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ASSESSING SELF-DRIVING VEHICLES AWARENESS IN HUNGARIAN REJECTING GROUPS

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Abstract

Autonomous vehicles can be seen as a radical innovation that develop innovative aspects in the mobility system, which can affect every part of our lives. Numerous studies have examined the attitudes of consumers toward autonomous vehicles with different models. It is striking that several models used questionnaires, and the empirical investigation of the social aspects of the issue of self-driving cars is complicated by the fact that people have little or no direct experience in Hungary. Research has demonstrated that there are certain groups that are more critical of technology. The aim of the research is to examine the attitudes of Hungarian people towards autonomous vehicles with a special focus and methodology: focusing on „rejection groups", we perform a series of analyses. The results obtained draw attention to the impact of social processes on innovation. The study contributes to a deeper understanding of the Hungarian population's attitude toward autonomous vehicles and our goal is to enrich further research with our results.

Keywords: autonomous vehicles, rejection groups, consumer perception

INTRODUCTION

Numerous studies have been conducted in the field of trust, suggesting that managing and continuously improving mutual trust between self-driving automotive systems and users is a primary challenge that professionals face when trying to promote the use of fully self-driving systems intelligence (Beer et al., 2014; Choi & Ji, 2015; Koo et al., 2015). Technological development greatly affects urban mobility (Miskolczi et al., 2021b). In recent years, great strides have been made in the development of autonomous vehicles (AV).

The interpretation of the challenges posed by self-driving vehicles is mainly based on the various levels of automation. According to the professional association Society of Automotive Engineers International (SAE), today's technological progress within the automotive industry is so rapid that it requires the development of technical standards. For this reason, SAE (2014) created a standard that defined degrees of automation at six different levels. With the help of this standard method, it is possible to group the various levels based on the relationship between human intervention and the control technology of one's own vehicle. In the first three levels,

the human driver is still present behind the steering wheel, who monitors and constantly checks and controls the driving. From level 3 onwards, the automated driver system monitors the immediate environment around itself during the journey.

However, research on consumer perceptions and attitudes toward AVs has lagged behind technological development. Some research has predicted that age as well as gender may influence consumer propensity to drive self-driving vehicles, however, none of these studies have explained these effects in sufficient depth (Howard & Dai, 2014; Rice et al., 2019; Sener & Zmud, 2019).

Recent research suggests that in addition to low levels of social acceptance (Hulse et al., 2018; Deloitte, 2020), its diversity may pose a significant problem, even though the latter is relatively little discussed in the international literature. Certain well-identified social groups, such as women, the elderly, those with a lower level of education, or those living in rural areas, are significantly more critical of AVs (König & Neumayr, 2017; Audi & Ipsos, 2019), which can have a noteworthy impact on self-driving technology market penetration.

Influencing the behavior of the critical, contradictory segment is not feasible with general strategies in many cases. This is predominantly the case when the psychological and neurological backgrounds of each segment differ significantly. However, the attitudes of men and women or the young people and the elderly cannot be shaped by the same interventions.

In addition to the benefits of self-driving vehicles, consumer acceptance can be influenced by several other factors. Shariff et al. (2017) suggest that factors hindering the social acceptance of these vehicles are of a psychological rather than a technological nature. The results of a study conducted in 2020 well illustrate that autonomous mobility, and thus a key long-term goal for self-driving vehicles, is to reach people who do not drive or drive less: including children, the elderly, women, or those who are unable to drive for some reason (Havlíčková et al. 2020). According to this research, the gap between technological readiness and social acceptance creates a paradox in the context of autonomous mobility, i.e. one of the biggest advantages of self-driving vehicles is most rejected by those who could benefit significantly from the use of AVs.

Both Slovic (1999) and Kahneman (2019) have explained in their research that society is constantly forming opinions in all areas and making judgments that are accompanied by the expression of our emotions. Moreover, it is proven that we shape our decisions and opinions on a given topic according to our emotions (Varga, 2016). Our emotional stimuli during certain processes and activities have an impact on our perceptions of emerging risks and opportunities (Kahneman, 2019).

