TALLINN UNIVERSITY OF TECHNOLOGY
School of Business and Governance
Department of Business and Economics

Aleksi Christian Parkkonen

UNIVERSITY STUDENTS' ATTITUDES TOWARDS SELF-DRIVING VEHICLES IN ESTONIA

Bachelor's thesis

Programme International Business Administration, specialisation Marketing

Supervisor: Giancarlo Pastor Figueroa, PhD
Co-supervisor: Susanne Durst, PhD

Tallinn 2021

I hereby declare that I have compiled the thesis independently
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The document length is 11 328 words from the introduction to the end of conclusion.

Aleksi Christian Parkkonen, 12.05.2021

Student code: 177768TVTB
Student e-mail address: a.parkkonen96@gmail.com

Supervisor: Giancarlo Pastor Figueroa, PhD:
The paper conforms to requirements in force

……………………………………………

(signature, date)

Co-supervisor: Susanne Durst, PhD:
The paper conforms to requirements in force
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(signature, date)

Chairman of the Defence Committee:
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TABLE OF CONTENTS

ABSTRACT

Self-driving vehicles have had major developments during the recent years and have the possibility of reshaping the whole transportation field in near future. A large part of the public has formed opinions and attitudes towards self-driving vehicles despite having limited actual experience with them, and these obtained opinions and attitudes greatly affect the acceptance of the new technology.

As limited data on the topic exist for Estonian population, this study aims to gather timely data about the knowledge levels, attitudes and expectations that the Estonian university students have regarding self-driving vehicles. The target group of the study is university students, as they are identified as the probable first adopters of the new technology, therefore providing the most useful and exact data on the subject. Empirical study is conducted, and an online questionnaire is created in Google Forms program to collect the data. Convenience sampling is used to gather the sample and descriptive statistical analysis and correlation analysis methods applied for studying the results.

Awareness about self-driving vehicles was found to be high among the respondents, but only about half of them indicated interest towards using the technology. Biggest advantages associated with self-driving vehicles were increased traffic efficiency and productivity during traveling while the main perceived disadvantages were cyber-security issues and reliability of the technology. Majority of the respondents believed that self-driving vehicles would see mass adoption in the next 5-15 years.

Keywords: Self-driving vehicles, autonomous vehicles, consumer attitudes, technology acceptance

INTRODUCTION

Self-driving vehicles have already been developed for many decades and have seen significant technological improvements during recent years due to the increased interest towards them from the industry, governments and the public (Mallozzi et al. 2019). Currently there are already various companies testing their self-driving vehicles on simulated environments (Vericav 2020), closed test circuits and even on the public roads (E-Estonia 2019) (Waymo 2021). Self-driving vehicles are projected to start seeing increased commercial use within the next ten years with public transport, shared vehicles through service providers and transport industry being the probable first adopters of the technology given its high initial expense (Litman 2020). Self-driving vehicles could possibly introduce many benefits including increased safety, traffic efficiency, environmental friendliness and improved access to transportation for everyone, but many risks are also present including increased traffic congestion, privacy and security concerns, new safety issues and wider social impacts (Nastjuk *et al.* 2020). Nevertheless, significant process has been made each year including technological advancements, large-scale tests and regulation changes which means that the autonomous revolution might not be that far away (KPMG 2020).

Estonia is a potential country for developing, testing and deploying autonomous vehicle projects and already has few companies with working products. The Estonian government is also committed to supporting the development of advanced driving technologies by adapting the legislation, investing in measures that help to attract both domestic and foreign companies and their investments and by testing the technologies in public projects. The existing experience Estonia has with e-government and digital state services is seen as an advantage for implementing and developing the new technology and self-driving cars as seen by the government as a way to increase the competitiveness of its transportation sector as well as a way to limit traffic accidents. Report on self-driving vehicles ordered by the Estonian government also noted that a change in attitudes is a major factor for the success of implementing the new technology. (Riigikantselei 2018)

It has been argued in previous research that even though the technology of self-driving vehicles still needs a lot of development, it is the user acceptance of the technology that plays a bigger part in determining the future success of self-driving vehicles (Panagiotopoulos, Dimitrakopoulos 2018). Since the technology has not gained widespread adoption yet, researching and understanding the public attitudes towards it and identifying factors that determine user acceptance for self-driving vehicles is needed to help increase the adoption of the technology (Xu *et al.* 2018). Attitudes have been found to predict actual use reliably by previous studies (Nastjuk *et al.* 2020) and timely information regarding them can therefore help direct future research and promoting activities significantly.

As university students are generally a younger demographic, are often interested in possibilities offered by new technologies, have a relatively high probability of obtaining a good level of income in the near future and often have greener values than the general public, they were identified as potential first adopters of the technology. As previous research shows support towards this assumption about these demographic factors positive affect on adoption of the technology (Acheampong, Cugurullo 2019; Gabrhel *et al*. 2020), they were chosen as the target group of this research.

Although the topic of publics attitudes towards self-driving vehicles is quite extensively researched in the world especially during recent years, very limited data on the topic is available that involves the Estonian population. The research problem identified was therefore the lack of recent info on Estonian university students' attitudes towards automated vehicles. The research focuses mostly on the self-driving vehicles that have the capability to transport people, like busses and cars, and how they are perceived from the end users' point of view.

The aim of the study was therefore to gather timely information of the awareness level and attitudes that the university students in Estonia have regarding self-driving vehicles. Due to the limited resources and smaller sample used, this research was mainly intended to be used as an exploratory study to gain initial understanding of the situation and to help direct future research on the topic, although it could potentially be helpful for policymakers and involved businesses as well. To reach the research aim the author chose to use the quantitative research method and created a structured online survey by using Google Forms online tool to gather data from the target audience. The following research questions were compiled to help reach the research aims:

RQ1: What is the level of awareness Estonian university students have at the moment regarding self-driving vehicles?
RQ2: What are the prevailing attitudes Estonian university students have towards self-driving vehicles?
RQ3: What are the expectations that Estonian university students associate regarding self-driving vehicles?

