Udvari B. (ed) 2020: Proceedings of the European Union's Contention in the Reshaping Global Economy. University of Szeged, Doctoral School in Economics, Szeged, https://doi.org/10.14232/eucrge.2020.proc.3

What drives you to use a driverless car? An investigation of behavioral intention and its influencing factors

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The investigation of driverless car from the economic perspective is one of the most discussed topics nowadays. Although it can be approached from various perspectives there is still a lack of studies focusing on the behavioral intention to use self-driving cars and its influencing factors. Over the last few decades, various psychological models have been developed to investigate the influencing factors of usage of certain technologies, but most of them cannot provide clear answers on consumer attitudes and intentions with regard to autonomous vehicles. Thus, new models have appeared to better describe the psychological factors of this new technological development that will revolutionize the future of mobility.

In our research CTAM (Car Technology Acceptance Model) was used to measure intention to using self-driving cars. In 2019, 314 participants responded to our questionnaire and provided answers to the given questions. We used structural equation modelling to investigate the linkages between the behavioral intention and influencing factors revealed during the literature review. According to the results, the most important influencing factors of intention are attitude, perceived safety and social norms, while anxiety (of using the technology), effort expectancy, performance expectancy, and self-efficacy have not been proven important factors. The model used in our investigation explains behavioral intention to a great extent (63%).

Keywords: self-driving car, consumer behavior, technological acceptance, intention, autonomous vehicles

1. Introduction

There is no doubt that we are facing a revolution in mobility, and the progress of development of autonomous vehicle technologies is faster than we have ever seen. Since the technology is almost on the market, there is a need for theoretical models that can investigate user acceptance of such technologies, and for research that investigate user attitudes towards driverless cars and allows us to understand the influencing factors of this car-related technology.

Davis (1989) developed the Technology Acceptance Model that provided a theoretical basis for almost all models that have been created in recent decades in this research field. This explanatory framework contributed a lot to better understand user opinion on various technologies and to present a wider set of possible associations (Ghazizadek et al. 2012). Nordhoff et al. (2016) suggest that user acceptance greatly depends on multiple psychological, situational, and socio-economic factors that emphasize that user intention and behavior is highly influenced by various factors and circumstances. Thus, there is a need to investigate these trends and their impact on vehicle users, including both passengers and drivers.

This study comprises four main sections. The next two sections demonstrate briefly the literature review focused on driverless cars and the theoretical model applied in our investigation. The third section describes the research method, including the research question, the collection of data and the characteristics of the sample. The fourth section provides a comprehensive overview of the research results, including both descriptive statistics and influencing factors of intention to drive driverless cars, while the fifth section summarizes the results and the consequences of the paper.

2. Literature review

In our study we focus on the driverless car and investigate user acceptance towards this technology with a theoretical model. Thus, we give a short introduction to research that has studied attitudes relating to self-driving cars, and provide a brief overview of theoretical models focusing on technology acceptance.

2.1. Driverless cars

The appearance of driverless cars could revolutionize mobility in many respects. Thus, we wish to highlight some research on this topic. Nielsen and Haustein (2018) investigated the attitudes towards driverless cars in Denmark. Three clusters were identified among the 3,040 respondents in regard as traditional and driverless cars. These clusters are the following:

- sceptics (38%)
- indifferent stressed drivers (37%)
- enthusiasts (25%)

According to the results, the clusters differ by their sociodemographic attributes. While the enthusiasts are mainly young men with a higher educational level who live in cities, the sceptics depend to a large extent on their car, their age is higher than the average in the sample, and they live in smaller towns or/and villages. These results suggest that young men of higher income express greater interest in and openness for driverless cars than the elderly generation in rural areas.

Another research also investigated the attitudes towards driverless cars, but it was conducted internationally. The survey was carried out in 109 countries and 5,000 respondents participated. The research aim was to better understand user acceptance, concerns about, and intention to purchase driverless cars (Kyriakidis et al. 2015). According to the research results, traditional cars with manual transmission provide maximum driving experience for the driver. Furthermore, 22% of the respondents would not be inclined to pay more for a driverless car than for a traditional car, however 5% of the participants would pay more than 30,000$ for a fully automated vehicle. The research also highlighted that the respondents were concerned mostly by software hacking incidents, legal and security problems. The research investigated the impact of age and gender, however the differences were slight and proved not to be significant in the research. However, male respondents did tend to be willing to pay more for driverless cars and were less concerned by driverless cars related fears.

A recurring issue in the area of autonomous vehicle is safety, which can be readily investigated in the case of automobiles and public transport vehicles. Some comprehensive research conducted in France approached this topic with qualitative and quantitative measures focusing on the perceived safety towards traditional public transportation vehicles compared to autonomous vehicles. According to the results, respondents perceive autonomous vehicles as safer in general, however they evaluate safety within the vehicle lower, because they cannot turn to the driver in case of need. Relating to these results, the research highlighted that female respondents would experience safety as being lower than male respondents. The research highlighted that one of the main barriers of introducing self-driving vehicles in public transportation is the low level of perceived safety instead of other factors (Salonen 2018).