THEORETICAL BACKGROUND

The technological development of self-driving vehicles is much more advanced than most of society would assume (Lukovics et al., 2020). The market penetration of self-driving vehicles highly depends on consumers, their preferences, and fears. Noy et al. (2018) explain that without consumer acceptance, the benefits of self-driving vehicles cannot be realized. If AVs become the norm, many opportunities can be attributed to their collective use, but the potential social benefits can only be achieved if they are accepted by a critical mass of society. Under optimistic scenarios, we cannot ignore the pessimistic, unintended consequences. We need to keep in mind that we have little information on which factors influence acceptance or rejection the most, and we must not forget that end-user acceptance is critical to widespread adoption. Widely used models are available to study technology acceptance, the most used in the research reviewed below being the Technology Acceptance Model (Davis, 1986) and the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), or the diffusion of innovation theory (Rogers, 2003).

The assessment of the expected social impacts of autonomous, self-driving vehicles in the literature shows a mixed, often contradictory picture. Acceptance of self-driving vehicles is limited among users. Car manufacturers need to consider trust requirements in the early stages of self-driving car development (Hakimi et al., 2018). According to a study by Carlson et al. (2014), the biggest challenge in the coming years and decades will be to attract the attention of average users, road users – who have high expectations of fully self-driving cars globally.

Until 2014, we retrospectively reviewed research related to the adoption of self-driving vehicles aiming to explore social attitudes internationally. Regarding autonomous vehicles, exploring empirical studies of social attitudes highlights the fact that many of them used the methodology of the questionnaire survey, and in some studies the segments that are more negative in terms of technologies can often be identified. However, questionnaire surveys often do not measure what we truly want to measure, as most research participants cannot even imagine AVs, having never physically encountered the technology. The majority of studies related to self-driving vehicles focus mostly on technical or natural science fields in Hungary, however social science research on the topic has recently become increasingly important (Kassens-Noor et al., 2020; Miskolczi et al., 2021a; Kovács & Lukovics, 2022).

Thanks to advances in technology, we can not only reap potential benefits but also cover several challenges that are yet to be seen. According to Braun (2020), revolutionary digital technologies that are already integrated into the transportation system may be able to crowd out

members of society from making judgments and making decisions. To all this, Braun adds that we are clearly faced with a wealth of potential opportunities that could lead to a more environmentally friendly, livable, and much more organized human-environment relationship. These subjects have the greatest impact on all the expected reforms.

Organized into a system, AVs can open extreme perspectives on mobility, the consequences of which will affect almost every area of ordinary citizen life. They can change our travel habits, create new business models, build new networks, open new city opportunities, and enrich our lives with new daily routines (Lukovics et al., 2018; Palatinus et al. 2021), therefore, it is a non-negligible topic that needs to be addressed.

Research on attitudes toward self-driving vehicles identifies segments that are more dismissive. In the case of negative, critical opinions about AVs, women (Schoettle & Sivak, 2014; Kyriakidis et al., 2015, König & Neumayr, 2017; Hulse et al., 2018; Liljamo et al., 2018; Audi & Ipsos, 2019; Pettigrew et al., 2019; Havlíčková et al., 2020; Raue et al., 2019; Wang et al., 2020), the elderly (Schoettle & Sivak, 2014; König & Neumayr, 2017; Hulse et al., 2018; Liljamo et al., 2018; Audi & Ipsos, 2019; Pettigrew et al., 2019; Havlíčková et al., 2020), those on lower incomes (Kyriakidis et al., 2015; Audi & Ipsos, 2019; Wang et al., 2020) those living in the countryside (König & Neumayr, 2017; Liljamo et al., 2018) parents with small children (AAA 2016) and those with no or less driving experience stand out (Audi & Ipsos, 2019; Raue et al., 2019).

However, the empirical examination of social aspects is greatly hampered by the fact that people have very little direct contact with these types of vehicles. Consumers receive information mostly from news portals and public opinions, and their effects can be felt to a large extent in consumer attitudes.

