger airline until the 1920s [5]. Similar concerns have been raised about the safety and reliability of self-driving car technology [6-9]. In addition, people are concerned about giving full control to a system whose operation is not fully regulated.

Car manufacturers spend billions every year on developing self-driving cars. However, various studies have shown that people are more concerned than enthusiastic about the emergence of this new technology [10]. The University of Michigan has conducted a number of studies that systematically demonstrate that drivers are concerned about fully autonomous cars, while they still want some automated features.

In 2011, Accenture conducted a survey with 2006 consumers in the United States and in the United Kingdom. Nearly half of the respondents reported that they would be comfortable using driverless cars, while the other half would be more likely to use a technology where they could retrieve control if needed [11]. In 2012, JD Power and Associates conducted a survey with 17 400 vehicle owners. Only 37 % indicated that they would be interested in buying a fully autonomous car, but this number dropped by 20 % when they were made aware of the costs [12].

The responses do not only differ between people aware of the potential price of the technology and those who are not, but also by age and gender [13]. While male respondents would generally be more open to using autonomous technology, the willingness drops with age. The same survey has shown that female respondents were less likely to offer full trust to (semi-) autonomous systems and were more eager to accept partially self-driving vehicles.

Table 1. Result of the resource of [13].

Response	Gender		Age				Total
	Female	Male	18-29	30-44	45-59	60+	
No self-driving	48,4	43,1	41,3	35,2	50,6	56,2	45,8
Partially self-driving	39,8	37,5	39,9	42,6	37,8	34,2	38,7
Completely self-driving	11,8	19,4	18,8	22,2	11,6	9,6	15,5

In 2014 even in the US, UK and Australia the majority of people were concerned when it came to autonomous vehicles, be it private or commercial vehicles. Interestingly they would have been happy to have more autonomy when it came to their driving experience, but were not willing to pay extra for such features [14]. Contrary to this, the research results of Kyriakidis et al. (2015) based on 5000 responses from 109 countries, see the future of self-driving cars in a much brighter light [15]. According to 2/3 of the respondents, self-driving cars will have made up 50 % of the vehicles on the road by 2050. Nonetheless, 2050 is still far away. In a recent research Kettles, Van Belle (2019) found that more than 60 % of the people are not willing to use self-driving cars within 6 months after their local availability and only 20 % would do so. The same study emphasised the importance of performance expectations and hedonistic motivation to be two of the most important motivators for using self-driving vehicles [16].

Interestingly, the public attitude is far more positive when it comes to public transportation. On the one hand, people do not really care or mind if the means of transport they are using is self-driving, as long as it takes them to their destination. Other features of the public transport, such as cleanliness, comfort are more important [17]. In addition, the overall perception is rather positive. However, there are differences based on socio-economic factors as well as traffic related variables, such as the location, route design number and duration of stops. There was also significant difference between the satisfaction level of male and female passengers [18].

All in all, we must state that even though the technology is available, the readiness to use it is still to catch up with the availability. Hence, in order to explore the limitations of the more widespread use of the technology, we need to investigate the factors related to readiness when it comes to self-driving vehicles.

As in case of any new technological developments, people's reaction differs over time. Early adopters rush to a new technology, but many are afraid of anything new, as the S curve of innovation also depicts [19]. While the speed of technology adoption is increasing, the readiness is still a phenomenon to be considered and measured.

The readiness of users and onlookers is almost as important of a factor when it comes to technological improvements as the technology itself, since it depicts the usability of the given technology. If the readiness level is low, it will induce lower level of acceptance, lower demand and at the end of the day, lower penetration, while with high level of readiness people are eager to join in on new experiences and explore fields and technologies previously unexplored. Hence, readiness, the people's trust in the "perfection" or well-functioning of a given technology is one of the most important factors to be considered, when it comes to self-driving cars [20]. What is more, trust is considered a general factor of ICT readiness [21].

