Beyond the questionnaires: An attempt to understand self-driving car acceptance by women through using movies and VR simulation

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Among the technological novelties of the digital revolution, the self-driving car is considered to be a radical innovation stand-out which will revolutionize the habits of people living in civilization. The technological development of these cars is in its last stages, but the preparedness of consumers is lagging behind. General impression is not uniform by gender: women in developed nations tend to be unenthusiastic about self-driving cars, which could threaten their entrance on the market. Furthermore, in mainstream research (TAM, UTAUT), attitude towards the technology has been measured by questionnaire and less than 10% of respondents can respond based on real experience.

The aim of our research is, on the one hand, to explore methods by which subjects express their attitudes towards self-driving cars based on their own experiences, and, on the other hand, to examine the impact of their own experiences on the opinions of rejecting groups.

Keywords: radical innovation, self-driving car, netnography, VR simulation

1. Introduction

The car plays a key role in mobility today: according to a Eurostat survey, 83% the nature of all passenger kilometres travelled by car in the European Union have not changed significantly in the last decade (Eurostat 2019). It can be stated that the lives of all people living in so-called civilized countries are determined by cars: both when traveling by car and as other actors in transport (on foot, by bicycle, using public transport) coming into contact with them.

One of the radical innovation breakthroughs of the Fourth Industrial Revolution is the self-driving car (EC 2019), which will fundamentally change the lives of all of us because of the above. Radial innovations typically lead to a paradigm shift, usually inducing a radical change in both organizational structures and the market environment, sometimes in everyday life.

The technological development of self-driving cars is very advanced, however, research on the social acceptance of self-driving cars has found there is low social preparedness and acceptance. This could be a problem, because the acceptance or rejection of innovations, as well as their spread, is based on people's judgments and decisions. The success of the proliferation of self-driving cars depends not only on the development of technology, but also on legislation, infrastructure, and social acceptance (KPMG 2018).

In addition to the low level of social acceptance, its heterogeneity can be a significant problem, despite the fact that there is very little talk of the latter in the international literature: certain well-identified social groups (women, those with lower education, the elderly, people living in rural areas, etc.) could slow down or even jeopardize the market penetration of self-driving technology.

Havlíčková and co-authors (2019) shed light on the paradox that self-driving cars are most often rejected by those who could benefit the most from their use. Among the more dismissive social groups, women stand out, their share among drivers is growing year by year and has already exceeded 50% in the USA (Sivak 2013). If we add to these statistics the fact that surveys show women are otherwise much more likely to prefer public transport to the car (OECD 2019), it is easy to see that women are a distinct target market for a self-driving car that mixes the two solutions.

Based on all this, the aim of our research is to study the typical patterns of Hungarian women's opinions about self-driving cars with innovative research methods and, based on these, to make suggestions for shaping women's attitudes towards self-driving cars. Our research fills a gap in two respects: on the one hand, the vast majority of the surveys focus on developed countries, and on the other hand, they do not focus on women, so our survey and the recommendations based on it may serve as valuable input for scientific and practical professionals.

2. Self-driving cars

Self-driving cars should not be a radical innovation simply because the steering wheel disappears from our cars - that would not yet radically revolutionize the everyday life of humanity (EC 2019). However, self-driving cars, organized into a system, open up new perspectives on mobility, the consequences of which will affect almost every area of our lives: new travel habits, new business models, new networks, new cityscapes, new daily routines, and so on (KPMG 2018, Duarte–Ratti 2018, Audi-Ipsos 2019, Lukovics et al. 2018).

Organized into a system, self-driving cars open up a new perspective on urban mobility: MaaS, (Mobility as a Service). To put it very simply, the point is that we will not be driving our own cars in the future, but fleets of self-driving cars will help us reach our destination (Utriainen 2018). The car-sharing model envisages fewer traffic jams, faster traffic, less environmental impact, fewer accidents, and a changing cityscape: in this system, parking spaces will be freed up, and a park, playground and community space could be created instead (Duarte– Ratti 2018). Some say the new model will be much cheaper than maintaining your own car (WEF-BCG 2018), so the space use of garages might also be rethought. The system involves a complete transformation of our daily routines and decades of habits.

Technological developments related to self-driving cars have accelerated greatly recently: street self-driving tests are currently taking place in nearly 150 cities around the world, doubling the number of last year. That is, it appears that more and more developers are in the final stages of technological development, just before market introduction. Self-driving cars are not yet finished and will be much delayed, writes The Verge[6] in its analysis, and then the author turns to the rise, fall, and merger of smaller and larger companies. Although technological developments in the field of self-driving cars are advancing rapidly at an international level, significant issues remain regarding

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[6] https://www.theverge.com/22423489/autonomous-vehicle-consolidation-acquisition-lyft-uber
(Accessed: August 10, 2021)

mobility services related to the development and integration of self-driving cars and technical specifications for vehicles and infrastructure, data use, safety and security, vehicle operation. obligations and responsibilities, ethics, social acceptance, and the coexistence of human-controlled and automated vehicles (EP 2018).