The research was divided into three main chapters, theoretical background, research methodology and empirical analysis. The first chapter introduces the concept of self-driving vehicles and the capabilities and limitations the technology has. The chapter also explores different consumer attitude and technology acceptance theories that were used to help create the research survey questions. The second chapter focuses on the research methods used in the survey and justifies why they were chosen. Third chapter includes the empirical part of the research and introduces and analyses the results gathered in the conducted survey. In the end the author makes conclusions based on the analysed data and provides suggestions for future research and recommendations for policymakers and businesses involved with the technology.

1. THEORETICAL BACKGROUND

The first chapter covers the theoretical background of self-driving vehicles as a phenomenon as well as few central theoretical models of consumer attitudes and technology acceptance. The term self-driving vehicle itself, often also referred to as autonomous or driverless vehicle, has some inconsistent definitions within the industry which might generate confusion. Generally accepted definitions that are also used in this research are that self-driving or autonomous vehicles (AVs) are able to move autonomously for a certain period of time and handle situations like emergency braking that require instant response themselves, but a human driver is expected to intervene if requested (level 3 automation and up, automation levels are further explained in Figure 1). Fully self-driving or autonomous vehicle is defined as a vehicle that is able to move autonomously without any human intervention in any conditions (level 5 automation).

1.1. The technology and development of self-driving vehicles

This chapter covers briefly couple of the important technological advancements and projects that helped to form the current self-driving vehicles, provides a quick overview of current situation in the world and in Estonia and explains the most common technologies used along with the levels of automation defined by the Society of Automotive Engineers (SAE), which are presented in Figure 1 (SAE 2018).

1.1.1 The history and current situation of self-driving vehicles in the world

Self-driving vehicles are not a new idea, as arguably the first concept in the form of the radio controlled "Phantom auto" built by Houdina Radio Control was demonstrated to the public in 1925 (Engelking 2017) and from those times people have been fascinated by the technology and the possibilities they could offer. Some of the first projects to feature a self-driving vehicle by today's standards were the Navlab and Autonomous Land driven Vehicle (ALV) in the 1980's, developed mainly by the Carnegie Mellon University along with other partners. These projects introduced technologies that are used in modern self-driving vehicles like lidar and autonomous steering control (Wallace *et al.* 1985). These projects were partly funded by the Defence Advanced

Research Projects Agency or DARPA, which is an agency under the United States Department of Defence and has played a big part in promoting the development of self-driving vehicles. For example, in 2007 DARPA organized the Urban Challenge which involved 11 teams representing major universities, some teamed up with big corporations, with the objective of navigating through a 96 km urban course that included other traffic while following California driving laws. The winning team of Carnegie Mellon University completed the course in 4 hours and 20 minutes in a 2007 Chevy Tahoe and claimed the main prize of 2 million dollars (Schedel 2008).

Around the 2010s self-driving vehicles had caught the attention of many big corporations in the technology and automotive field and companies like Google, Mercedes Benz, BMW, Volkswagen Group, Toyota, General Motors and many more started to develop their own technologies and projects (Tirumalapudi, Vedaraj 2020). During the last ten years there have been many successful fully autonomous projects completed and many million kilometres covered without human involvement which has not only helped work towards the vehicles of the future but also helped to developed technology that has made todays vehicles safer e.g., different driver assistance systems (Mora *et al*. 2020).

Regardless of companies testing their self-driving vehicles on the public roads and some like Waymo even utilizing SAE level 4 vehicles to provide transportation services to the public, there are currently no self-driving vehicles (SAE $\geq$3) that would be widely available for consumers to purchase. Honda has recently launched a version of their Legend model with certified level three autonomous driving technology, but only 100 cars will be made initially which will only be available on the Japanese market as a lease sale. The situation is expected to change in the near future as other manufacturers like Mercedes-Benz are also planning to launch their self-driving vehicles in 2021. (Sugiura 2021)

Waymo (subsidiary of Alphabet Inc) is concidered as one of the frontrunners in the industry as they are one of the only service providers of publicly available rider-only transportation without a backup safety driver, offering the service currently in the Metro Phoenix area in the United States. Waymo has been developing and testing its technology for over ten years and uses vehicles like Chrysler Pacifica and Jaguar I-Pace as base vehicles, turning them into fully autonomous by installing their own equipment into them including lidar, radar, AI, cameras and an array of other sensors. Waymo is also developing an autonomous solution for moving goods called the Waymo

Via and is currently in the process of testing heavy duty trucks in the United States that are equipped with their self-driving technology. (Waymo 2021)

Tesla has become known in the automotive industry for thinking outside the box and introducing new technological inventions in their cars. On October 16, 2016, Tesla announced that all of their cars produced from that moment onwards will include the hardware needed for full self-driving capability. This hardware includes surround cameras around the car, ultrasonic sensors, forward facing radar and a powerful onboard computer that according to Tesla together provide a better view of the surroundings than any human driver could process. At the moment Tesla's cars are not fully autonomous due to regulatory reasons and ongoing process of gathering data to make the systems more reliable, but as the regulation adapts and Tesla becomes confident with the reliability of the system the fully autonomous capabilities can be activated by software update in the future. (Tesla 2016)

The public sector has also started to get involved in projects aimed to advance the technology and its acceptance. The SHOW project for example is aimed to promote the deployment of automated mobility in urban settings by organizing real life demonstrations across 20 cities Europe. The project is funded by the EU and includes 69 partners from different European countries and also collaborates with international organisations around the world. (UITP 2021)

1.1.2 Self-driving vehicles in Estonia

Estonia is already known around the world for its digitalization of public services and the Estonian government has also acknowledged the possibilities of self-driving vehicles and is committed to supporting their development on a national level (Riigikantselei 2018). At the moment the testing of self-driving vehicles is allowed on public roads in Estonia as long as there is an operator who can take control over the vehicle if needed either within the vehicle or remotely and takes responsibility in case of accident (Vahtla 2017).

One of the most known autonomous vehicle projects in Estonia is the Iseauto bus, developed in co-operation with the Tallinn University of Technology (Taltech) and Silberauto AS. The project was started in 2017 and features a small self-driving electric bus designed for low speed last-mile transportation. (Rassõlkin *et al.* 2018) The Iseauto bus has already been operational in multiple locations in Estonia as well as in Greece to gather data on how it performs in different climatic conditions (Taltech 2020).