Trust as a basic requirement of the widespread use of autonomous vehicles on the roads has long been recognised by scientists as well as practical specialists. With the increasing complexity of intelligent systems, the perceived vulnerability of users increases in an extreme speed [22]. Hence, trust in such complicated and inconceivable systems is not easy to be established. While trust offers the deliberate acceptance of the state of vulnerability (being in risk) from certain agents in return for foreseeable advantages – and, therefore, it can be used as a substitute for the lack of control in certain situations – there is no straightforward way of how to efficiently induce or improve trust towards AI, or more specifically, in autonomous vehicles.

What is more, in case of the wide scale emergence of self-driving cars on the roads, we shall not only consider the individual layer of the phenomenon, but we must also take into consideration the ethical and social dilemmas that may be raised by the greater public [23]. While the software and hardware providers for autonomous vehicles will most possibly stick to the most self-protective approaches – i.e the driver always needs to provide supervision to

the system, even if it is labelled autonomous – the reality is not only about who is responsible or who takes the blame in case of an accident, but also about how and whether people are comfortable with self-driving vehicles on the road that are (or are not) sufficiently supervised by their drivers [23]. What is more, ever since Asimov we have all well known that it is not only the fear of those who are outside of the vehicle that must be considered, but also the fear of losing or having no control over the vehicle and the car deciding against its driver or passengers is also an extremely prevalent phenomenon. [24].

Self-driving cars and the computer program that controls them must make difficult moral decisions in extreme situations. These hypothetical situations are often debated and explored by researchers of autonomous vehicles. One such situation is when a child runs out in front of a car and a collision is inevitable. The question is whether the car should jerk the steering wheel, endangering the passengers, or it would rather hit the child on the road [18]. Many researchers have sought answers to the question of how machines should make ethical decisions. For example, the Massachusetts Institute of Technology [25] has created the Moral Machine, which was designed to gather human perspectives on ethical issues related to self-driving cars. The questions they tried to explore were:

- How should the car be programmed to act in the event of an inevitable accident?
- Should the vehicle minimize the loss of life, even if it means sacrificing the passengers, or protect those inside at all costs?

Answers to these ethical questions are important because they can have a big impact on the acceptability of autonomous cars in society. The question is not only hypothetical, after all who would buy a car programmed to sacrifice the owner [26]?

The dilemma about inevitable accidents where people have to decide the outcome of the event, was presented to hundreds of workers on Amazon Mechanical Turk [26]. Participants were given tasks in which one or more pedestrians could be rescued when the car hit an obstacle, killing the passenger or pedestrian while saving the other pedestrians. According to the research results people are generally comfortable with the idea that self-driving vehicles should be programmed to reduce casualties. However, these results only prevailed while respondents viewed the problem from the perspective of a pedestrian or an unaffected third party, and perspective suddenly changed when respondents were supposed to relate to the casualties imagining that they were sitting in the car (see trolley problem).