In our view, the problem is caused, on the one hand, by the fact that developers, with very few exceptions, focus exclusively on technological development, and, on the other hand, by the fact that the drastic change described above is much closer at hand than what could be realistically be prepared for at the societal level. It is therefore necessary to extend development work to the social sciences, thereby accelerating social adaptation for humanity to be able to process the projected drastic change.

3. The psychology of male and women's opinion

Influencing the attitudes of large numbers of rejection groups is in some cases not feasible with pooled strategies. This is usually true in cases where the neurological-psychological background of each group or segment differs significantly. As we have seen in previous chapters, women and men are present in approximately equal proportions among drivers, however, women are significantly more reluctant to drive self-driving cars. However, the attitudes of men and women cannot be shaped by the same interventions!

The anatomical differences between the male and female brains are well established. Men have larger brains, while women use a more compact and larger part of the brain than men (Kimura 2004). Because several significant differences were found in different areas of the brain as well as in the grey and white matter, this explains why the two do not generally behave or think differently (Storms 2019). This is even explained by hormonal differences and traces of evolution (Brizendine 2011).

Women are more influenced by their emotions; they experience both positive and negative emotions more strongly than men (Hohenberger et al. 2016). Related to this is a proven fact that they also make their simpler decisions driven by their emotions faster than their male counterparts (Gray 1992). The "female intuition" used in everyday vocabulary also refer to this: in small-scale issues, they make quick decisions based on their intuitions. Furthermore, in a decision-making situation, personal influences affecting human destinies are also considered, and the world is usually perceived more comprehensively and assessed through the nature of human relationships (Storms 2019). In contrast, men mostly neglect these aspects of decision making, feeling redundant.

Van den Bos et al. (2013) also found a difference in information processing between women and men in the decision-making situation. Women are usually slower and find it harder to reach a decision than men. Accompanied by several questions, with more information and considering several factors, they form an opinion on a larger issue (Brizendine 2011). In this case, the decision-making process is longer and more complicated, but the decision is usually more comprehensive and balanced than that of men.

Because of information gathering, decision-making is more time-consuming than that of men who seek logic in almost everything, think more rationally, and examine longer-term effects (Kaileigh–Darrell 2015). On the other hand, when making

an opinion or decision of a kind that does not raise questions or possibly doubts, it is considered. to be a smaller volume, and a clear and quick resolution on the part of women. Men initially reject additional information, focusing mostly on future opportunities and consequences, compared to women, who are heavily influenced by external information sources. Women process much more detailed, comprehensive information, pay more attention to social guidance, and are more interested in personal, human contexts, and moral considerations (Kaileigh–Darrell 2015). It is also important from the point of view of our topic that according to the research results of Slovic (1997), women are more inclined to judge risks more deeply and are more concerned about the issue of safety.

It follows that when it comes to smaller, general opinion-forming, that is, it does not raise questions or doubts, such as *"What do you think about the self-driving car?"*, women express their views from simple messages based on their first intuitions. However, if they are already faced with a real and far-reaching decision, that is, they feel closer to it, such as *"If you had to decide now, what aspects would you consider to replace your car with a self-driving car?"*, they need more information and details to make that decision.

4. Women's opinion about self-driving car in developed countries

Plenty of international research has addressed the issue of technology acceptance in relation to the issue of self-driving cars, and these are usually the TAM and UTAUT models, and most of the results of the research have been obtained through a questionnaire (Schoettle–Sivak 2014, Kyriakidis et al. 2014, König–Neumayr 2017, Hulse et al. 2018, Liljamo et al. 2018, Havlíčková et al. 2019, Raue et al. 2019, Wang et al. 2020), but it masks freedom of opinion. It is important to point out that these surveys usually examine the opinions of civilized people in such a way that the majority of respondents have not even encountered a self-driving car at all, and presumably have only vague ideas about technology that may even form a misconception in people's minds.

To the best of our knowledge, women's attitudes have not yet been studied in the international literature, but data on women can be collected through the demographic delineation of the most significant empirical studies conducted in developed countries. Thus, several international studies have found that men attribute a more important role to self-driving technologies than women (Kyriakidis et al. 2014, Schoettle–Sivak 2014). In contrast, according to research by Frost & Sullivan (2014), after a few years, women will prefer high-tech vehicles, including self-driving vehicles.

In the international research of the research pair Schoettle and Sivak (2014) (American, English, and Australian), as well as data from Kyriakidis et al. (2014) and in terms of benefits, there were more men who thought they would benefit in the future. According to research by Kyriakidis et al. (2014), approximately a quarter (23%) of men, while slightly more than 10% of women, said they considered this innovation important. In this research, men would be willing to spend more on this innovation.