Tóth (2019) explains that the car system in Hungary is not comprehensive and decisive in its current state, owing to which the introduction and social acceptance of new innovations presumably differs from that in other countries. The empirical investigation of the social aspects of the employment of self-driving cars is undermined by lacking or insufficient direct experiences in Hungary, allowing us to capture only the development and current status of public opinion shaped by public perceptions (Csizmadia, 2019), moreover, the lack of self-driving systems can lead to high rejection rates as people do not meet the technology. Csizmadia (2019) notes that the subject of self-driving vehicles is an extremely exciting topic, not least due to the social, psychological and sociological aspects of the introduction of machines making

decisions for us. Tóth (2019) notes that half of the Hungarian households do not have their own car, presumably leading to high rates of inclusion in the new mobility system.

DATA AND METHODS

The research is primarily an idiographic approach, an inductive, exploratory research, as it seeks to gain insight into underlying causes, opinions, feelings, and possible problems. The aim of the study is to *examine the attitudes of Hungarian society towards autonomous vehicles with a special focus and methodology: we performed a series of analyses that included visual experiments with a focus on rejection groups*.

Qualitative data combined with quantitative tools were used to (Tab. 1) describe the acceptance of autonomous vehicles in Hungary. The aim of the study is to provide a basis for the development of appropriate strategies by understanding the characteristics of the rejection segments related to self-driving vehicles in Hungary. To this end, we conducted a *netnography* using nearly 5,500 posts on online platforms. The qualitative information derived from this, supplemented with quantitative tools. We surveyed which segments were more negative toward AVs with an *online questionnaire*. This was supplemented by additional qualitative methodologies, such as *emotion research through in-depth interviews*, which examined immediate emotions and reactions in the case of rejection groups during a video projection. Finally, we conducted with rejecting subjects a *virtual reality experiment through in-depth interviews*. The study's significance lies in that through the qualitative collection of user-generated online content from netnography we were able to categorize consumers according to their trust and curiosity, allowing us to learn more about the reactions and opinions of the rejection groups.

Table 1 Applied methods and main expectations

Applied methodology	Objectives, main expectations
Netnography	Analyzing posts and comments on articles related to AVs on various domestic portals on Facebook, with the aim of exploring attitudes, then creating categories from the comments.
Online questionnaire	Exploring and examining the rejection segments in Hungary, and studying the attitudes of these groups in relation to self-driving technology.
"Emotion research" through in-depth interviews	Exploring the attitudes of rejecting groups on the basis of stimuli evoked by a short film and detecting and understanding the subjects 'emotions about AVs.
Virtual reality simulation through in-depth interviews	Introducing a virtual reality driving experience for rejecting groups to gain a better understanding and a deeper insight into the operation of AVs

Source: own construction

Netnography

The media can greatly distort our judgments and be of paramount importance in our decision-making. Based on this, we can categorize certain things, finding ourselves in the face of prejudice. Netnography can be well applied to map the structure and mechanisms of different online communities (Kozinets, 2010), based on information from online platforms. Netnography involves both the observation and coding of online content, as well as the analysis of content. In the case of netnography, researchers look for logical patterns through categorization. In the analysis of communication in online communities, it is possible to draw conclusions not only about the examined text but also about the context of the text (Krippendorff, 2018). In observational netnography, the researcher is present as an outsider, an "observer" but will not be a member of the community (Kozinets, 2007).

Identifying the combinations between the content and visual elements of the posts can help to explore the connections between the posts and their activating effect. Analyzing the posts can help us understand user opinions and consumer attitudes. The weakness of netnography is that it is difficult to analyze demographically, in addition, the Facebook algorithm prefers news and comments which have a negative attitude toward topics. Therefore, the online platform itself can influence the type of comments.

The Crowd Tangle platform was used for the netnographic analysis. Based on the aggregated data of 2021, out of the 10 most popular pages in Hungary[24], the posts of *24.hu*, *index*, *origo*, and *hvg* (including Autó and Tech) were included in our analysis. We also considered it important to examine the posts of news portals that put vehicles in the forefront, so the *Totalcar* and *Vezess* portals were also analyzed. The analysis covers a one-year period, and we reviewed the articles related to AVs posted before April 1, 2021, by searching for the keyword "self-driving," which received 154 hits. We removed the posts that no one commented on. A total of 5,476 comments were analyzed during the study period.