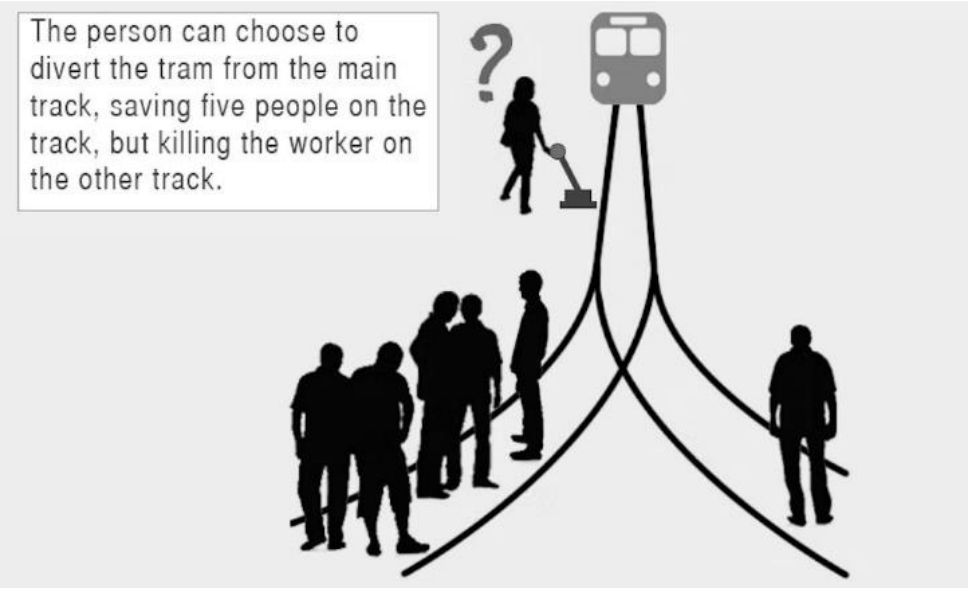

Figure 2. The trolley problem [27].

As it has already been stated in the introduction of the present article, autonomous systems are already available for public and private transport. The necessary hardware and software products have been created, and novel designs for (semi-) autonomous vehicles are launched every year. However, besides the hardware, it is extremely important that the software is regularly updated; since it is the software and the artificial intelligence running in it that evaluates its own environment based on the collected data and makes decisions to achieve the goal. Trained on a large amount of data, the system will be able to judge traffic situations and decide on the behaviour of the vehicle, as well as to recognize patterns for later situations. The software must know that traffic signs exist as objects, and that these signs have their meanings, and therefore they should be differentiated from similar objects (e.g. advertising signs) [28].

Overall, the software in the car must know everything and be able to prepare for any situation, since it takes care of the lives of the people sitting in it. Any computer that communicates with or is accessed in some way by another computer is vulnerable to computer hackers. In recent years, there has been a lot of news about hackers breaking into various databases and viruses infecting a large number of computers. This is not the first time that cars have been used as a tool for terrorist acts [29] This might even be easier with self-driving cars in the future. If someone hacks into the system, they can have the data and take control of the car – so they can even stop the brakes or control the steering, etc. An example of this was when in 2015 two hackers, Charlie Miller and Chris Valasek, took over a Jeep Cherokee's UConnect system (Internet-connected computer function) for testing, which controls everything from the navigation system to the driver's outgoing calls [30]. The Wired journalist was just sitting in the car helpless and shocked, while the hackers controlled the car, the pedals and the steering wheel as well. In view of this, building a safety system is a huge challenge for car manufacturers and also for consumers, because as long as the car is not safe, people will not trust them.

In line with the above described, and in addition to social and ethical dilemmas, technological insecurities must also be tackled to achieve the widespread use of autonomous vehicles on the roads. Furthermore, issues arising from the encounter between a self-driving vehicle that always considers safety first, and a vehicle that is driven by a person who knows that the other will surely behave 'properly' also need to be addressed. In such cases, self-driving vehicles are expected to always give priority to other cars in order to avoid accidents. Hence, "drivers" of such vehicles will experience handicaps on a regular basis in everyday traffic situations, which can also be a great drawback when it comes to purchasing decisions.

According to Jiang et al. (2021), providing more information might increase a specific segment of people's trust, namely that of technical trust. However, to complicate the situation, providing more and more information about the system, its internal logic and technological parameters might not improve the situation, but it might make everyday people trust autonomous vehicles less [31]. Since their perceived level of understanding, and in line with this, their perceived level of potential exertion of control in dangerous situations might even decrease as a result. Hence, while transparency and communication related to autonomous vehicles is a must, the sufficient level of information provided might be up to rigorous market research [32]. To be able to work around this information trap, to lessen the stress and anxiety induced by the systems and increase the perceived level of information, the awareness of people towards autonomous systems in general must be improved. Only then will they be ready to accept self-driving cars around them [33].