2.2. Car Technology Acceptance model

As we reported previously, Technology Acceptance Model (Davis 1989) provided the theoretical framework for investigating user acceptance in the case of various technologies. In recent decades there have been many studies that refined the model and tailored it to different contexts resulting in more developed frameworks.

While Technology Acceptance Model (TAM) was originally developed for investigating the *perceived ease of use* and *perceived usefulness* in the case of personal computers at home and workplaces, TAM2 and TAM3 models were developed for other purposes due to the introduction of various technologies to the consumer market in the 1990s. While TAM2 model focused mainly on *perceived usefulness* and extended the original model with additional factors, like *subjective norms*, *voluntariness*, *image*, *job relevance*, *output quality*, and *result demonstrability* (Venkatesh–Davis 2000), TAM3 investigated *perceived ease of use* and its influencing factors: *computer self-efficacy*, *perceptions of external control*, *computer anxiety*, *computer playfulness*, *perceived enjoyment*, and *objective usability* (Venkatesh–Bala 2008).

As previous user acceptance models investigate user attitudes from various contexts in the case of various technologies in general, there was a need to develop a model with a special focus on driver acceptance towards in-car technologies. As a result, Osswald et al. (2012) provided a framework for investigating car-related technologies that can be applied in our study. It also built on other technology acceptance models, such as Unified Theory of Acceptance and Use of Technology (UTAUT) which emphasize the role of *performance expectancy*, *effort expectancy*, *social influence*, and *facilitating conditions* (Venkatesh et al. 2003).

The Car Technology Acceptance Model consists of 7 factors that can be interpreted in the case of car-related technologies. These factors are the following: *attitude towards the technology*, *perceived safety*, *social influence*, *performance expectancy*, *effort expectancy*, *anxiety*, *self-efficacy*, and *facilitating conditions*. In our study we will use this model and its factors and validated scales to measure potential user opinion relating to driverless cars.

In the next section we will describe the methodology applied in our study.

3. Methodology

In this paper we describe the survey that we carried out in Hungary and its results. The methodology describes the following topics: research question, research method, and the sample. This chapter provides a comprehensive overview of the research and its circumstances.

3.1. Research question

The aim of the research is to investigate the determining factors of intention to use a self-driving car in the future. Although there are various models for investigating behavioral intention, we used a Car Technology Acceptance Model (CTAM) to test various factors in our study. Thus, our research question is: *what factors play the most critical role in the behavioral intention to use a driverless car?* Although driverless cars are not available although similar but less developed technologies are already on the market, we measure the behavioral intention in the context where users cannot experience the technology but can express an opinion about it. This could be a limitation of our study.

We determined 3 hypotheses in order to test our theoretical model. These hypotheses focus on the whole model itself, safety, and anxiety:

H1: The Car Technology Acceptance Model explains to a great extent intention with the factors investigated.

H2: Anxiety plays an important role in intention.

H3: Safety plays an important role in intention.

H1 focus on the model and provides information on the extent to which factors describing the respondents' opinion about driverless cars can be investigated. This is an important hypothesis because it can give a clear answer on whether the model is useful or not. Meanwhile, H2 and H3 provide information about more psychological-related fears towards driverless cars. Anxiety during using the technology and safety are important factors, thus these 3 hypotheses will be tested.

3.2. Research method

In order to answer the research question, we developed a questionnaire based on the literature review. The questionnaire consists of various questions which were partly adopted from previous studies, whilst some of them were developed by ourselves. The next figure demonstrates our model:

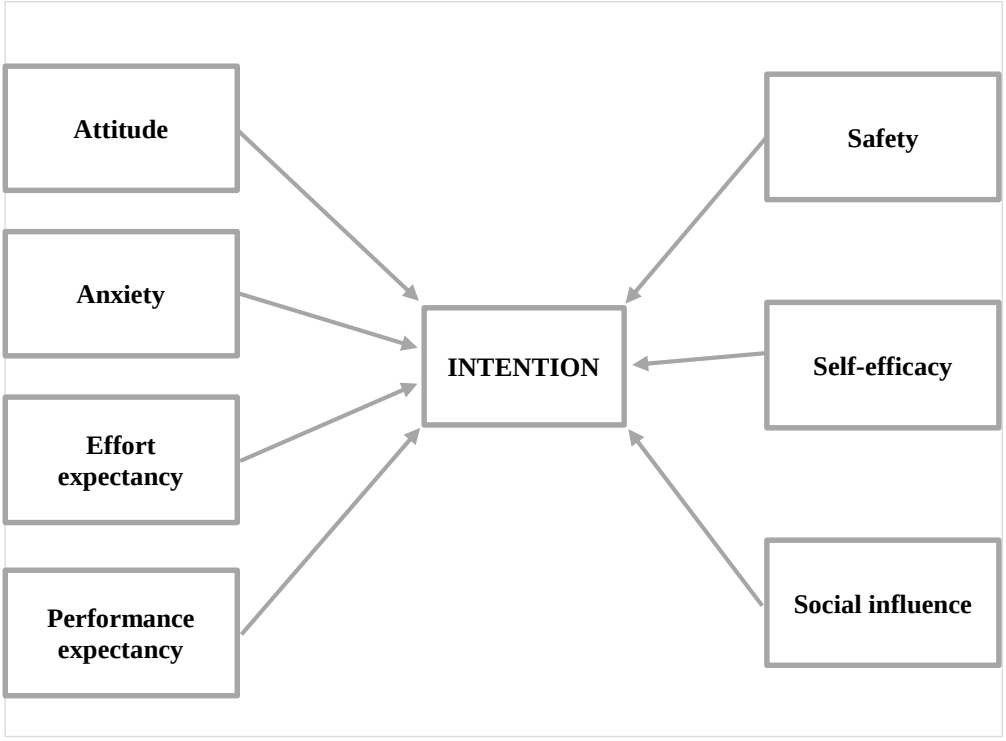
The questionnaire was distributed among students at the faculty of Economics and Business Administration at the University of Szeged and to users of social media channels. In the case of the students, the links of the questionnaire were uploaded to an educational platform on which students have access to teaching materials. Participation in the survey was voluntary and anonymous.

The responses were recorded online and the raw database was exported to Microsoft Excel. The database was cleaned and coded in IBM SPSS Statistics 20 software and was also exported to a .csv format. This database was also processed by SMART PLS 3.0 software to investigate the relationship between different factors.

While IBM SPSS Statistics was used to demonstrate the descriptive statistics of the results, SMART PLS allowed us to gain a better understanding of the influencing factors with partial least squares structural equation modeling (PLS-SEM).

In order to test Car Technology Acceptance Model, structural equation modeling (SEM) was applied, which enabled us to simultaneously investigate the influence of the relevant factors on intention to use driverless cars. Along with the development of more specialized statistical methods, the application of SEM in the field of strategic management has expanded rapidly in recent decades (Shook et al. 2004). SEM represents an extension of general linear modeling (GLM) and allows scholars to investigate latent structures measured by multiple variables. This technique is widely used for testing hypothesized models (Lei–Wu 2007), a term which refers to a variety of statistical models including covariance-based structural equation modeling (CB-SEM) and partial least squares structural equation modeling (PLS-SEM). While the former is the most widely used version of SEM, in many cases scholars are not aware of the disadvantages and application conditions of this technique, such as sample size, equal distribution, etc. In contrast, PLS-SEM is more applicable because it can be used on small samples and uneven distributions of variables as well (Hair et al. 2012).

Figure 1 Our hypothesized model



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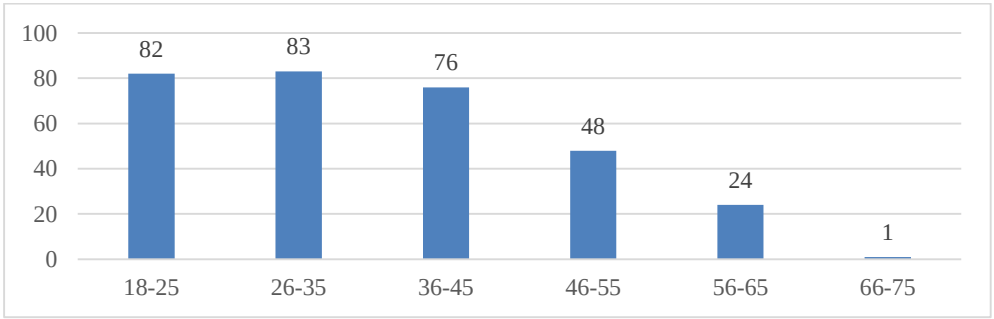
3.3. The sample

In this section we provide a comprehensive overview of our sample from two perspectives. Firstly, the demographic attributes of the respondents will be demonstrated, secondly, the habits and preferences of the respondents will be described in general in order to better understand participant characteristics.

The promotion of the research at the University and through social media channels resulted in *314 valid responses*. The gender distribution in our sample is quite representative, since 52% male (163) and 48% female (151) respondents participated in our survey. Regarding age, most of the respondents were between 18–45 years.