Online questionnaire

The development of the online questionnaire is based on a poll conducted by Schoettle & Sivak (2014). The number of answers to the series of questions was 1,005 at the Hungarian level. We distributed the online survey using social media platforms. The main topics focused on the following: general opinions about AVs, the expected benefits of self-driving vehicles, and possible concerns. The next block focused on issues related to possession, ownership and

[24] https://nmhh.hu/cikk/220235/Internetes_kozonsegmeresi_adatok_2021_I_negyedev

willingness to pay, and last but not least, we examined the time liberated instead of driving. We closed the questionnaire with demographic questions. We asked a total of eleven questions which were multiple-choice questions. The results of the questionnaire were analyzed using a chi-square test, which is a statistical test that can be used to analyze the relationship between variables. Our aim was to detect whether there is a significant relationship between some variables. The test can be used for nominal or ordinal measurement level variables.

The gender distribution of the respondents is as follows: 57.2% are male and 42.8% are female. In terms of educational attainment, 50.3% of the subjects in the research have a lower than a bachelor's degree. The average age of the respondents is 29 years, and the median is 24 years.

“Emotion research” through in-depth interviews

We conducted a series of special in-depth interviews during which we projected a short video, edited by us, to our subjects belonging to the pre-identified rejection segments. We kept pausing the video and asking about their emotions. Audiovisual stimuli are the most accepted method for evoking basic emotions, as they can elicit very similar stimuli from humans (Fernández et al., 2019; Siedlecka & Denson, 2019), which is why we consider them to be a useful method.

The video featured an AV in increasingly complex traffic situations. We assessed how the level of trust changes in each situation. The experiment involved 34 people who were more dismissive, half of whom were men and the other half women. Participants ranged in age from 20 to 66 years, while their management experience ranged from 0 to 45 years.

Virtual reality simulation through in-depth interviews

The increasingly common use of virtual reality is not only a result of technological advances but also of a paradigm shift in research. Virtual reality expands our perceptions of our immediate environment and our available experiences with information that is not available to us or may be difficult to access. With the help of virtual reality, we can update our knowledge, assisting our everyday judgments and decisions.

For the virtual reality simulation, we used one of the applications of Wind River Automotive Solutions. The Wind River app provides a unique virtual reality experience that puts the user in an entirely self-driving car, which allows them to experience what it feels like to drive without human intervention. During the implementation of the experiment, we took care to ensure that the experiments supplemented with in-depth interviews take place in person, as body language

and facial expression can also contribute greatly to a deeper understanding of attitudes and feelings. In the choice of the location, our main priority was to conduct the experiment in a relaxed atmosphere.

During the experiment, a smartphone-compatible virtual reality goggle was attached to the subjects' heads, through which the self-driving car simulation was projected. Meanwhile, a blood pressure monitor was installed on each participant to measure any increase or decrease in blood pressure and heart rate. In the experiment, when the subject turned his head, he could see a part of the car and the environment immediately surrounding the car.

The experiment involved 16 individuals selected from the rejection segments. The application was voluntary. Half of the participants were male, and the other half were female. The age ranged from 23 to 72 years.

RESULTS

In the case of *netnography*, different categories (Tab. 2) could be formed according to the degree of trust and curiosity after examining each post. Respondents were categorized according to their level of confidence in self-driving vehicles and their interest in the technology. Based on these, *rejectors (52.3%)*, *doubters (28.7%)*, *conformists (11.2%)*, *experts (4%)* and *enthusiastic fans (3.8%)* or "early adopters" could be distinguished. Powerful characters have developed among members of the communities. The contents of the posts varied over the one-year interval. It can be clearly stated that the strongest statements were expressed in the case of accidents involving self-driving vehicles and in the case of writings organized around already known brands.

In the case of enthusiastic fans and rejectors, a dedication was observed, so in one post they constantly commented on previous objections, reacting to those positions that were unacceptable to them. They commented in detail on the subject. In the case of enthusiastic fans, they felt it was their mission to convince the rejectors, while in the case of the rejectors, complete disappointment was felt.