There are several differences in the attitudes of women and men, women are much more restless (Denise 2015, Nasr–Johnson 2016, AAA 2016, Smith–Anderson 2017, Lienert 2018). Women are less interested (Denise 2015, Raue et al. 2019) and have less information about self-driving cars (Smith–Anderson 2017). Twice as many

men think positively about self-driving cars than women (Liljamo et al. 2018). Most women question the safety of self-driving cars (Denise 2015, Nasr–Johnson 2016), while many men feel stressed by the disappearance of the driving experience. Men seem to be more interested in trying out cars, as well as owning and buying them (Denise 2015, Nasr–Johnson 2016, Smith–Anderson 2017). Based on the results of Lienert's (2018) research, the majority of American women would feel uncomfortable driving without a driver, while male respondents were less valued, and when examining other actions on the road, they found that women did not want to spend time with other activities and would rather keep their eyes on the road in the interest of safety (Nasr and Johnson 2016).

If we look at various studies in this area, such as the AAA (2016) research, we can see that the reason *"they feel the use of technology is too complicated"* was mentioned by twice as many women as men, which is why they don't want to use technology.

Based on the above, it can be concluded that women have less information and are more reluctant about self-driving cars. The results from developed countries show that women are more likely to question this technology than to accept it. Men are proving more accepting of driverless cars, although they still have doubts in some areas. Although the degree of mistrust and skepticism is still quite high, society is curious about the technology.

5. What do Hungarian women think about the self-driving cars?

We examined the attitudes of Hungarian women towards self-driving cars and their reasons with four layers of empirical surveys, expecting different answers from each type of survey:
- We expect netnographic research to explore and categorize the underlying attitudes.
- We expect answers from 496 completed questionnaires on how opinions about self-driving cars differ by gender, and how these change over time because of expanding information.
- We expect an answer from moving image emotion research to the reasons behind an attitude on how these change because of one's own specific experience, and what emotions these experiences evoke.
- With virtual reality simulation, our aim was to examine participants' reactions and feelings about self-driving cars and through these reactions to find out whether virtual reality experiments can help in the acceptance of self-driving cars or not.

5.1. Netnographic exploration

As our aim was to explore a pattern of underlying attitudes, a netnographic research was used. Put simply, netnography covers online ethnography, which analyzes Internet posts using scientific methods (Dörnyei–Mitev 2010 / b). In netnography, interactions on Internet interfaces are valued as cultural reflections that result in deep human understanding (Kozinets 2010). Emotional and confidential posts also become available through the possibility of anonymity (Puri 2009), which in the case of ethnographic research is extremely time-consuming (Csordás–Markos-Kujbus 2018). Of course, not

all online communities meet the requirements for netnographic fieldwork, which are as follows (Kozinets 2010):

- – be relevant to the focus of the research,
- – there should be active communication between the contributors,
- – be interactive,
- – critical mass prevails,
- – have many different posts and make detailed, rich data available.

The HVG Tech and Car sections, the index.hu Tech section, the Origo Tech section and the Totalcar met the above-mentioned requirements the most. On the four platforms, we analyzed the writings related to self-driving cars and the related 1,050 comments related to one year back (January 1, 2019 to January 1, 2020). In many cases, the involvement of the readers was very intensive, contradictions and minor conversations were noticeable among the commenters, and it could be observed that some of them also included links and contents that appeared on other pages to support their claims.

It is very striking that female posts were much lower than male posts: only 7% of respondents were female. The contributors found on the Internet social interfaces can be organized into different groups and categories (Dörnyei–Mitev 2010/a).

Based on the comments, we identified six different groups, these categories are surrounded by a distinctive tone, and it can be concluded that these groups represent different values. The six main "in vivo" groups are as follows:

1. Rejection, critical (30.8%): several arguments are put forward to express their displeasure or even outrage and to endorse self-driving cars with a critical opinion. Their views change in some situations because of new information.

2. Eternal skeptics (19.2%): stand out among the rejecting, critical contributors. They are the ones who see only the downsides of self-driving cars and speak out completely against them. In most cases, there is no argument behind their opinion, in their case the reason for rejection is difficult to discover.

3. Optimistic (19.2%): The greatness and future potential of the technology was justified by positive reasons for listing the benefits. In many instances, those who showed completely different attitudes expressed their opinions based on each other's counterarguments. Hopeful opinion-formers were largely characterized by moderate affectivity.

4. Realists (38.5%): they see the existing obstacles as well as the potential opportunities.

5. Informants, experts (3.8%): they usually reflect the answers of rejectors and problem takers. They they try to support the critical opinions and the questions that may arise with their own, well-founded knowledge, even with external sources.

6. Problem raisers (7.7%): they ask further questions on the subject and on the future of transport, or in some cases feel that the article is incomplete or even consider that the information provided does not necessarily reflect reality. In some cases, they reflect on speakers who wish to be informed and address their questions to them.

66.7% of the women who spoke belonged to the negative, critical group, 20% to the group of realists, and 6.7% to 6.7% to the group of perpetual skeptics and informants. It is striking from the results obtained that there were no women who expressed only a positive opinion on the topic of self-driving cars, nor were there any problem raisers.