Another big company focusing on AVs in Estonia is Starship Technologies with their self-driving delivery robot. The small robots are designed to deliver small packages and food within a 6 km radius utilizing pedestrian walkways to make the last mile delivery of goods faster and more affordable. The company was launched in 2014 and currently provides services in multiple cities in the United States, United Kingdom, Germany and Estonia, mostly focusing on providing the service at college campuses at the moment. The robots have completed over one million autonomous deliveries so far. (Starship Technologies 2021)

1.1.3. The technology of self-driving vehicles

When self-driving vehicles started gaining popularity a few different organizations aimed to define the different levels of autonomy, but the Society of Automotive Engineers 6 levels of automation quickly became the widely accepted industry standard. The levels range from 0 (no automation) to 5 (fully autonomous) and are presented more closely in the Figure 1below.

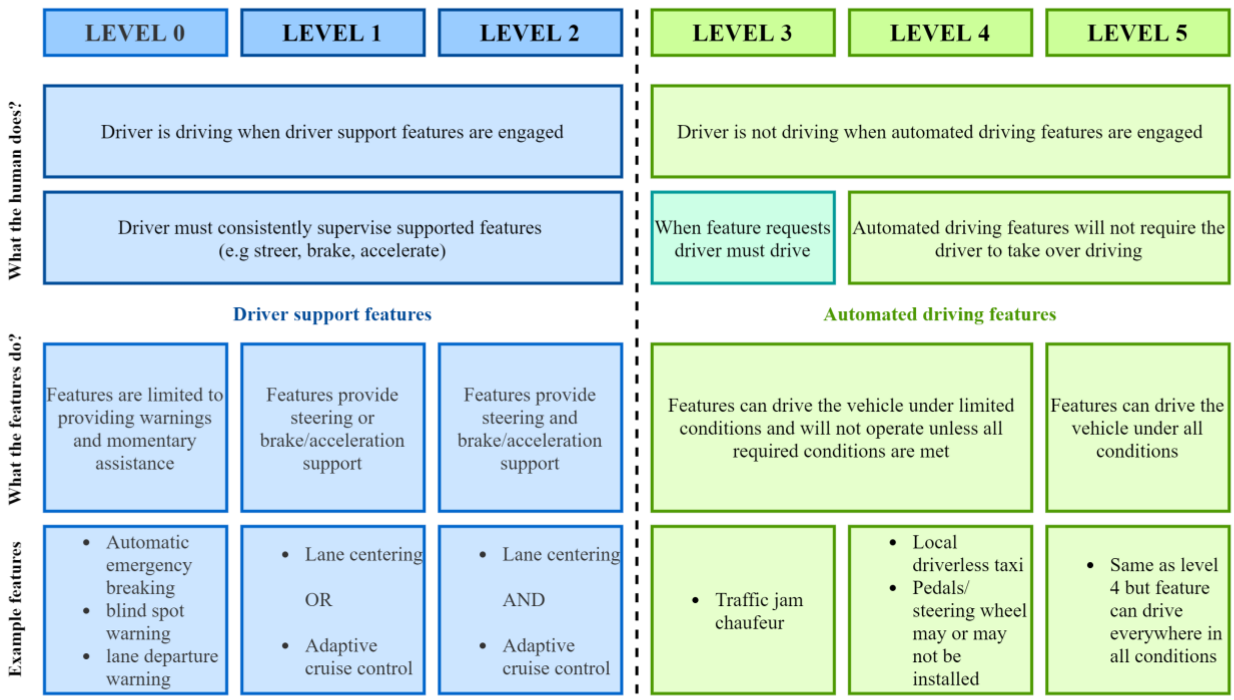

Figure 1. SAE J3016 Levels of automation
Source: SAE (2018), recreated by author.

Level 1 systems feature a single factor of assistance such as automated acceleration or steering in certain situations, e.g., adaptive cruise control. Level 2 features the ability for the system to take over both speed adjustment and steering in certain conditions, but a human driver is still expected to monitor the road and be able to take over control instantly if needed. In level 3 systems the vehicle is able to fully take over the driving, but human driver is expected to be able to take over control if requested. Level 4 vehicles do not require the human driver to take over control, but still have the possibility for manual driving and can be limited in where or under what conditions they can drive autonomously. Finally, level 5 vehicles are fully autonomous in all conditions and mostly do not even feature the possibility for manual override (no steering wheel or pedals). (SAE 2018)

The technology used in self-driving vehicles varies between manufacturers, but similar technology and sensor combinations are used in most of the projects. Some companies like Waymo have opted to attach their own technology onto an existing vehicle while others like Tesla have integrated the technology in the vehicle already starting from the design phase. The most common sensors include radar which uses radio waves to measure distance and speed of objects, lidar which measures range using laser technology, GPS which is a satellite navigation system that detects the cars position and different type of cameras that capture the surroundings of the vehicle and objects like traffic signs. (Figure 2)

