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How Perceptual Variables Influence the Behavioral Intention to Use Autonomous Vehicles †

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Abstract: The rapid development of technology makes the acceptance of autonomous vehicles (AVs) in modern transport a key issue. The aim of the present research was to explore the impact of AVs on behavioral intention to use. An online survey was conducted, in which factors such as perceived usefulness (PU), perceived ease of use (PEU), perceived trust (PT), social influence (SI), and behavioral intention to use (BIU) were investigated. As a result of the investigation, the correlation analysis revealed that there was a significant positive relationship between the intention and all the factors examined. The practical utility of this research is that the results will support developers and vehicle manufacturers in understanding how different social factors influence the adoption of AVs.

Keywords: autonomous vehicle; acceptance; behavioral intention to use; technology acceptance; online survey; consumer behavior

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1. Introduction

Today, smart cities are becoming more widespread, and AVs are playing an important role in this. Smart cities are emerging as a result of the Internet of Things, next-generation mobile networks, and other rapidly developing technologies [1,2]. Automated vehicle systems can include, among others, autonomous cars or autonomous shuttles, which can transport up to 10–12 people at a time [3]. In addition to convenience and sustainability, safety is also an important factor in transport. The correct use of automated technologies can reduce the number of road accidents [4].

Assessing the acceptance of AVs is a major area of interest today, as consumers tend to be wary of new technologies, and thus often fail to take advantage of the benefits of the technology. Such benefits may include increased road safety or environmental protection. The results of acceptability studies can help technology developers and all stakeholders to increase acceptance among the public so that the benefits can be exploited. However, in addition to the benefits, automation developments also have drawbacks that engineers and researchers are trying to eliminate through continuous improvement [5]. One group that is more prone to be dismissive of automation is those for whom driving is an experience and who do not want to be out of control in any way, as they trust themselves and find it a source of joy [6]. There are also consumers who want to use their time more efficiently in today's fast-paced world and would see the advantage of not having to focus entirely on driving while travelling, but also being able to carry out work or personal tasks [7]. There are also consumers who are not so much motivated by the environmental and safety benefits of AVs, but by status and trend [8].

In addition to increasing safety, AVs could be used to increase mobility, an example of which could be the transport of a drunk passenger or even transporting an elderly or sick person [5]. In a study by Payre et al. [9], a survey on AV acceptance was conducted, and the

results showed that 71% of respondents said they would use an AV in a case of illness or injury. In situations where a person is unable to drive for any reason, such as not having a driving license or being disabled, the level of acceptance of AVs is higher, and the situations used as examples can increase urban mobility [7]. One of the most widely used methods related to the acceptance of technological innovations is the use of technology acceptance models. The theory of planned behavior (TPB) analyses the impact of behavioral attitudes on actual consumer behavior [10]. A commonly used and accepted model is the technology acceptance model (TAM), of which several extended versions can be found [11]. In addition to the TAM, the unified theory of acceptance and use of technology (UTAUT) has also been shown to be effective for this type of analysis [12]. Deng and Guo [13] conducted a study in the area of proximity safety related to autonomous driving technologies, and the results showed that cognitive biases in consumers may pose a risk to safety. In addition to safety concerns, legal and ethical issues associated with AVs can also be a challenge [14]. Kyriakidis et al. [15] conducted an online survey of a sample of 5000 people, revealing that participants found manual driving to be the most enjoyable and that they were most concerned about safety and legal issues.

Trust is crucial for building acceptance among users of AV technology, as it determines how safe and reliable individuals believe these systems to be [16]. The importance of user trust for addressing concerns by technological risks related to cocreation is proposed by studies where trusted relationships will then drive adoption [17]. In an urban context, the trust and comfort pedestrians have with regard to AVs are heavily influenced by factors like system transparency and communication [18]. Influencing the readiness to use, belief in automated vehicles also minimizes indecision, which leads to broader social acceptance [17]. The personality traits, control, and both extrinsic and intrinsic motivations are some of the aspects the authors have examined that contribute toward shaping user attitudes in the context of autonomous driving systems. Trust in automation seems to reduce concern and result in user control, which in turn increases the rate of adoption [19]. Personality traits, such as openness to experience, have been related to the elevation of openness and acceptance and trust levels in emerging technologies. For example, Kraus et al. [20] report that in the group of persons who accept new technologies, there is a significant variance in open personality traits. Zhang et al. [21] note specifically that initial trust and social influence are the crucial active drivers of the acceptance of AVs in China.