Netnography has shown that negative contributors tend to change their minds because of new information, and that their concerns relate to specific groups of topics: technological maturity, safety, accidents, liability, and so on. That is, it is all about a topic that would require much more information from contributors

5.2. Trend study 2018–2020

Year after year, more and more information about self-driving cars becomes available: scientific articles, blog articles, social media posts, etc., which also reach an increasing number of those who are less interested in the topic. Over time, the amount of active and passive information about self-driving cars is constantly increasing in society, which raises the question of how perceptions of self-driving cars change over time and with the amount of information.

At the beginning of 2018 and 2020, we interviewed a total of 496 respondents with an online questionnaire. Our sample is not representative. Among those who filled in the questionnaire, 44.9% of respondents were women. 84% of men and 58% of women felt that they had received new information about self-driving cars in the last two years. All this is clearly reflected in the change in general awareness: while in 2018, 13.7% of responding women had not heard of self-driving cars, in 2020 this figure dropped to 6.3%. Only 1.3% of men had not heard of self-driving cars in 2018, while by 2020, there were no more men who had not heard of the technology (Figure 1).

*Figure 1* Awareness of self-driving cars by gender (%)
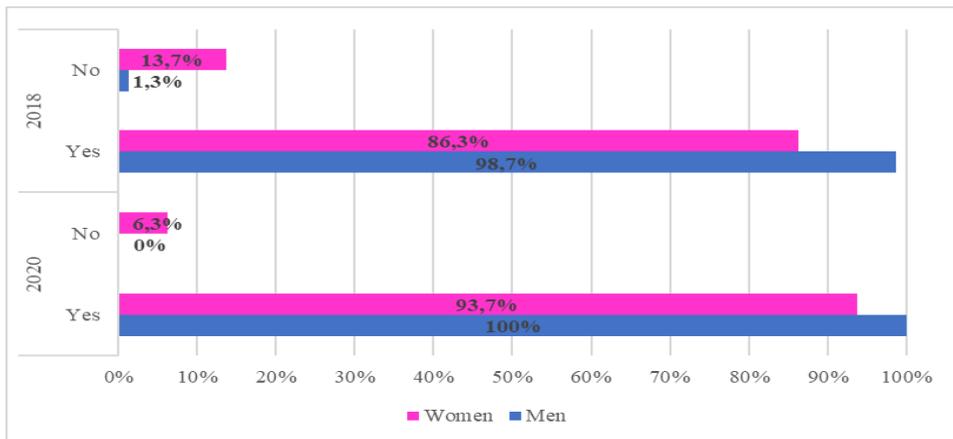
Source: own construction

The overall perception of self-driving cars was measured on a 5-point Likert scale for international comparability. The general perception among men is clearly more favorable in both years. Notable, however, for both sexes is a relatively significant

(approximately 6 percentage points) decrease in the histogram of negative opinions and an increase in the column of neutral and positive opinions for both sexes (Figure 2).

Figure 2 General opinions on self-driving cars by gender in 2018 and 2020 (%)
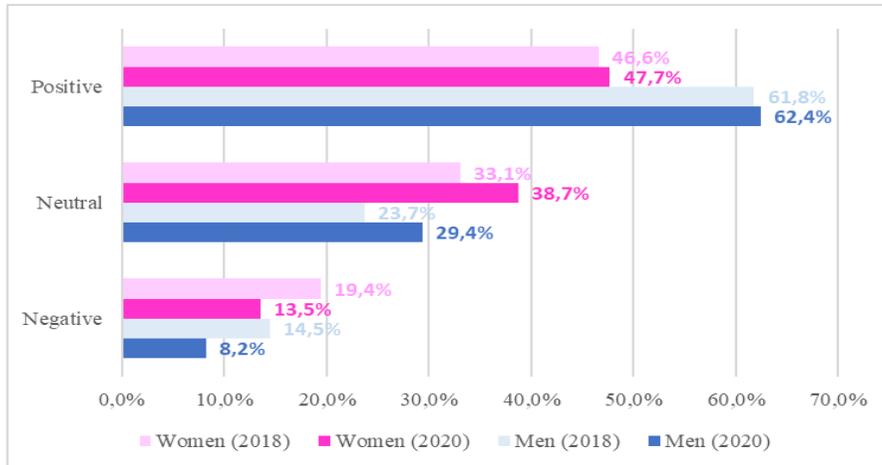
Source: own construction

In the next question, respondents were asked to indicate how likely they were to see the occurrence of certain events with a positive outcome. The result is remarkable: women in both years, without exception, are less likely than men to expect any positive outcome (the largest difference is 20.2 percentage points). Women in this case are clearly significantly more pessimistic than men (Figure 3).