Figure 2 Age distribution



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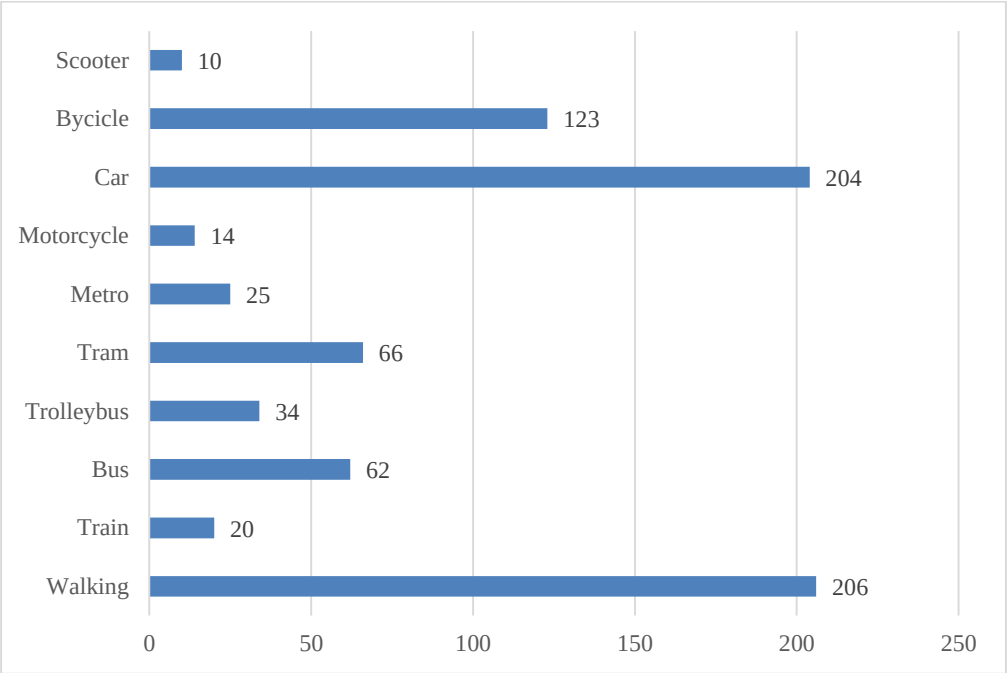
According to the level of education, only 1 respondent finished only primary education, and 89 participants had graduated from high school. The majority of the sample, 224 respondents had graduated from higher education, which is a quite high ratio. Regarding settlement type, 78% of the respondents lived in towns (including county towns as well), while 12% lived in the capital city. The rest, 10% lived in villages or smaller settlements.

84% of the respondents possessed driving license while 16% did not. 20% of the participants had 1–5 years of experience, 11% had 6–10 years of experience, while 46% had more than 10 years of experience in driving. 23% of the sample did not answer this question or do not have driving license.

43% of the participants drove regularly (137), while 27% of them drove weekly. 30% of the respondents drove less often or did not have driving license. 71% of the participants possessed or had access to a car they could use anytime.

We also asked the respondents to indicate which vehicle or services they used regularly (Figure 3).

Figure 3 Regarding mobility preferences



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4. Research results

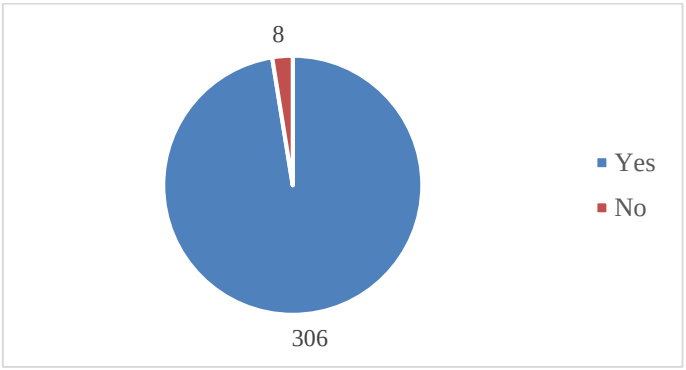
In this section we will provide a comprehensive overview of the research results consisting of the descriptive statistics of related topics and the Car Technology Acceptance model.

4.1. Awareness of driverless cars

This first topic is about the awareness of driverless car, and can be approached from two perspectives. Firstly, how many of the respondents are aware of the driverless cars, secondly, do the respondents gather information relating to driverless cars?

Firstly, respondents had to answer the following question: *„Have you ever heard about driverless car?"* Respondents had two options to answer: „Yes" or „No". 97% of the sample stated that they had already heard about these vehicles. This result contributes to the assumption that driverless cars are already well known in society, however, there is still a small proportion of people who are not aware of them or cannot associate this phrase with this particular vehicle.