According to the Technology Acceptance Model (TAM) [34] model, which is especially adequate when it comes to understanding early adopters of a new technology, external environmental factors affect users/buyers through two mediating variables, namely: perceived usefulness and perceived ease of use of the technology under scrutiny. In case of self-driving

cars, the latter one is a clear advantage of the technology, since it does not require prior training or knowledge. On the other hand, the perceived level and assortment of benefits differ from user to user. While some regard driving as a hobby, other only look at is as a way of transportation. Hence, the perspective of the abovementioned groups of users will be undoubtedly different.

THE RESEARCH

In order to explore the individual attitudes of potential users/buyers, we have initiated a quantitative research study with the help of an online questionnaire. The sampling was comfort sampling hence the data cannot be regarded representative. However, since we have managed to reach 666 people in a time frame of 3 months from 2022 January to 2022 April, the data shall be regarded as relevant for the topic of our question under scrutiny. The majority of data came from Hungarian respondents (N = 550), but an additional 116 responses were collected from international respondents to see if there is a pattern of difference in the responses by country of birth. While the number of non-Hungarian respondents was relatively low, there were no significant differences to showcase for any of the countries involved in the research (namely Albania, Finland, Germany, Kazakhstan, Mongolia, Poland, Romania, Serbia and Slovakia). As a consequence, all collected data is presented further in the text.

The sample contained 368 male and 288 female respondents' responses while 10 respondents opted for not disclosing their gender. The average age of the respondents was 27,366 years, with a standard deviation of 10,978 years, indicating that the respondents were mostly young people, but the query managed to reach a wide variety of people from age 12 to 70.

The distribution of the respondents by age is shown in Figure 3.

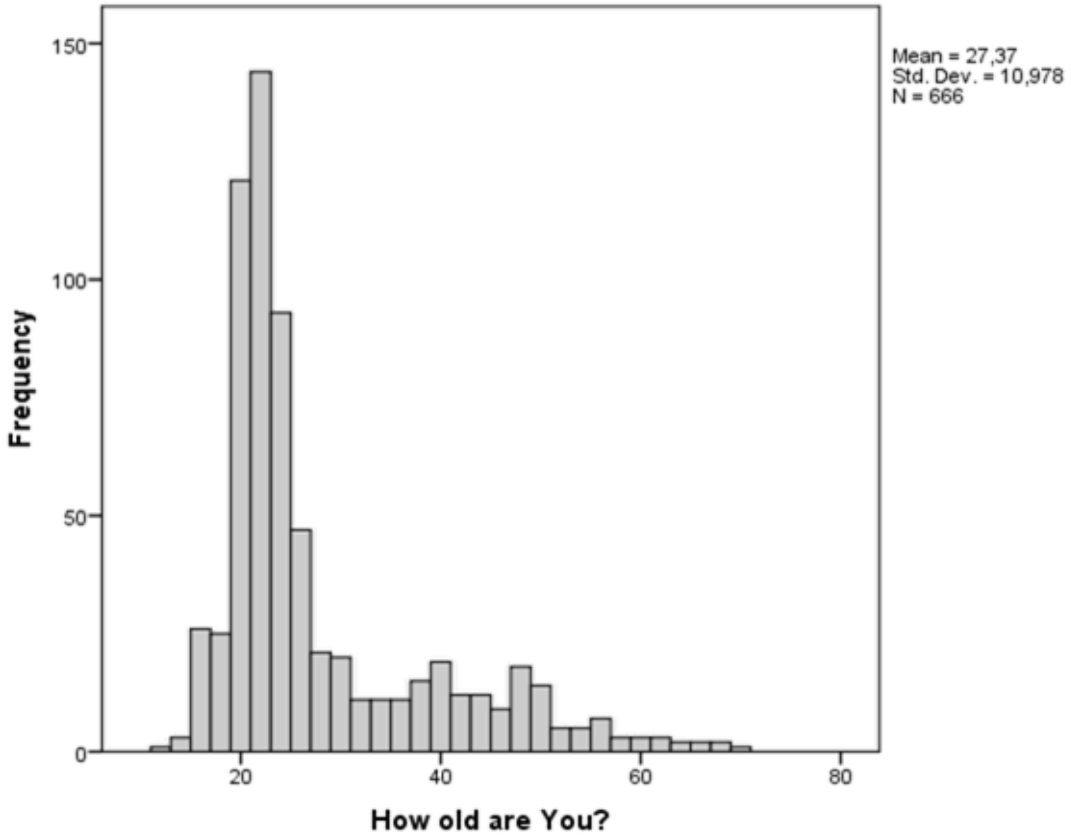

Figure 3. Distribution of the respondents by age.