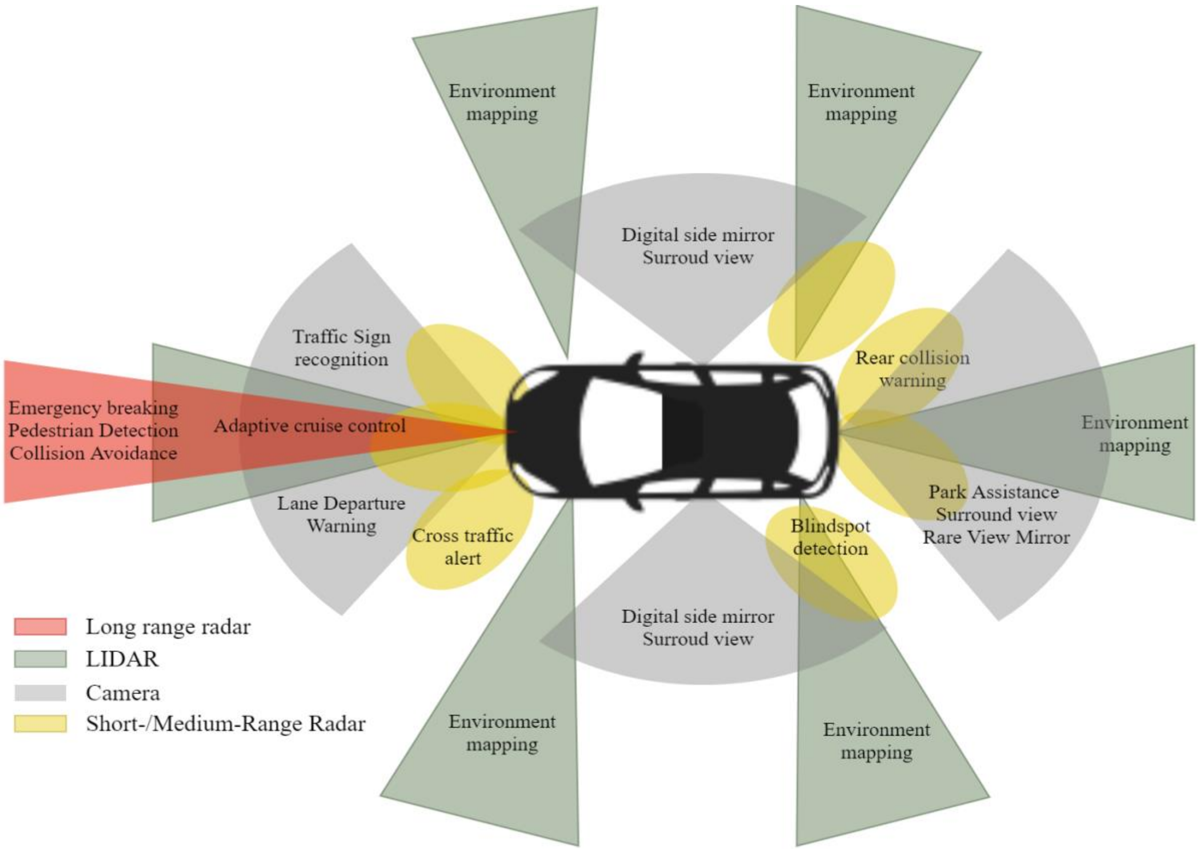

Figure 2. Overview of most used sensors in self-driving vehicles(varies between manufacturers)
Source: SAE (2016), recreated by author

One of the important new technologies related to self-driving vehicles is 5G network, which considerably increase the speed of communication over internet. One of the key elements of self-driving vehicles will be the ability to communicate and share data with each other, for which a fast and reliable connection is vital. This means that some features of AV’s may be limited in places where 5G is not yet available, but eventually self-driving technology could achieve a point where things like stoplights or speed signs are not even needed as vehicles are connected with each other and can coordinate their actions without them. (Wade 2020)

Majority of the self-driving vehicles have an electric powertrain as it is often easier to integrate with the autonomous technology and most of the manufacturers focusing on autonomous vehicles are either turning their focus towards producing more electric vehicles (EV) or are already only using electric powertrains in their products. As the battery technology improves over time bringing the costs of EVs down and new policies are implemented for limiting carbon emissions, this trend is unlikely to change (European Commission 2021).

1.2. Capabilities and limitations of self-driving vehicles

This chapter introduces the projected beneficial changes that self-driving vehicles might introduce to society as well as the possible limitations and risks that could be associated with the technology. Summaries of the advantages and risks associated with self-driving vehicles are presented in Table 1 and Table 2.

1.2.1 Advantages offered by self-driving vehicles

Self-driving vehicles are expected to bring many advantages over traditional vehicles including improved flow of traffic, environmental friendliness, better access to transportation for everyone and decreased costs of transportation but arguably the most important effect would be increased road safety. According to a study conducted by the National Highway Traffic Safety Administration (NHTSA), of a sample of 5 470 crashes investigated 94% were caused by human error, most common reasons being driver distraction, wrong driving speed and falling asleep behind the wheel (NHTSA 2015). Therefore, removing the human factor from traffic should bring significant safety increases which in turn would not only saves lives but also money as according to WHO traffic incident costs amount yearly to approximately 1-2% of nations GDP (Peden 2004). Of course, accidents would still occur as the technology will potentially introduce new risks and mixing self-driving vehicles and traditional cars with human drivers will be challenging but overall safety could still be improved especially through improved sensing and responding capabilities and by design philosophies that prevent reckless behaviour like disobeying traffic laws or speeding (Mueller *et al.* 2020).

Table 1. Self-driving vehicles potential benefits

Potential benefits introduced by self-driving vehicles	
User impacts	**Increased productivity during travel**: users can focus on things like work or entertainment during travel instead of driving. **Increased access to transportation for everyone:** transportation possibilities for people who cannot drive themselves for any reasons or can't afford transport would be improved. **More affordable transportation services:** savings from driver costs could potentially reduce prices of transportation services. **Less parking problems:** no need to park the vehicle at the destination, less stress on user, decreased parking costs, could even affect city planning.
Societal impacts	**Increased safety:** may reduce accidents through eliminating human errors like driver distraction and reckless driving. **Improved traffic flow:** connected self-driving vehicles could optimize traffic flow and reduce traffic jams e.g., by platooning. **Increased environmental friendliness:** through making transport more efficient and increasing electrification, noise and air pollution and the use of fossil fuels could be decreased.