Figure 3 Probability of occurrence of positive events by gender in 2018 and 2020 (%)
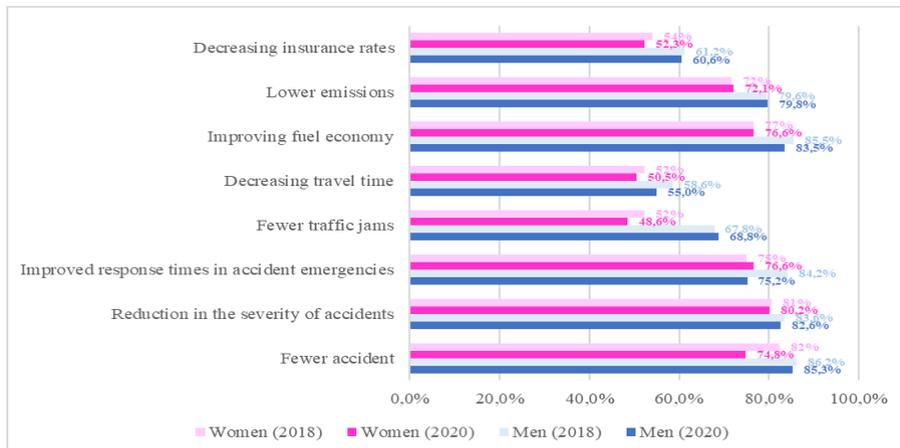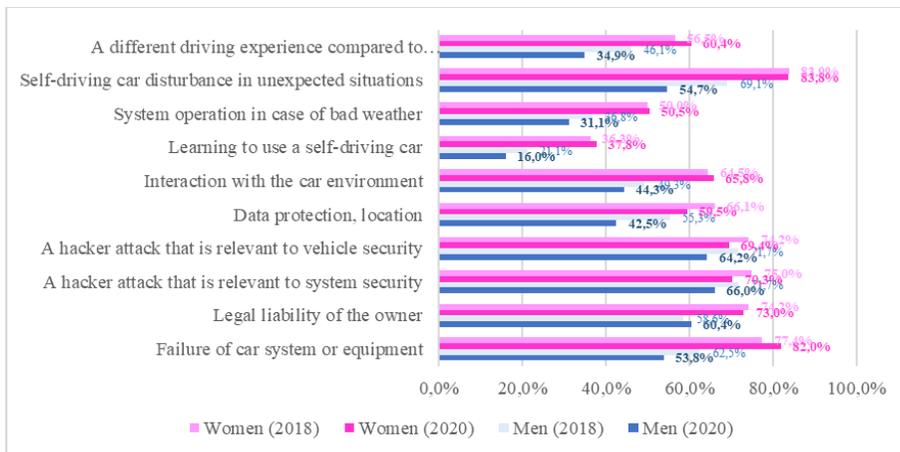

Source: own construction

We also asked about the most common concerns that the international literature has revealed about self-driving cars. It can be seen in Figure 4 that in both years, women

gave higher values in all cases, i.e., disturbing events were more likely to occur in women than in men (the largest difference was 29.1 percentage points). Even in this case, women are more pessimistic than men. All this is statistically significant according to the following in 2020: failure in the car system (χ^2 = 19.895, sig = 0.000), legal liability of the car owner (χ^2 = 3.888, sig = 0.049), data protection (χ^2 = 6.276 sig = 0.012), interaction with the environment (χ^2 = 10.07, sig = 0.002), learning to use the car (χ^2 = 13.017, sig = 0.000), system operation in case of bad weather (χ^2 = 8.364, sig = 0.004), confusion in unexpected situations (χ^2 = 21.645, sig = 0.000), different driving experience (χ^2 = 14.077, sig = 0.000). The values of the Cramer coefficient show a medium to strong relationship in several cases.

Figure 4 Probabilities of occurrence of disturbing events by gender in 2018 and 2020 (%)

Source: own construction

Examining the topic of renting and owning, a larger proportion of women – 68.5% in 2018 and 73.9% in 2020 – are concerned with this option. In the case of men, this proportion was smaller, in 2018 there was only a 10 percent point difference in action, while this year the gender difference in these positions reached almost 20 percentage points. 41.4 percent of men surveyed said in 2018 that they would be interested in owning such self-driving technology, compared to an increase in this year, with 45.3 percent voting the same way. Analyzing the issue of additional costs, it can be seen in 2018 that 73.2% of domestic respondents would not be willing to pay them, compared to 76.6% based on this year's data. For men, this proportion was much lower in 2018, as only 57% of them would not have issued extra costs, in 2020, this proportion showed a slight decrease to 55.9%. It was also observed in the case of women and men that the higher the level of education, the more they expressed their positive opinions, and it was characteristic of men that they showed negative and neutral attitudes to a greater extent with a lower level of education. For women, this was observed at the neutral response option.

Over the course of two years, it has been observed that there has been a positive shift in women's and men's perceptions of self-driving cars. The more information the research participants have, the fewer rejection can be discovered.

5.3. Moving emotion research

The questionnaires provided answers to how opinions about self-driving cars differ by gender, and how these change over time. Netnography was apt to explore and categorize the underlying attitudes, which revealed that the concerns of negative contributors were related to specific topic groups. At the same time, we did not get an answer to the question of what the reasons are behind the attitudes, and how they change as a result of our own specific experience, and what emotions these experiences evoke.