A striking phenomenon was that the rate of consumer comments was much more intensive, and the number of reactions was higher in the case of posts reporting negative events (accidents, hits, corpses). We could not ignore the negativity bias theory, which shows that negative stories on Facebook are more viral because evolutionary people are more likely to react to negative events. Thanks to the spread of the Internet, any civilized person across the globe can easily obtain this information, causing them to be shocked by what they see, hear, and read. The

emotions that develop within us in relation to media content can vary depending on how far a particular tragic event has taken place, both in space and time.

Table 2 Categories according to the level of trust and curiosity toward each post

Level of trust	Degree of curiosity	Segment	Description of attitude	Quote
Low	Low	Rejector	They completely reject the technology, do not trust it at all, and show no interest in its direction. They argue about the disadvantages of vehicles, they don't need this technology at all.	*"They will be able to unscrew the steering wheel from my cold little dead hand. Seeing myself sitting in a remotely hackable autonomous tin when even our data has been leaked these days isn't as likely as a klezmer band's success at the skinhead festival."*
Low	Moderate	Doubter	They have reservations about the technology and less trust in it. They are still waiting.	*"Then when it's here, we'll grab it, taste it, test it, and see what it knows for how much. Until then, we're just guessing. …."*
Moderate	Low	Conformist	They are not particularly interested in the current state of the technology and shall see what the future holds. In a few years, after the tests, the vehicles will have reached maturity anyway.	*"Excluded in five years! Not necessarily due to the technical possibilities, but also because of the legal environment. Today, on the one hand, there is no legislation that can or wants to create a fair legal environment in all this time. On the other hand, a chemically clean legal environment should be created in an area that no one knows perfectly well yet. Also, you can't even know it because it's not formed yet. There are ideas at best. One kind for lawyers and one for technicians …"*
Moderate	High	Expert	They address the issue of autonomous vehicles with curiosity, and their confidence is moderate. In many cases, statistics are brought under the posts, linking to additional pages that can help other contributors and readers as a guide. In some cases, they reveal that they work or conduct developments in the automotive industry.	*"This is interesting and important news. It's just that journalists again don't understand anything, they know nothing, they just portray the superficial things about the investment. No background. Briefly outlining the reasons. In freight transport, self-driving can come first because there is a bigger car, more space for small boxes, more electricity for small boxes, and most importantly, more money and more benefits of self-driving. …"*

Table 2 (continued)

Level of trust	Degree of curiosity	Segment	Description of attitude	Quote
High	High	Enthusiastic fan/"early adopters"	They strongly express their confidence in the technology and are curiously awaiting self-driving vehicles. The benefits of the vehicles are extremely welcomed, technology is believed to make their lives easier.	*it will be good and there are those who do it well. Many of the parked cars will finally be removed from the streets and other people in the city center, not just motorists, will be able to drive in a human way.* *You won't have to go to a service station, wash, replace a wheel, you won't have to look for a parking lot if you go somewhere – and it will cost as much as your own car. There will be no accidents, no need for a police officer, parking guard, ambulance, and with time, neither traffic lights nor signs.* *One-fifth will be enough, so fewer car factories, less pollution due to production.*

Source: own construction

Due to difficulties of mapping the demographic features of each group in the categories identified by netnography, we used the *online questionnaire*. The subjects of our study came from the rejection groups, so we examined which groups were more critical of the technology in Hungary. Due to the values of $\chi^2 = 7.640$, sig = 0.02 obtained in the chi-square test, a significant relationship can be detected between education and knowledge of self-driving vehicles. The higher the qualifications of the respondents, the more familiar they are with the technology. Between education and general attitudes (χ^2=18.358, sig=0.001), it can be stated that there is a significant relationship, the strength of which is weak (C=0.096). The higher the qualification of the respondent, the more they declared a positive attitude towards self-driving vehicles. The analysis shows that there is a significant difference in the awareness of women and men (χ^2=45.335, sig=0.000). The women in the research are those who have not heard of the technology in a larger proportion (10.5%). Examining the issue of possession by gender, a significant difference can be detected. The test values of the statistical chi-square were: χ^2=27.872, sig=0.000. Based on the results obtained, we have found identifiable rejection segments in the social perception of self-driving vehicles. In terms of age categories, the rejection of the older age group is noticeable, in addition, there is also a divergence according

to levels of educational attainment. The less educated showed a higher degree of negative resistance. In terms of gender, women were more critical.