Source: Composed by author

With private cars, self-driving vehicles could greatly increase the productivity during travel as the driving task would not require human input. This means that all the passengers in the vehicle could focus on working, sleeping or entertainment during travel and the interior of vehicles could also be designed to complement the new style of traveling. Parking problems would also be significantly reduced as the vehicles could drop off the passengers at their preferred destination and drive themselves to nearby parking area. As people would be willing to travel longer distances in self-driving vehicles due to the increased productivity, comfort and convenience, it could even lead to people opting to live further away from city centres where most workplaces are located and therefore reduce urbanization. In city areas self-driving vehicles could free space that is currently reserved for parking as they could drive themselves to more remote parking areas and car sharing programs could decrease the overall number of cars. (Anderson *et al*. 2014)

Although privately owned self-driving vehicles have many advantages over traditional ones, most nations and policymakers, including the EU, aim to decrease the level of private car ownership and rather promote the adaptation of shared mobility models and public transport with the help of self-driving vehicles as an alternative to individual mobility. As self-driving vehicles could decrease the cost of transport by eliminating driver cost and reduce travel times through improved traffic flow and efficiency, they could increase accessibility to transport for all people and therefore even promote social equity. With decreased costs, public transport networks could also be larger which would reduce the need for private cars. In addition to the environmental benefits that could be achieved through improved traffic flow, self-driving vehicles mostly rely on electric powertrains which are seen as a big factor in reducing emissions and therefore in improving the quality of life through cleaner air and preventing climate chance. If policymakers are able to create appropriate governance systems and limit the increase of private car travel to decrease traffic congestion especially in urban areas, self-driving vehicles together with supporting systems could create a more accessible, safer, efficient and environmentally friendly future of transport. (Alonso Raposo *et al*. 2019)

1.2.2 Limitations and risks posed by self-driving vehicles

As an innovative technology with fast development, the wider adoption of self-driving vehicles includes many different risks and unintended consequences that could negatively affect the acceptance towards them by the public. Risks associated with factors like safety, privacy and transport industry impact can be controlled by governments through implementations of different governance strategies but choosing the right methods can prove to be very challenging. Governments around the world are working to find strategies that balance between managing the risks while still allowing the development and testing of the technology without too many restrictions and hurdles. Concerns about governments ability to keep up with pace of innovations in the industry to perform timely responses are also present. (Taeihagh, Lim 2019)

Table 2. Potencial risks introduced by self-driving vehicles

Potential risks/consequences introduced by self-driving vehicles	
User impacts	**Cyber security and privacy issues:** who gets to see and use the data that is being constantly collected. Also, hacking could even lead to physical harm. **Increased costs of private vehicles:** self-driving technology is expensive and needs regular service which could potentially increase vehicle prices.
Societal impacts	**New safety issues:** accidents caused by system failures or users taking more risks. **Transport industry impact:** replacing human drivers with self-driving vehicles could significantly affect employment rate in transport industry. **Increased vehicle travel:** increased overall travel due to easier accessibility and reduced costs could introduce problems like increased congestion and pollution.

Source: Composed by author

Studies have estimated that even over 90% of vehicle accidents occur as the result of human error (NHTSA 2015). Although adopting self-driving vehicles could therefore potentially reduce significantly the number of accidents on the road, they can also introduce new safety concerns. As people both using self-driving vehicles as well as other drivers and pedestrians around them may feel safer due to the new technology, they could start taking additional risks e.g., reduce seatbelt use or be less cautious in traffic to compensate for the increased feeling of safety and therefore actually reduce road safety (Millard-Ball 2016). Additionally, even if accidents caused by human error could potentially be greatly reduced by self-driving technology, increased accidents caused by hardware and software problems would compensate the situation as the technology is much more complex than in traditional vehicles.

Self-driving vehicles are prognosed to significantly improve not only safety, but also time utilization, travel and energy efficiency as well as reduce travel cost through factors like saving on driver costs. With reduced costs both in money and time, overall travel is expected to potentially increase significantly and therefore lead to a rebound effect in regard to many of the perceived benefits. Significantly increased travel could lead to problems like net increase in accidents, congestion and pollution even though self-driven vehicles would decrease these issues at current travel levels. Policymakers therefore face the challenge of promoting self-driving vehicle implementation while at the same time addressing the potential unintended impacts they might introduce. (Taiebat et al. 2019)

One debated topic involving self-driving vehicles is how they should be programmed to function in unavoidable accident situations and who should assume liability for them. As self-driving vehicles lack the capability of subjective thinking, crash algorithms need to be programmed in the vehicles to determine how they react to moral dilemmas. The crash algorithms can be programmed to prioritise the passengers, which might lead to sacrificing other road users or they can aim to minimize all social losses, which may mean sacrificing the passengers to save more road users. The ethical behaviour of self-driving vehicles has a significant impact on their implementation and users' attitudes towards them, but so far widely accepted consensus has not been reached on the issue. (Coca Vila 2018)

How to divide the liability between the passengers, manufacturers and third parties involved in the design or operation of the vehicle is also unclear at the moment, but the responsibility will most likely shift towards the manufacturers and third parties as people become less involved with the driving and may not even have the possibility to override the system (Collingwood 2018). As safety and liability concerns can greatly affect the manufacturers reputations and users' perceptions about self-driving vehicles, some companies like Volvo have addressed the problem by accepting full liability for accident situations caused by their cars in autonomous mode (Gorzelany 2015).

As self-driving vehicles need to collect a lot of data to operate safely, concerns exist regarding with type of data exactly is collected and more importantly who controls it and what is it used for. Whether it is location data or even video that is collected from users of vehicles that provide transportation services, the data can lead to many unwanted consequences if not managed properly. In addition to privacy policies, cyber security becomes increasingly important with self-driving vehicles as not only could hackers gain access to a large amount of sensitive data but also to control the vehicle which could lead to serious physical harm to the passengers or other road users. (Dave *et al*. 2019; Lee 2017)

As with many other technological advancements that increase the possibility of automation in an industry, self-driving vehicles could pose a significant threat to current jobs within the transportation industry. As the driving task of physical taxi, bus or truck drivers is replaced by the new technology, companies in the industry are estimated to gain significant financial gain on the expense of decreased employment by saving on driver expenses. These obsolete lower skilled workers could have further negative impact on the whole job market, generating downward pressure on other low skilled occupations salaries as they look for replacement jobs and therefore increasing inequality in society. (Alonso Raposo *et al*. 2019)

The level of effect the risks mentioned in this sub chapter have largely depends on the governance strategies that policy makers adapt regarding self-driving vehicles. So far governments have avoided strict controlling policies and rather opted for more lenient guidelines in order to promote the development of the technology. As the technology is evolving fast, councils and work groups have also been created to keep up with the advancements and to help determine best governance actions. The actions taken to control self-driving vehicles risks also vary greatly between different nations due to the lack of international standards, so a lot of work is needed to properly manage the different risks while still allowing for self-driving vehicle development and implementation without too restricting control methods. (Taeihagh, Lim 2019)

1.3. Consumer attitudes and technology acceptance

This chapter looks into different models of human attitude and behaviour established during the years to predict their formation and to gain a better understanding on how they could be observed and influenced. The chapter also includes overview of technology acceptance theories to gain insight on what are the factors affecting adoption of new technology.