Figure 4 Awareness of driverless car technology



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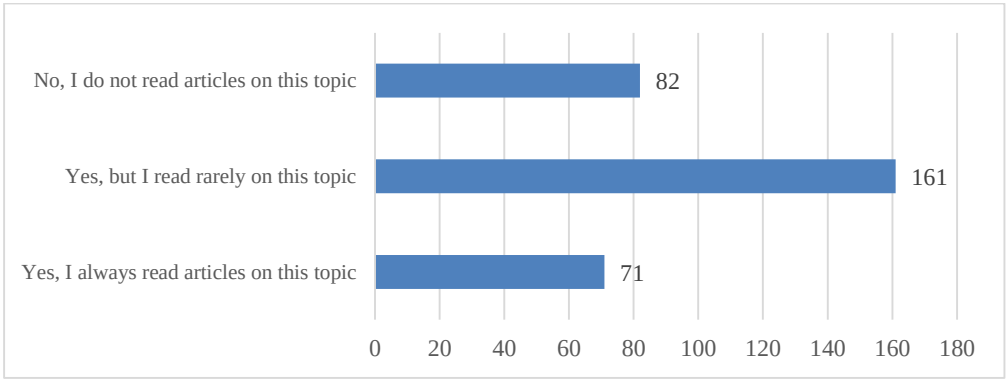
Although the large majority of respondents are aware of the driverless cars, there is still a question of whether they are actively seeking information about this technology or just passively receiving news relating to this topic? According to the results, around ¼ of the respondents regularly read articles on this topic while ¼ do not read about it at all. About half of the sample read articles about driverless cars but did so only rarely.

Figure 5 Reading articles about driverless cars



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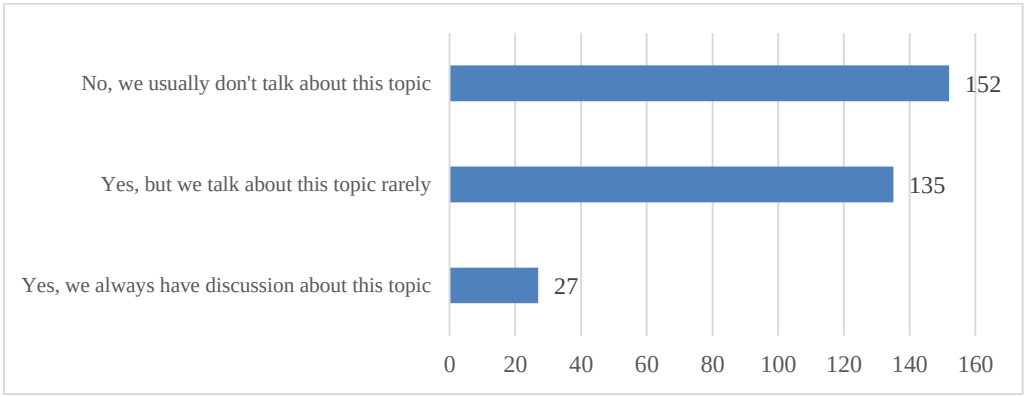
4.2. Social influence

The influence of peers, friends, and family members is a well discussed topic in social behavior. In this sub-section we asked respondents to provide information on whether they have any discussion with others about driverless cars and whether they perceive their social environment as being interested in driverless cars or not.

According to the results, 48% of the respondents do not talk to others about this topic while 43% of the sample does, but they do it rarely and only 9% regularly have discussions on the topic with others.

Figure 6 Discussion with others about driverless cars



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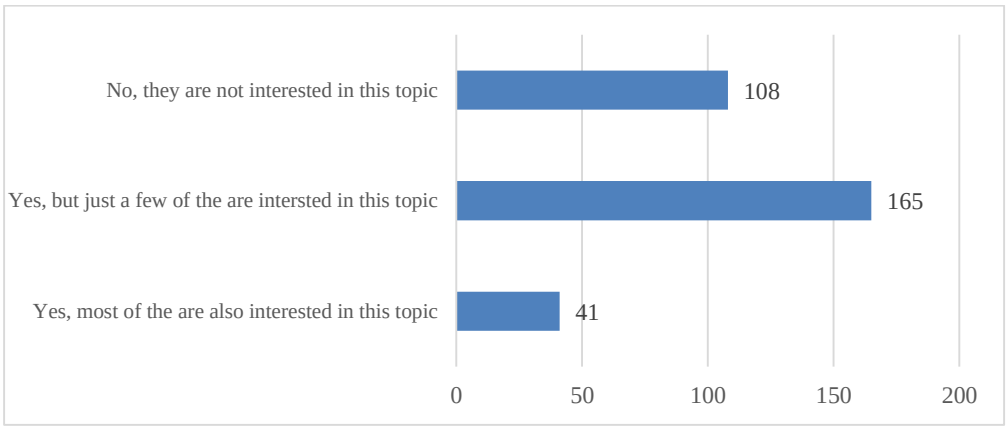
Another question investigates the interest of friends and family members towards driverless cars. According to the respondents, 34% do not perceive them as being interested in driverless cars while 53% do, but only in the case of few friends and family members. Only a small proportion, 13%, stated that most of their friends and family members are interested in this topic.