The female population was slightly older (Avg.:28,326, Std.Dev.:11,989) than the male population (Avg.:26,696, Std. Dev.:10,087), but the difference was not significant owing to the big variance in ages.

The respondents had different attitudes towards self-driving cars and autonomous vehicles in general. Assessing their trust in such vehicles with the help of the six stages of autonomy described previously, the distribution is created as shown in Figure 4.

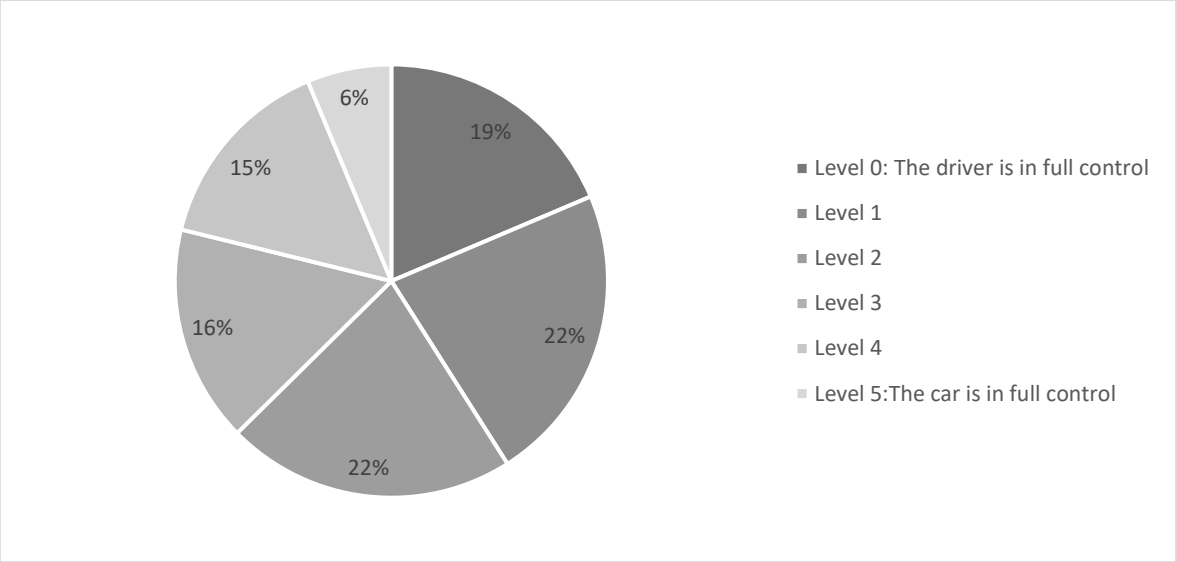

Figure 4. Six stages of autonomy.

As is seen in Figure 4, the majority of the respondents was only interested in a lower level of autonomy provided to their vehicles. Only 6 % would be interested in using self-driving vehicles, where the car is in full control, and 15 % would want to use self-driving cars if they would still be able to regain control in case it would be needed. These data are in line with the previously mentioned international findings. The majority of the population is not ready for self-driving cars yet.

For this purpose, the responses to the statement "I would support the introduction of autonomous vehicles" were used. The distribution of the respondents is shown in Figure 5.