Several studies in the literature have pointed out that knowledge and trust can greatly influence the use and acceptance of ADASs. The lack of knowledge about ADASs highlights that car buyers and sellers are not always well informed about the technology, which can affect usage [22]. Even though many car owners have certain ADASs, such as adaptive cruise control, many of them do not fully understand how they work. This lack of value can lead to security risks [23,24]. Adequate training and education is essential to increase confidence in ADASs [25]. Increasing consumer awareness and reinforcing positive experiences with the systems can contribute to wider adoption of the technology [26].

The aim of this research is to investigate the attitude of Hungarian consumers towards AVs and their acceptance of them. To investigate this, a questionnaire survey was carried out, in which attitudinal statements were used to measure acceptance in five dimensions. The objective of this research was to examine whether BIU is influenced by PU, PEU, PT, and SI. To this end, four hypotheses were formulated, based on the literature, and tested using correlations.

- H_1: Perceived usefulness has a positive effect on behavioral intention to use.
- H_2: Perceived ease of use has a positive effect on behavioral intention to use.
- H_3: Perceived trust has a positive effect on behavioral intention to use.
- H_4: Social influence has a positive effect on behavioral intention to use.

2. Materials and Methods

A questionnaire survey was used to investigate consumer attitudes and acceptance of AVs. The questionnaire was created using Google Forms and completed by a total of

128 people. The results of the questionnaire were analyzed using SPSS statistical software 29.0 (IBM, Armonk, NY, USA).

The Table 1 illustrates the type and number of questions asked in the questionnaire and the scales used. Four types of questionnaire questions/attitudes were distinguished: (1) demographic; (2) travel and driving habits; (3) awareness; (4) AV acceptance. The questionnaire contained a total of 24 questions and a 5-point Likert scale was used for the attitude statements. In the present questionnaire, only the acceptance of AVs in general is investigated, without going into the different levels of autonomy (SAE levels). However, these levels are very different, and the level of acceptance is likely to vary. The questionnaire also comprised questions that allowed for the evaluation of participants' prior knowledge and experience with AVs, since prior research has indicated that the level of familiarity with the technology of AVs impacts public acceptance. However, one-way additional refinement could be carried out is by asking specific questions related to the participants' role—for example, driver versus pedestrian and environmental variables, which clearly are going to influence how this person interacts with the AV, such as weather conditions or volume of traffic.

Table 1. Survey questionnaire.

Question/Statement Type	Number of Questions	Scales
Demographic	4	Multiple-choice
Travel and driving habits	4	Multiple-choice, five-point Likert scale
Awareness	3	Multiple-choice
AV Acceptance	14	Five-point Likert scale

To measure acceptability related to AVs, we used 5 dimensions, with validated scales adapted from the study by Panagiotopoulos and Dimitrakopoulos [27]. With the dimensions defined, the aim was to see whether each dimension had an observable relationship, positive or negative direction, and the strength of the relationship (Table 2).

Table 2. AV acceptance dimensions.

Dimensions	Statements	Source
Perceived usefulness (PU)		
PU1	I would find AVs useful in meeting my transportation needs.	
PU2	If I were to use AVs, I would feel safer.	
PU3	Using AVs would make driving more interesting.	
PU4	Using AVs would decreasing accidents.	
Perceived ease of use (PEU)		
PEU1	Learning to operate an AV would be easy for me.	
PEU2	Interactions with AVs would be clear and understandable to me.	
PEU3	It would be easy for me to become skillful at using AVs.	
Perceived trust (PT)		[27]
PT1	I generally have concerns about using AVs.	
PT2	AVs are somewhat frightening to me.	
PT3	I have concerns about the safety of AVs.	
PT4	I have concerns about the system security and data privacy of AVs.	
Social influence (SI)		
SI1	I would be proud if people saw me using a AV.	
SI2	People whose opinions I value would like to use AVs.	
Behavioral intention to use (BIU)		
BIU1	Likelihood of having or using AVs when they become available on the market.	

3. Results and Discussion

The data collected by the questionnaire are presented using descriptive statistics and correlation calculations. The first part of the results describes the sample in terms of demographics, travel habits, and awareness. In the second part, the relationship between the dimensions of acceptability related to AVs is described.

Demographic Characteristics and Travel Habits

The Table 3 shows the demographic data of the participants. In terms of gender distribution, 51.33% of respondents were male and 48.67% were female. The highest proportion of respondents had secondary education (62.50%) and belonged to Generation Z (66.40%).

Table 3. Demographic data of the respondents.