Figure 7 Interest of friends and family members towards driverless cars



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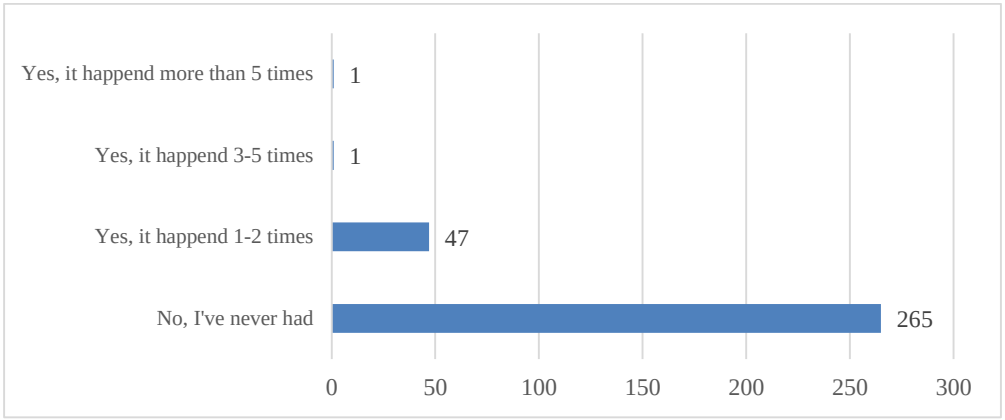
These results suggest that the driverless car is not a hot topic among the respondents, however a significant number of respondents talk about it rarely and a few of their friends and family members are interested in the topic. But just a small amount of them talk about it regularly and pursue interest towards this technology.

4.3. Safety

Safety is one of the most important aspects in the case of driverless cars because there is a general fear regarding car accidents caused by the technology which will shed a new light on traffic accidents. First of all, we asked the respondents to indicate how many car accidents had happened to them in the last 5 years. According to the responses most of the participants had never had any car accident, but around 15% of them had had 1–2 in the last 5 years.

Figure 8 Number of car accidents in the last 5 years



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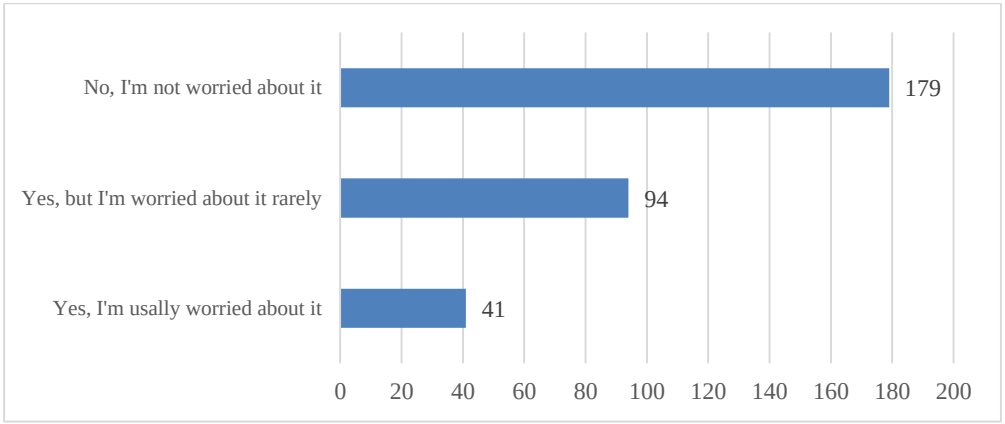
As we have seen, most of the respondents have not experienced any car accident in recent years. However, asking about their fears, almost half of the participants stated that they worry about car accidents usually or rarely (Figure 9).

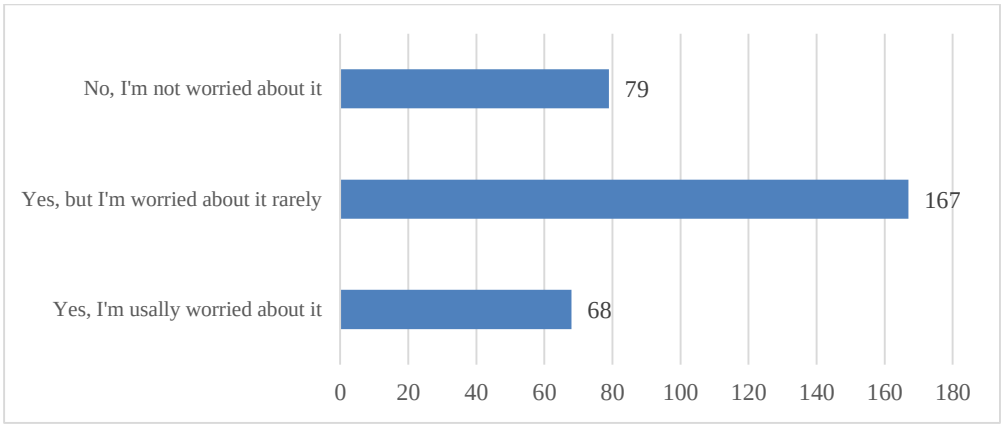
Figure 9 Number of respondents worrying about causing a car accident



Source: own construction

Another important aspect of safety is suffering a car accident caused by others. In the survey we also investigated this question, showing that respondents have greater fear of suffering a car accident caused by others since around 75% of them worry about it usually or rarely (Figure 10).