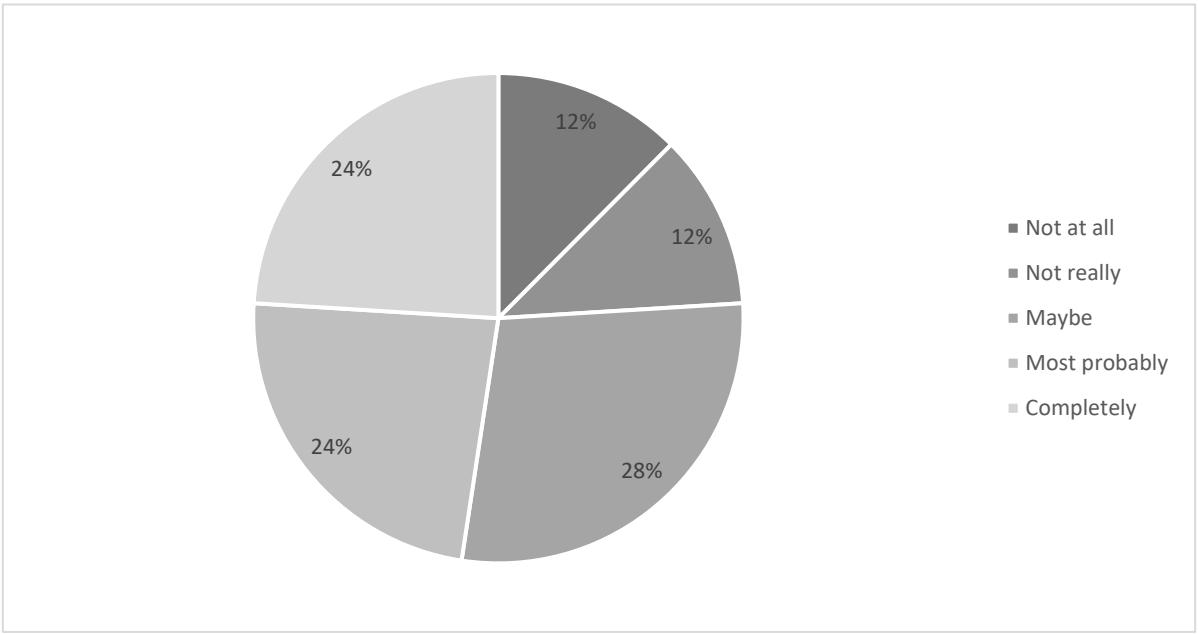

Figure 5. Distribution of the respondent's reluctance to accept autonomous vehicles.

The major question is whether there is a pattern based on which it can be clearly identified who are in favour of self-driving vehicles and who are against their widespread use on the roads.

While the numbers are in line with the data highlighted in Figure 5 indicating the reluctance to accept autonomous vehicles, approximately half of the respondents (maybe not as a direct user/owner) would support the introduction of self-driving cars. In comparison, only one fourth of the respondents were against it. The respondents with an intermediate "maybe" answer are considered neither for nor against the notion of autonomous vehicles, hence, in the following analysis they will be excluded and only a sample of 470 respondents will be considered.

Interestingly, as depicted in Table 2, the distribution of those against the introduction of automated vehicles by gender was balanced. However, there were more males supporting the introduction of autonomous vehicles than females. Hence, the autonomous vehicles and their acceptance can be regarded as a gendered topic, which is fully supported by international literature introduced previously.

Table 2. Distribution of respondents by gender and attitude towards autonomous vehicles.

	What is your gender?		**Total**
	Male	**Female**	
Does not support the introduction of autonomous vehicles	78	79	157
Supports the introduction of autonomous vehicles	208	105	313
Total	286	184	470

According to our research data those who would like to have self-driving cars have some distinctive features. The Table 3 shows only the values explored through our questionnaire, where the averages of those for and against self-driving cars were significantly different.

Table 3. Difference between those who want to have self-driving cars and those who do not.