1.3.1 Attitude and behaviour models

Attitudes are a vital part of human identity and play a big part in our everyday lives. Attitudes have been studied extensively for a long time and have been a central part of social psychology since its beginning leading to many different definitions and theories established during the years. In one of the most known publications about attitudes, *The Psychology of Attitudes,* attitude is defined as “a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour” (Eagly, Chaiken 1993, 1). This definition includes the idea that expressing an attitude involves making an evaluative judgement about the particular issue or object. When attitude is regarded as an evaluative judgement, there are two ways it can vary. First variable is the direction of an attitude, as they can be neutral, positive or negative towards an object. Second variable is the strength of an attitude, as people can feel very strongly about a stimulus or be almost indifferent about it and anywhere between. (Haddock, Maio 2008, 114). One of the most known models for attitude is the multicomponent model (Eagly, Chaiken 1993), in which there are three different components that together lead to the formation of attitude: affective, behavioural and cognitive. The affective component refers to the emotional reaction that a given attitude component triggers in a subject, for example, many people fear snakes and the negative affection likely leads to a negative attitude towards snakes. There are many ways how feelings become associated with attitude objects and studies have also shown that there are many ways how the affective component of attitude can be deliberately altered. For example, a study by Zajonc (1968) showed that repeated exposure to a stimulus object enhances the persons attitude towards it. The behavioural component refers to the previous actions that people have had with a certain attitude object, as many studies have demonstrated that people often base their attitudes on previous actions (Bem 1972). The cognitive component is the persons beliefs or previously acquired knowledge about certain attitude object, for example reading reviews before buying a new piece of technology.

In addition to attitude models academics have also developed multiple models explaining the relation between attitude and behaviour with one of the first and most known ones being the theory of reasoned action (TRA) (Fishbein, Ajzen 1975). According to this theory, planned behaviour is determined by individual's intention, which in turn is determined by attitudes and subjective norms. In the model the attitude of a person consists of the expected consequence that the behaviour will produce as well as the value attached to the perceived consequence. Subjective norms on the other hand include the expectations of people around the subject (normative beliefs) and the subject's motivation to comply with these motivations. Later it was discovered that person's own opinion about whether they could perform the relevant behaviour, called perceived behavioural control, was also a significant factor in predicting behaviour, which led to a revised version of the theory called the theory of planned behaviour (TPB) (Ajzen 1991).

Overall, the theories concerning human attitudes and behaviour have concluded that attitudes are relatively effective at predicting behaviour and they can also be measured in sufficient detail. The many models developed also efficiently show how attitudes are formed and studies in the field have also found many ways how they can be affected (Haddock, Maio 2008, 112-133). The mentioned factors support the aim of this study to identify the attitudes that the target group associates with self-driving to find the prominent negatively perceived attributes of self-driving vehicles and with the help of the result possibly support the creation of campaigns that aim to change the given attitudes.

1.3.2 Theories of technology acceptance

Various models of user's technology acceptance have been developed over the years to help measure the acceptance of various technologies and enable comparison between different studies. The technology acceptance model (TAM) (Davis 1986) shown in Figure 3 is one of the first and most known information systems theories that was introduced by Fred Davis as an extension to the theory of reasoned action (TRA) (Fishbein, Ajzen 1975). The model identifies two major factors that affect users' decisions when they are presented with a new technology, those factors being perceived usefulness (PU) and perceived ease of use (PEU). PU refers to how much the adopting of the new technology will enhance the user's performance in certain activities or tasks. PEU reflects the user's belief of how effortless the use of the technology will be. Together these factors form the behavioural intention to use the technology which in turn affects actual use.

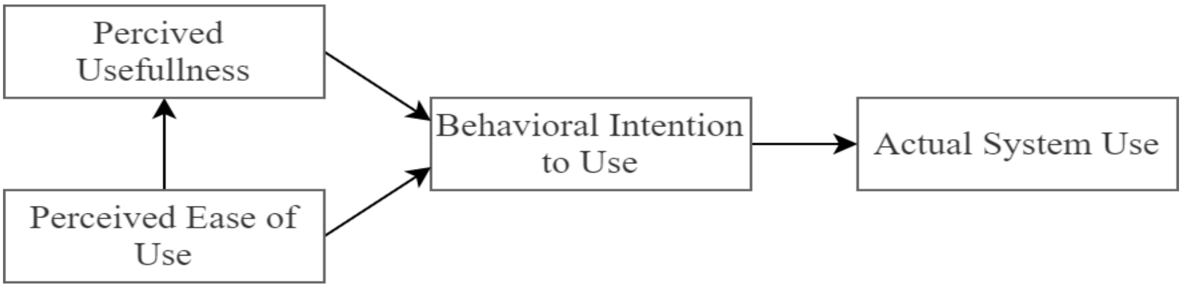

Figure 3. Technology acceptance model
Source: Davis (1986), recreated by author

In 2003 the unified theory of acceptance and use of technology (UTAUT) was formed as a successor to the TAM model by Venkatesh at al. (2003) by reviewing and combining many existing models of user acceptance. The four key factors of the UTAUT model are: 1) performance expectancy, how the users perceive the technology will increase efficiency; 2) effort expectancy, ease of use of the system; 3) social influence, the influence of other people's perceptions on the user's behaviour and 4) facilitating conditions, how the user perceives the infrastructural and organisational support for the system. The UTAUT factors can quite easily be applied to user perception of self-driving vehicles. For example, infrastructure created to support autonomous vehicles can create facilitating conditions, where users show higher acceptance towards self-driving technology (Hewitt *et al*. 2019).

The models mentioned and many others provide a strong base for assessing user acceptance and have been extensively used as reference in self-driving vehicle research. Despite the extensive research on the topic, there is yet to emerge a standardized model or questionnaire base for self-driving vehicle studies that would be widely accepted. Nevertheless, these models identify some common key factors that affect the acceptance of new technology like the ease of use, which in turn helps to create surveys and research that collect relevant and meaningful data on the subject.