Demographic Information	
Gender	
Male	51.33%
Female	48.67%
Education	
Primary school	0.00%
Secondary education	62.50%
Higher education (BSc, MSc)	33.60%
PhD	
Generation	
Generation Z	66.40%
Generation Y	15.50%
Generation X	16.40%
Baby Boomer	1.70%

Table 4 illustrates habits related to driving and travelling: 60% of participants own or lease a vehicle. About half of the participants, 52.80%, drive or travel in a car every day. Results are more mixed for public transport use, with 35.70% of the sample not using public transport. When travelling by car, participants feel safe, with an average mean score of 4.29 on a scale of 5. Furthermore, 92.2% of participants had heard of AVs, but only 46.1% had heard of autonomous shuttles.

Table 4. Travelling and driving habits of the respondents.

Habits	
Car ownership	
Yes	60.20%
No	39.80%
Driving/travel frequency by car	
Every day	52.80%
A few days a week	33.10%
A few days a month	11.80%
Never	2.40%
Frequency of public transport use	
Every day	13.50%
A few days a week	27.80%
A few days a month	23.00%
Never	35.70%

Table 5 shows the mean, standard deviation, and sample number of items for the five dimensions analyzed. The averages show that participants have concerns about AVs. The highest mean value was achieved by PEU, which stated that they do not think that using these vehicles would be so difficult for them. The lowest mean scores were achieved by BIU and SI. The highest standard deviation value was observed for this BIU with a value of 1.290, indicating that participants were relatively divided in their opinions. The sample size for each of these dimensions was 128.

Table 5. Descriptive statistics.

	Mean	Std. Deviation	N
BIU	2.560	1.290	128
PU	3.047	0.971	128
PEU	3.604	0.995	128
SI	2.555	0.030	128
PT	2.928	1.077	128

Table 6 shows the correlation matrix performed by SPSS for BIU, PU, PEU, SI, and PT. The results show that there is a significant correlation between the factors under study ($p < 0.01$). The aim of this research was firstly to investigate whether there is a relationship between BIU and the other factors under study, but the table also illustrates the relationship between all the factors. The strongest positive relationship is observed between BIU and SI, with a Pearson correlation value of 0.649. SI is also strongly related to PU, with a correlation value of 0.622. The second strongest relationship is observed for PU, with a correlation value of 0.516. Thus, as the sense of utility increases in consumers towards AVs, so does the intention to use them. However, this positive relationship holds for all the dimensions studied, with the smallest positive relationship for BIU being observed for PT with a correlation value of 0.325.

Table 6. Correlation between AV acceptance dimensions.

		BIU	PU	PEU	SI	PT
BIU	Pearson correlation Sig. (2-tailed)	1				
PU	Pearson correlation Sig. (2-tailed)	0.516 ** 0.000	1			
PEU	Pearson correlation Sig. (2-tailed)	0.334 ** 0.000	0.463 ** 0.000	1		
SI	Pearson correlation Sig. (2-tailed)	0.649 ** 0.000	0.622 ** 0.000	0.313 ** 0.000	1	
PT	Pearson correlation Sig. (2-tailed)	0.325 ** 0.000	0.355 ** 0.000	0.227 * 0.010	0.329 ** 0.000	1

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Correlation analysis showed a significant and positive relationship between BIU and the variables PU, PEU, SI, and PT ($p < 0.01$), which resulted in the hypotheses H_1, H_2, H_3, and H_4 being supported.

4. Conclusions

A questionnaire survey was carried out with 128 respondents to assess consumer acceptance of AVs. The aim of this research was to explore whether behavioral intention to use is influenced by, and thus whether there is a relationship between, these factors. A correlation analysis was conducted to explore the relationship. The correlation analysis resulted in the strongest relationship between BIU and SI (r = 0.649; $p < 0.01$), suggesting that social acceptance and status associated with the use of AVs have a significant influence on intention to use. A positive strong relationship is observed between BIU and PU (r = 0.516; $p < 0.01$), suggesting that consumers who find AVs more useful are more likely to use them. The positive significant relationship between BIU and PEU (r = 0.334; $p < 0.01$) may be due to the fact that those who find it easy to use these systems and who would easily become tired of using them would also be more likely to be more willing to use them. Furthermore, a positive relationship was observed between BIU and PT (r = 0.325; $p < 0.01$); thus, confidence to use the system also positively influences intention to use. For

these reasons, we recommend that developers and car manufacturers strive for simplicity of use, easy transferability, and ease of use of the system, as it can increase the intention to use it. Furthermore, we recommend informing consumers about these new systems, as they are generally reluctant to embrace this new technology and are not aware of the potential safety or convenience benefits. Although the survey is focused on users mainly in their capacity as drivers, future studies should also involve pedestrians, because this is a very important aspect of interacting with an AV. Additionally, a number of environmental factors could exist that might influence user behavior, for example: structural aspects of roads, weather conditions, and social norms. A limitation of this research is that, despite the results showing a significant relationship, the sample number could be increased.

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