Figure 10 Number of respondents worrying about suffering a car accident caused by others



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According to the results, car accidents is an important topic even if just a small proportion of respondents have suffered car accident in the last 5 years. Most of the fear of suffering car accidents involves those caused by others rather than causing it themselves.

5.4. Car Technology Acceptance Model

In this subchapter we will investigate the influencing factors of behavioral intention. Intention plays an important role in human behavior since it is usually the trigger factor of actions. In this section we use PLS-SEM to investigate the linkages between the factors and intention. Firstly, we tested the scales used in our survey in order to check the quality criteria. This test was carried out in the case of four quality criteria, namely Cronbach's Alpha, rho_A, Composite Reliability, and Average Variance Extracted (AVE).

According to the results five out 8 factors, meet all quality criteria which are the Effort Expectancy, Intention, Performance expectancy, Perceived Safety, and Social Influence. Self-efficacy (0.699) and Attitude (0.669) does not meet the criteria level of Cronbach's alpha, however Cronbach's alpha in the case of these two factors deviates slightly lower below the quality level. Thus, we accepted these factors for inclusion in our model. However, Anxiety does not meet the criteria of Cronbach's alpha (0.560) and Rho (0.617) which makes the quality in the case of this factor questionable. Since the results do not differ remarkably from the quality level, and there is no strict rule regarding this, we ran the test in the case of all factors.

Table 1 Quality criteria

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Anxiety	0.560	0.617	0.764	0.523
Attitude	0.669	0.820	0.849	0.739
Effort expectancy	0.726	0.726	0.879	0.785
Intention	0.849	0.850	0.930	0.869
Performance expectancy	0.751	0.762	0.889	0.800
Perceived Safety	0.839	0.873	0.892	0.677
Self-efficacy	0.699	0.741	0.867	0.765
Social influence	0.793	0.801	0.878	0.706

Source: own construction

After carrying out the test we can observe that three out of the seven factors were proven to be significant in the case of intention to use driverless car technology (Table 1). According to the results, Anxiety does not show any remarkable relationship with intention, since its influence (β= –0.081; p=0.115) is quite low and represents a negative linkage with intention. This assumes that Anxiety from using this technology does not have any impact on the individual even if it exists. Although university students may fear the usage of the technology, they tend to use it and vice versa.

We can conclude the same in case of Effort expectancy, because there is no significant relationship towards intention (β=0.020; p=0.672). According to this result, we can suppose that those respondents who perceive significant difficulties in using the technology will also tend to use it in the future. The literature review found this factor to be an important barrier which can hinder usage of certain technologies, however – in case of driverless car – respondents show differing opinions towards the technology, thus the role of this perceptional barrier is not clear and does not influence their intention.

Performance expectancy wasn't found to be relevant either. According to the results, its effect is quite low and does not exert any influence on intention (β=0.034; p=0.551). One could assume that those people who do not believe in increased performance by using self-driving cars also tend to use this technology and vice versa, while the opposite is also true among these respondents.

The fourth factor which was not significant either is Self-efficacy. This construct does not exert any influence on intention (β= –0.025; p=0.546) however it is a widely used psychological factor in behavioral studies. In our case respondents with different levels of self-efficacy also tend to use the technology, whilst those respondents who expressed lower level of intention have different levels of self-efficacy.

Table 2 Impact of investigated factors on intention

			Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Anxiety	→	Intention	–0.081	–0.084	0.051	1.578	0.115
Attitude	→	**Intention**	**0.378**	**0.375**	**0.054**	**7.032**	**0.000**
Effort expectancy	→	Intention	0.020	0.018	0.048	0.423	0.672
Performance expectancy	→	Intention	0.034	0.032	0.056	0.596	0.551
Perceived Safety	→	**Intention**	**–0.222**	**–0.224**	**0.057**	**3.859**	**0.000**
Self-efficacy	→	Intention	–0.025	–0.023	0.041	0.603	0.546
Social influence	→	**Intention**	**0.269**	**0.269**	**0.056**	**4.829**	**0.000**