The added value of *emotion research through in-depth interviews* is that the presumption of the large-sample questionnaire survey about the characteristics of critical segments was more or less confirmed. It became apparent from the results of the experiment that there was a male – female polarization. In some cases, we found negative attitudes among the elderly and those living in smaller settlements. In other cases, rural respondents or those without a license were reluctant to answer the questions asked and expressed fear in the case of multiple responses. However, in addition to the different demographic situations, it has been shown that past transport experiences, with which emotions have been associated, play an important role. Based on the responses, we have found that in the case of self-driving vehicles, attitudes are influenced by previously acquired information, vehicle-related experiences, pre-perceived opportunities, and dangers (car breakdown, loss of control, hacker attack), and emotions related to self-driving vehicles.

The *virtual reality simulation through in-depth interviews* method has a clear added value, as fully realistic self-driving car situations were able to evoke emotions in the participants, allowing them to express their personal opinions freely. It clearly contributed to making the opinion of rejecting subjects more positive. Older people and those with lower levels of education in the countryside also had a more positive view of self-driving technology at the end of the research – before and after the experiment, we asked them how they felt about self-driving vehicles, and there was an unequivocal positive shift. Our experience shows that the more information they acquired about the technology, the more they learned about its operation, the more the previously existing differences in attitudes tended to disappear. Experimental rejection segments showed less rejection when participating in the virtual reality simulation.

Netnography helped to segment consumers, and based on the comments, we created categories characterized by distinctive features. The online questionnaire identified differences in education, age and gender, as well as who were more dismissive (elderly, low-educated and women). Emotion research through in-depth interviews, the subjects of which were selected from the rejection groups, revealed that the more a person learnt about the technology, the more experiences and impulses they acquired in the field of autonomous vehicles, the higher their confidence became. Based on the virtual reality experiment through in-depth interviews, and our observations simulating the real self-driving vehicle experience, we found that pre-existing differences in attitudes tended to disappear.

DISCUSSION AND CONCLUSION

The future of passenger transport is characterized by a high degree of uncertainty (Miskolczi et al., 2021c), leading Ekman and co-authors (2018) to distinguish phases in the process of building trust in self-driving cars. The first stage is referred to as the learning phase, which begins with the very first interaction (between a self-driving car and the subject) and lasts until the user becomes familiar with self-driving systems. In the simulation used in their experiment, they found the learning phase to be the most important in the acceptance process, although the duration of this phase appeared to vary from subject to subject. In the learning phase, trust is mainly acquired by gaining a deeper understanding and knowledge about the performance of the system and its reliability.

With the help of netnography, it was possible to identify 5 separate groups based on the Facebook comments of online portals using the spectrums of trust and curiosity, ranging from naysayers to die-hard fans. We tried to make up for the shortcomings of the method (demographic data) by using an online questionnaire. It was clearly visible that women, the older age group, and those with a lower educational level have a less positive attitude towards self-driving vehicles. With the help of "emotion research" through in-depth interviews, we attempted to bring the technology even closer to the interview subjects, and the initial doubts regarding the demographic aspect were less present by the end of the experiment. The VR experiment aimed to make the "AV experience" more realistic and tangible for the Hungarian subjects. The responses to our interview questions after the experiment show that previous negative opinions could turn into positive ones.

The empirical survey of our study concludes that acceptance can be increased through awareness: the more respondents learned about the technology, the more receptive they were toward the technology. We observed how additional information could reverse the dismissive behavior of subjects. From all of this, we concluded that the attitudes of rejection groups towards self-driving vehicles could be improved by providing them with newer and more detailed information. The exact method for this is a wide-ranging topic, the elaboration of which should be the task of a wider professional community. We believe that there is a need to carry out consumer acceptance and design research that is mindful of the suggestions of road users, in order to ensure the successful implementation of self-driving vehicles in existing, established traffic systems.

It is important to note that qualitative research methods are not able to fully cover the representative sample, even with the most thorough planning of sampling, which can be

mentioned as a major limitation of our study. For this reason, we believe that it is worthwhile to conduct our research on a larger sample in the future and to develop strategies based on the results obtained.

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