To answer these questions, we defined a special in-depth interview in which we screened a short film to our subjects while asking about their emotions. Nowadays, the research of emotions has developed into a multidisciplinary field. Psychologists have long been involved in the study of human emotions (Fernández et al. 2019, Siedlecka et al. 2019). The aim of these procedures is to examine the expressions, behaviors, and thoughts of participants under the influence of certain stimuli and to better understand and understand our emotions (Fernández et al. 2019). Audiovisual materials are one of the best-used and most accepted techniques for evoking basic emotions, as they can evoke very real-life stimuli from humans (Fernández et al. 2019, Siedlecka et al. 2019).

The experiment involved 34 people, 17 men and 17 women. The youngest participant was 20 years old and the oldest was 66 years old. Subjects' driving experience ranged from 0 years to 45 years. Residents of both small towns, medium and large cities were included in the sample.

The short film was deliberately put together so that the subject always had to go through a new situation as follows:

1. self-driving car with safety driver at low speed
2. self-driving car with safety driver at high speed
3. self-driving car without safety driver
4. a self-driving car has an accident and overturns

In relation to what was seen in the video, the goal was to gradually build confidence in self-driving cars from the perspective of respondents, all by involving and presenting increasingly complex traffic situations. In each case, we assessed on a scale of 1 to 6 how, based on what they saw, respondents would judge their sense of security if they were sitting in the car seen in the video. And after building gradual trust, after an accident, we wondered how they would respond to the level of trust associated with the technology. Did all this change the level of trust or did it not affect you at all? We wondered what might be behind the more dismissive behavior of women, and we compared all these responses with male responses.

During the experiment, male and female polarization were clearly demonstrated both in the perception of security and in the process of opinion formation (Figure 5). In all four simulated situations, women experienced a 17–34% lower sense of security during the experiment than men. The biggest difference was when the self-driving car was still driving with a safety "driver" but at a higher speed. Women were emotionally based *("shocked that no one was sitting in the driver's seat"),* men lined up rational

reasons *("it's already a mature technology, it can't be wrong")* behind their sense of security (or lack thereof). Among the basic emotions, women felt the most surprise and fear.

Figure 5 Mean values of the feeling of security by examined situation, by gender (on a scale of 1–6)
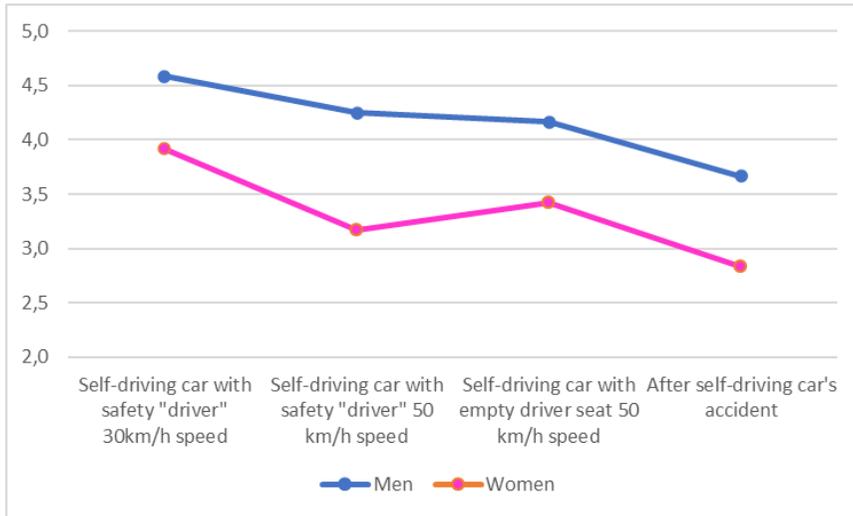
Source: own construction

An important result of the in-depth interview emotion research is that the results of the large-sample questionnaire surveys on the marked rejection groups are only partially confirmed: a significant difference between men and women was detected in this case as well. In the latter cases, the traffic, and emotional situations previously experienced, which the video seen brought back to the surface, are much more important than the demographic status. That is, someone was more dismissive than emotion research because they were older or because they live in a smaller settlement, but because they were reminded of the previous negative life situation of the situations they experienced in the experiment. This is an important result in terms of the fact that due to the complexity of the topic, it is also very important to explore the underlying causes.

We have also shown that newer information can make dismissive behavior accepting. A particularly interesting result of the experiment was that in 40% of the participants in the experiment, the sense of security against our expectations did not decrease when the safety driver was removed from the picture. These subjects indicated an unchanged or increasing sense of security on the grounds that *"I am already accustomed to this situation, no longer bothered that no one is driving".* That is, the relationship between increasing information and acceptance can be clearly demonstrated, and that once you see and experience how technology works, your acceptance increases.