1.4 Previous studies in the field

Although studies in Estonia regarding self-driving vehicles have been limited, the topic has gained a lot of academical attention globally especially during recent years. The technology of self-driving vehicles is still evolving and in need of development, but it is argued that user acceptance of the technology plays a more important part in determining the future success of self-driving vehicles than technological advancements (Panagiotopoulos, Dimitrakopoulos 2018). Since the technology is still new to the users, understanding their attitudes towards it and identifying factors that determine user acceptance levels is vital for the success of self-driving vehicles (Xu *et al.* 2018).

A research by Nastjuk *et al.* (2020) studied acceptance factors for self-driving vehicles utilizing qualitative research methods and research model based on the technology acceptance model. The study found attitude being a significant predictor of self-driving vehicle use intention, with the results being in line with previous work showing that positive attitudes generally lead to usage intention and therefore to actual use. It was also shown that perceived ease of use and perceived usefulness correlated with attitudes, therefore it was concluded that self-driving vehicle use is largely dependent on how useful and easy self-driving vehicle use is perceived to be by the users.

A review of over 200 previous studies related to public acceptance and perceptions of self-driving vehicles performed by Othman (2021) aimed to conclude the main trends related to the topic. The perception of safety and trust towards self-driving vehicles were found to have significant influence on the attitudes the public had towards them. The public acceptance of self-driving vehicles was also shown to decrease over previous years, as accidents involving them became presented in the media and increased fear levels towards them. The ethical dilemma of self-driving vehicles crash programming also has noticeable negative impact on perceptions, while previous experience with self-driving vehicles was found to have a positive effect on the attitudes towards them. For demographic factors young and higher educated males were found to be most positive towards self-driving vehicles with females being significantly more concerned about the risks associated with them.

Acheampong and Cugurullo (2019) studied the behavioural determinants behind self-driving vehicle adoption by creating conceptual frameworks based on previous models and testing them on a random sample of 507 Irish citizens. General perception of self-driving vehicles was found to be positive with majority of respondents expecting positive benefits from them and more than 80% of the respondents agreeing that technological advancements affect the society positively. Positive attitudes towards environment, collaborative consumption and technology were all found to correlate positively and increase the acceptance of self-driving vehicles while car ownership correlated negatively with pro-environment attitudes and therefore decreased the acceptance. External social environment was found to affect the perceived benefits and ease of use of self-driving vehicles as acceptance towards them was observed to increase if people saw their significant others or the larger population using them. Increased perceived behavioural control regarding self-driving vehicles was found to correlate with positive attitudes towards technology and therefore positively effect self-driving vehicle adoption. Concerning demographic factors, it was found that higher education correlates positively with supportive attitudes towards technology, collaborative consumption and environment and negatively with car ownership, therefore higher education increased people's acceptance towards self-driving vehicles. Females and older people were found to be more sceptical of the benefits and safety of self-driving vehicles and had lower acceptance towards them.

Liljamo *et al.* (2018) studied self-driving vehicle perceptions in Finland using a mail and internet survey with a sample size of 10 000 people. Majority of respondents perceived self-driving vehicles positively with following factors of higher education, living in city, younger age and not owning a car correlating positively with favourable attitudes towards them. Safety, reliability of the technology and moral questions were the biggest concerns among respondents while privacy questions were not a significant worry for respondents. Majority of respondents did not trust that self-driving vehicles could handle every situation by themselves and stated that possibility for manual override should always be present. People who currently did not own a car were more interested in higher levels of automation (SAE 4 and 5) while current cars owners showed more interest towards assisting systems (SAE 1 and 2). Majority of respondents were however found to be more interested in shared self-driving vehicles than privately own if they would be available with short notice and would have lower cost levels.

2. RESEARCH METHODOLOGY

This chapter gives an overview of how the research was planned and conducted, including the research methods used, questionnaire design and data collection and analysis methods.

2.1. Research plan and design

The aim of this study was to gather information on the perceptions and attitudes that the Estonian university students have towards self-driving vehicles. To gather a wider set of data in order to get initial understanding of the topic, primary quantitative research method of questionnaire research was used. Online questionnaire was chosen as the data gathering method for its convenience especially during current restrictions and Google Forms platform was used for designing the survey for its ease of use.

Convenience sampling was used as the sampling method, meaning that the author executed the selection of sampling units to reach the target population effectively. Convenience sampling was chosen as it is one of the fastest and most affordable method to reach cooperative and large enough sample size (Malhotra 2007, 341). The chosen method also has its limitations being a non-probability sampling technique and it is theoretically not meaningful to generalize the results to the population based on a convenience sample.

The survey planning started by developing question topics based on the authors research questions and background information gathered about the topic of self-driving vehicles. The questions were then developed with the help of attitude and technology acceptance models and theories introduced previously and by observing survey designs of previous research in the field relying on similar models (Manfreda *et al.* 2019; Acheampong, Cugurullo 2019) and adapting them to fit the aim of this particular study. Close-ended multiple-choice questions with either one or multiple answer options were mostly used with the addition of some five-point Likert scale questions and open-ended questions. A pilot test was conducted with the help of the authors few friends and family members and appropriate changes were made on the basis of the authors supervisors and pilot audiences' suggestions before the final survey was sent out.

The structure of the survey was kept simple and included the introduction of the research and questionnaire, main part with questions related to attitudes, expectations and awareness regarding self-driving vehicles and final part with questions related to demographic factors and transportation habits. Respondents were also presented with an opportunity to present feedback or questions about the survey in the final part through an open-ended question. Time that it took to complete the survey was tested to be about 5-10 minutes on average, which was considered to be an appropriate length to keep the respondents attentive and interested.

2.2. Collection of data

The survey was distributed mostly by using the authors own contacts and shared through different social media platforms like Facebook and WhatsApp. As the target group of the research was relatively narrow and finding respondents proved to be rather difficult, school staff was also contacted to get help with reaching university students in Estonia. Although TalTech school staff were kind enough to provide help by sharing the link through their channels, this method unfortunately proved to be rather ineffective as only a couple of percent of the people that received the survey link through email actually filled it out. The data collection period was one week from the 7^{th} of April to the 14^{th} of April 2021 and provided a total of 73 responses.