		Levene's Test for Equality of Variances		**t-test for Equality of Means**				
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Diff.**	**Std. Error Diff.**
I would be afraid of self-driving cars in my environment	*	17,165	0,000	13,567	475	0,000	1,652	0,122
Self-driving cars will positively affect emission	*	19,269	0,000	–14,127	475	0,000	–1,499	0,106
Self-driving cars will positively affect the society	**	0,971	0,325	–21,211	311,78	0,000	–1,980	0,093
Self-driving cars will reduce the occurrence of accidents	*	14,153	,000	–22,519	475	0,000	–2,023	0,090

As these data indicate, those in favour of automated vehicles believe autonomous cars to positively affect not only the occurrence of accidents owing to their heightened reaction speed

provided by the sensory system and the computing capacity which is far superior to that of humans, but also the society and carbon emission, and through it, our natural environment as well. On the other hand, those who would not like to have an autonomous car are also afraid of having them driving around in their surroundings, Table 4.

Table 4. Difference in the relevance of various fear-inducing factors.

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. 2-tailed	Mean Diff.	Std. Error Diff.
Fear: Hackers tamper with the car	**	1,709	0,192	4,071	328,468	0,000	0,557	0,137
Fear: The self-driving system breaks down	*	34,534	0,000	7,574	475	0,000	0,819	0,108
Fear: The car decides different from how I would like it to	*	13,075	0,000	9,264	475	0,000	1,048	0,113
Fear: Fear from the new technology	*	6,691	0,010	7,639	475	0,000	0,928	0,121
Fear: People (in various professions, such as chauffeurs) will lose their jobs	**	3,473	0,063	6,241	289,252	0,000	0,857	0,137
Fear: Control cannot be regained	*	17,769	0,000	7,190	475	0,000	0,920	0,128
Fear: I lose the joy of driving	*	11,664	0,001	7,150	475	0,000	0,974	0,136
Fear: The security of personal data cannot be provided	**	0,467	0,495	6,610	317,859	0,000	0,836	0,127

While in general those who are not ready for autonomous vehicles have a generally higher level of fear of potential negative consequences, such as hacker attacks, system malfunctions, or lack of control, the fear is triggered differently in case of different concerns. While the difference is the biggest in case of decisions made in an alternative way – which is different from that of the driver, and the smallest in case of hacker threats, the above table underlines that the fears are significantly different in all cases.

SUMMARY AND CONCLUSIONS

While autonomous vehicles are already an inevitable part of the public transport system in many cities, the private use of autonomous vehicles is still in its infancy. Autonomous systems are already available for public and private transport. While adequate hardware and software have been created for autonomous systems to be readily available, and the number of (semi-) autonomous vehicles is increasing year by year, their acceptance still seems to be low. In line with international literature from various countries and the research data presented in the current article, many are afraid of not only using, but also being around them.

The current article, after introducing the relevant literature of trust in autonomous vehicles and the factors affecting it, presents the data of an international quantitative research of 666 people.

While the questionnaire was disseminated online, with the majority of respondents belonging to the Z and Y generations, the research managed to reach out to other age groups, too.

In line with the data presented in the article, the biggest perceived threats and their prevalence is gendered – female respondents are less open and accepting with autonomous vehicles. As a consequence, manufacturers and producers must be ready to separately address the two groups' requirements. In addition to the exploration of how males and females differ regarding autonomous vehicles, the article highlights and also tries to uncover why more than half of the respondents are afraid of autonomous vehicles.

According to the research data, those who are not ready for autonomous vehicles have a generally higher level of fear of potential negative consequences, such as hacker attacks, system malfunctions, or lack of control. However, whether it is a root cause of their negative attitude, or its consequence is yet to be explored.

The findings also suggest that those in favour of automated vehicles believe autonomous cars to positively affect not only the occurrence of accidents, owing to their heightened reaction speed provided by the sensory system and the computing capacity which is far superior to that of humans, but also the society, the carbon emission, and through it, our natural environment as well. In line with the previous statement, this discrepancy may also be the result as well as the reason for the respondents' attitude towards self-driving cars.

All in all, the article managed to clarify some factors related to trust in autonomous systems, enabling manufacturers and policy makers to tackle the listed issues so that autonomous vehicles could become an innate part of the private transport system of future smart cities.

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