5.4. Virtual reality simulation

The results of the methods presented above showed that the closer subjects can feel about what self-driving is all about, the more they have a positive attitude towards technology. This gave us the idea to look at what happens when people get one step closer to the real feeling, i.e. we called virtual reality for help. We conducted an empirical experiment in a simulated self-driving car test. Our aim was to examine the reactions and feelings of humans towards self-driving cars, selected from rejection groups, and whether virtual reality experiments can help in the acceptance of this technology in the social groups mentioned above.

During the experiment, smartphone-compatible VR goggles were worn by the subjects, through which we presented a self-driving car simulation implemented by the Wind River application. Meanwhile, a blood pressure monitor was installed on each participant to measure any increase or decrease in blood pressure and heart rate while showing the 1.5-minute video, which represents different kinds of traffic situations. When the participant turns his/her head, he/she can see the surrounded environment and the moving car ahead. It was very interesting, but no significant differences were observed in heart rate and blood pressure, but some changes were measured in all cases.

16 people participated in the experiment. Unfortunately, due to the COVID-19 epidemic, there were difficulties in surveying the higher number of participant because the experiment requires a face-to-face meeting. We would like to emphasize that the device also covers the nose, for this reason extreme care had to be taken and therefore the number of people in the experiment was less than planned. For this reason, our goal changed slightly to see if VR is getting any closer than previous studies, and if so, this might be continued and deepened in the future. During the research, we focused on the attitudes and emotions of women and the elderly (over 60 years of age). The participants came from different parts of the country and were made up of different age groups, which helped us to approach the problem in as diverse a way as possible, and to gather as much information as possible about the expectations and opinions of the respondents regarding self-driving cars.

Prior to the start of the experiment, all participants expressed curiosity and excitement. Prior to the start of the research, as they saw the VR goggles, all older participants and all women showed fear, as none of the participants had yet encountered this device and the women called the technology bizarre. Moreover, all participants in the experiment said that they had not tried small virtual reality glasses before, so they did not have the benchmark of previous experience. It can be concluded that the experiment and its results made it possible for the participants in the research to gain experience with driverless vehicles before they are placed on the market.

When asked how safe they felt when traveling by the car on a scale of 1 to 6, the average for both women and men was 5.8, and for both sexes, those in the older age group were those who gave a lower value to safety than the average. Examining how well the subjects felt, there was also a similarity in terms of gender in the case of the averages, as we obtained a value of 5.6, in which case those over 60 years of age also gave a lower value.

Table 1 Comparison of characteristics of female and male participants' opinions

|	Women's opinions	Men's opinions
Changes of trust in a self-driving car during the experiment	Positive displacement	Positive displacement (to a greater extent)
Characteristics of attitudes towards self-driving cars	Surprise Consternation Excitement Joy Enthusiasm More emotional Experience orientation Comfort Sensitivity of the system	Surprise Consternation Joy Enthusiasm Desire for adventure Experience orientation Issues due to loss of control Risk of system failure
Subjective impressions gained during an experiment	Throughout the experiment, the participants were characterized by excitement, perception of relaxed expression. Less openness to real trying.	Throughout the experiment, the subjects were characterized by excitement, a desire for adventure, and a perception of confident expression. Openness to real trying.

Source: own construction

The young respondents were characterized by joy after the experiment. They looked back on the virtual reality simulation as a huge experience. The older age group was characterized more by a neutral facial expression after the experiment. It was more characteristic of the young women that they expressed their emotions more strongly. During the experiment there were joyful cries and surprised reactions as well.

We concluded the study by again asking the subjects how much they would trust the self-driving car after the experiences they experienced, reminding them how much value they gave before the experiment on a scale of 1 to 6. All participants gave a higher value one by one than we initially experienced. For women, this averaged 5.1 (0.7 percentage point increase) while for male subjects it was 5.4 (1 percentage point increase) on average. In the case of women, again, the subject over 60 gave a lower value, and in the case of men, the older value was lower.

Our research methods prove that consumer attitudes and opinions about self-driving cars are greatly influenced by information about technology, our previous experience with motor vehicles, and the potential opportunities and dangers with self-driving cars, and last but not least by emotions, a sense of security being the most important.

Figure 6 Factors influencing attitudes towards self-driving cars
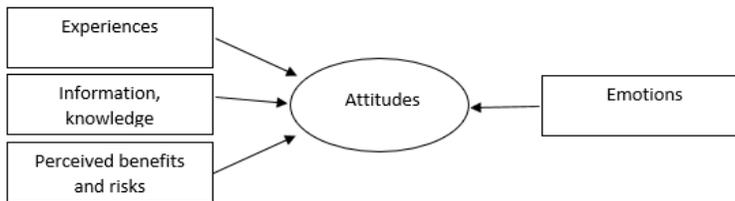
Based on our results, we believe that attitudes towards self-driving cars are strongly influenced by the information and knowledge gained about them, any experience with motor vehicles, the perceived benefits and risks of self-driving cars, and emotions where safety is dominant (Figure 6). The research clearly demonstrated that as information increased, the difference in attitudes between women and men narrowed. Hence, it was shown that increasingly sophisticated methods, on the one hand, helped to pass on more and deeper information to the participants, and on the other hand, were able to blur gender differences.