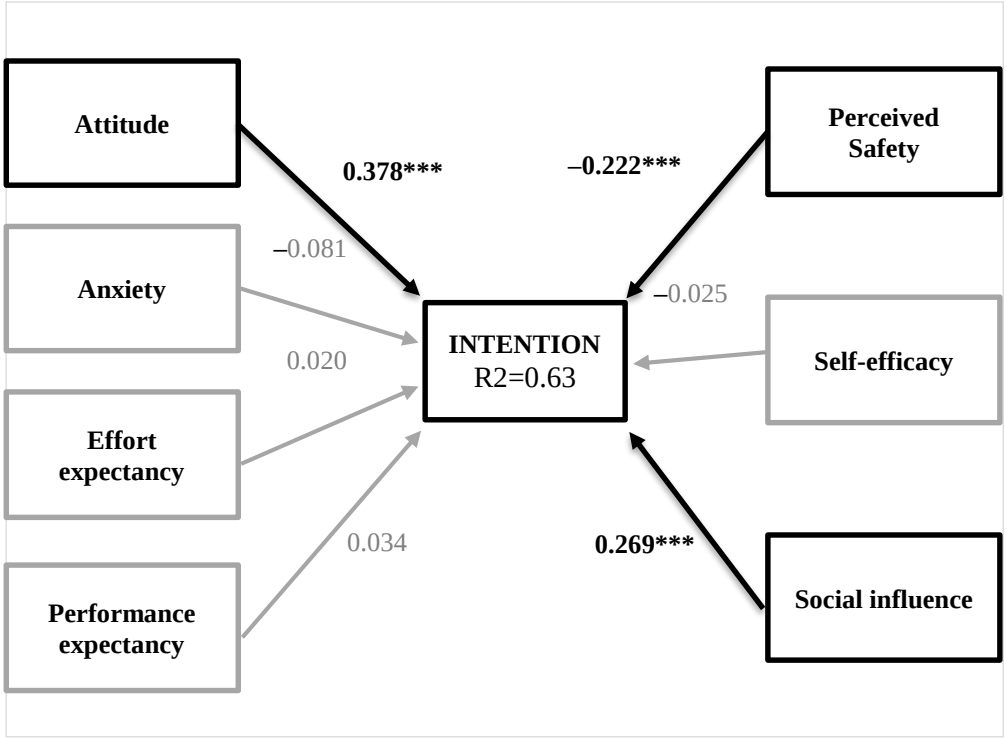
Source: own construction

There are only three factors which were proven significant in our model, and these factors exert strong influence according to the statistical results (see P Values in Table 2). Attitude plays the largest role in the trigger factors, from which it can be assumed that favorable positive Attitude contributes to higher propensity of intention to use the technology. In this case, general opinion regarding technology matters, increasing awareness and creating positive view in the target group, is really important.

Social influence exerts the second highest influence on intention, indicating that the opinion of friends and family members is also important for the individual in this topic. We can assume that if friends and family members express negative opinions relating to the technology, then they do not encourage – or deter – intention to use driverless cars, while those respondents whose friends and family members are supportive, would rather use it in the future.

Perceived Safety has proven the third determining factor in our model which can contribute to intention. These scales were negative scales in our survey thus negative relationship with intention represents that higher perception of danger will lower the propensity of intention and vice versa. If the respondents perceive driverless car as being safe (lower rate on Likert scale) then they will tend to use it in the future. Figure 11 demonstrates the linkages between the factors, Beta coefficients, and the results of the test of significance. This visual representation provides a comprehensive overview of the model with the results.

Figure 11 Impact of investigated factors on intention



Source: own construction

According to the results we can accept H1 and H3, however H2 has been proven as not important in our investigation.

	Hypotheses	Decision
H1	The Car Technology Acceptance Model explains intention to a great extent with the investigated factors.	accepted
H2	Anxiety plays an important role in intention.	rejected
H3	Safety plays an important role in intention.	accepted

6. Conclusion

In this paper we provided a brief overview of driverless car related research in the literature, and demonstrated a framework for scientific investigation. Although in recent decades, various psychological models have been developed for investigating user attitudes and intention to use certain technologies, hopefully these models will be improved in the future for other research purposes and technologies.

We investigated three important topics relating to driverless cars such as awareness, social influence, and safety. In addition, we used Car Technology

Acceptance Model to better understand the impact of the studied factors on user intention to use driverless cars. As the results showed, almost all respondents are familiar with driverless cars and most of them read articles on this topic regularly. Regarding the social influence, driverless cars are not a common topic in conversations with friends and families, however around half of the respondents stated that friends and family members express interest in autonomous cars. Furthermore, respondents have fears of car accidents. The study also investigated the impact of some factors on user intention to drive autonomous vehicles. According to the results, the most important factors are attitude, perceived safety, and social influence. These results suggest that those drivers who will tend to use autonomous vehicle have positive opinions about the technology, perceive the benefits of driverless cars, and receive encouragement from family members and friends to use self-driving cars. Regarding safety, those respondents who do not fear from potential risks of car accidents would engage with the technology. In sum, general opinion, peer influence, and safety play the most important determinants in intention. In order to foster the usage of driverless cars in society, companies should take steps to further improve safety, and communicate this to the target groups.

The respondents represented almost all age groups and the gender distribution was equal, however the distribution of the questionnaire took place mainly on social media channels, which could have had an impact on the results. In order to get more detailed insights into user opinion, further investigations should narrow down the target audience and focus on certain consumer groups who could afford driverless cars. That might lead to other conclusions.

Acknowledgments

The research was supported by the project entitled The aspects of developing a smart, sustainable and inclusive society: social, technological and innovation networks in employment and digital economy with identification number EFOP-3.6.2-16-2017-00007. The project is implemented with the support of the European Union, co-financed by the European Social Fund and the State of Hungary.

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