6. How to improve women's attitude about self-driving cars?

In our study, mostly, the qualitative results show that the Hungarian women interviewed are significantly more reluctant to drive self-driving cars than men. As the proportion of women drivers increases year by year and has already exceeded 50% in the US, women represent a critical mass of rejectors who are able to negatively influence the spread of self-driving technology. Thus, self-driving technology developers also need to focus on social aspects, including rethinking their *"women's strategy"*.

The empirical survey of our study clearly concluded that acceptance increases with awareness: the more informed the respondent, the more likely he or she is to accept self-driving cars. We have also shown that newer information can turn dismissive behavior into accepting in the case of Hungarian respondents.

It follows from all this that women's attitudes towards self-driving cars can clearly be improved by providing them with more information. The exact way to do this is a very diverse topic, the detailed elaboration of which is the task of a wider professional community. The framework of our present research is realistically only suitable for outlining the basic ideas that, based on our research, can serve as an important input for the development of specific actions. Based on our results, it can be concluded that the female attitude towards self-driving cars can be effectively influenced if the *"women's strategy"* meets at least the following criteria:

1. *Messages and content specifically tailored to women:* the psychological aspects of women's opinion-forming must be considered (emotion-centered, colorful messages, etc.) (Meloni et al. 2014, König–Neumayr 2017, Anagnostopoulou et al. 2018).

2. *Indirect messages:* as the automotive industry is not a priority for women, it is proposed to link the messages to topics that are of particular importance to women (beauty, children, animals, gastronomy, travel, entertainment, etc.).

3. *Quick messages*: Women prefer very quickly-consumed messages that can be processed in a fraction of a second: a simple sentence and associated visual content.

4. *Simplified*: women prefer easy-to-understand messages that they can process while multitasking: infographics, visually acceptable solutions.

5. *Entertainment content:* Women prefer entertaining content over educational content. This is true for both the theme and the appearance: a light theme with moving (video, gif) packaging is most effective (Anagnostopoulou et al. 2018)

6. *Selecting "women's channels":* It is extremely important that messages are delivered to women through a channel that they use daily. For example, the majority of Facebook, Instagram, and TikTok users are women, but the proportion of female users on Pinterest is 25% higher. All this also opens space for influencer marketing.

7. *Chat-like messaging:* Messenger is an interface used by billions of women daily (Statista 2021). You may want to implement chatbot enhancements that can be a powerful tool for women by offering ask-and-answer options.

8. *Innovative, attention-grabbing solutions*: in the long term, the topic of self-driving cars can be effectively brought to women's attention if they are served in some exciting way: VR experience, trying a self-driving car, etc. (Schrammel et al. 2015).

In our view, strategies based on the above key considerations are appropriate to take the first steps to ensure that self-driving car developers consider and address the attitudes of a large rejection group, women. If we consider the result of our research to be globally valid, according to which increasing awareness reduces the rejection of self-driving cars, the application of our suggestions could positively influence the attitudes of women towards self-driving cars.

7. Conclusion

This decade could see a significant step forward in self-driving car technology. In our study, we pointed out how the proliferation of self-driving cars could bring drastic changes to the daily lives of all societies. This new solution will change transport in a way that nothing else has done in the last hundred years, but the transition time may take decades and will not be smooth These changes could fundamentally change our daily routines and decades of habits, and affect our travel habits, the business models around us, our networks, and the image of our environment. This system creates the opportunity to eliminate traffic jams, drive faster, put less strain on our environment, have fewer accidents on the roads, or even have green areas and public spaces in place of the current car parks and not have our own car in the future.

All in all, the prevalence of self-driving is a huge problem in our era. We highlighted the problems that (i) with very few exceptions, self-driving car developers focus exclusively on technological development, (ii) the projected drastic change is much closer than what could be realistically prepared for at the social level, (iii) self-driving cars represent the technology from which we could benefit the most, and (iv) there is no strategy to shape the attitudes of rejecting groups. As women represent half

of all drivers in order of magnitude, neglecting their rejection could delay or even jeopardize the successful introduction of the technology as a whole.

The clear conclusion of our study was that in the case of the Hungarian respondents' acceptance increases with awareness: the more informed the respondent, the more likely he or she is to make an accepting statement about self-driving cars. We have also shown that newer information can turn dismissive behavior into accepting in the case of research participants.

It is therefore necessary to extend development work to the social sciences, with a special focus on rejection groups (especially women), thereby accelerating social adaptation for humanity to be able to process the projected drastic change. The aim of this study is not to convince rejection groups of self-driving technology, but we consider it of paramount importance that information be provided to society by appropriate means. In addition to information, we believe that consumer involvement is also a priority in approaching the topic.

With our results, we would like to draw attention to the fact that the topic requires an interdisciplinary approach, as technological development is not enough, but social science aspects must be included in innovation processes, with a special focus on clearly identifiable segments such as women.

Acknowledgments

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