First question of the survey asked if the respondent was currently studying in an Estonian university or applied university, for which four people answered no. Therefore, the final sample size of the study and number of respondants in every other question in the survey was 69. Out of the 69 respondants, 30 were male and 39 female which represents quite closely the actual population of university students. The age groups of respondents are visualised below in Figure 4, which shows that most of the respondents were between 19 to 30 years old as is expected with university students, with the most popular age group being 22-24 years olds.

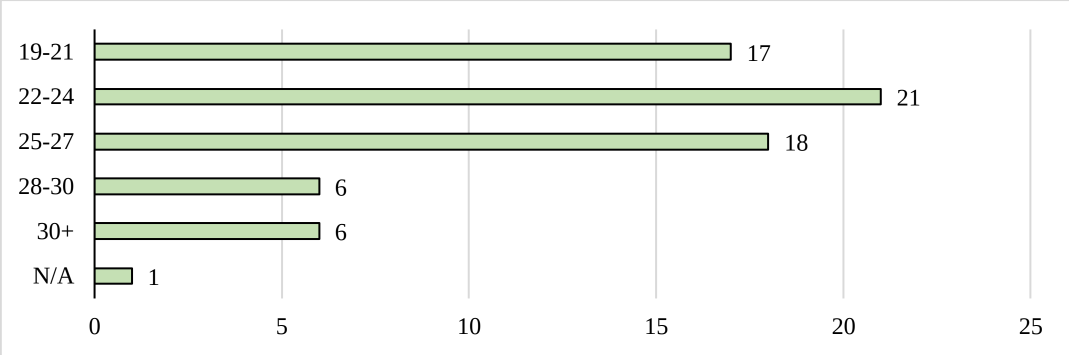

Figure 4. Age groups of respondents, n=69
Source: Composed by author

The questionnaire gathered answers from many different nationalities as the survey was also shared with international students studying in Estonia with the most common ones being Estonian (34 respondents), Finnish (19) and Nigerian (4). More detailed info on the nationalities of respondents is presented below in Figure 5.

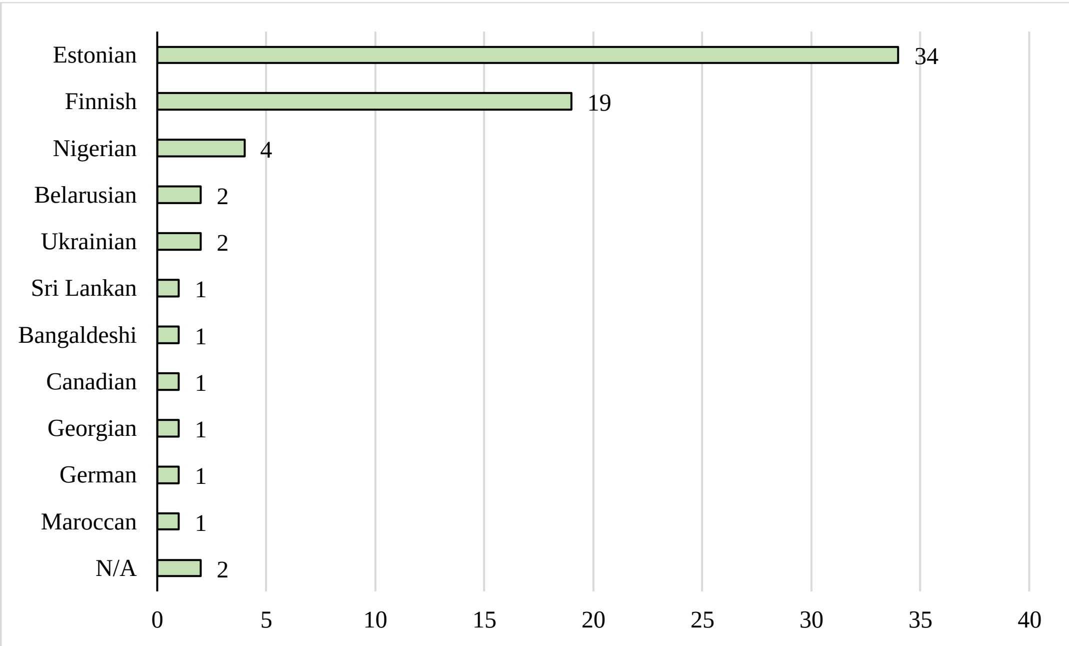

Figure 5. Nationalities of respondents, n=69
Source: Composed by author

Most common field of study for respondents was business with 44 answers, followed by social sciences with 10, engineering with 7 and other fields making up the rest of the answers.

2.3 Analysis of data

After the data collection period ended the gathered data was checked manually for any problems with the answers and then imported into Microsoft Excel for further analysis. By using the help of MS Excel, descriptive statistical analysis method was used to organize the data and create charts to help visualize the results. IBM SPSS was used for finding correlations between the statements about self-driving vehicles presented in Figure 11, for which the results can be inspected more closely from Appendix 2.

For finding possible correlations between statements, Spearman's rank correlation coefficient ρ (rho) was calculated for some of the data. Spearman's correlation is calculated with the ranks of the values instead of actual values, which makes it suitable for ordinal data like a Likert scale. Spearman's coefficient ranges from -1 to +1 with 0 meaning no correlation between the data and 1 or -1 meaning perfect correlation. Coefficient value of 0.10-0.39 shows weak correlation, 0.40-0.69 moderate correlation, 0.70-0.89 strong correlation and 0.90-1.00 a very strong correlation between the data. (Schober *et al*. 2018)

For the statements about self-driving vehicles (Figure 11), the Likert scale data was also converted to values according to the following scale: 1- strongly disagree, 2- disagree, 3- neutral, 4- agree and 5- strongly agree, in order to be able to calculate the average agreement levels for further analysis. Average values for agreement levels were calculated for all answers (n=69), as well as for male (n=30) and female (n=39) respondents answers separately to allow for comparison between the two groups (Appendix 3). Familiarity with the concept was also compared between male and female respondents in Figure 6.

3. EMPIRICAL ANALYSIS

The first part of the empirical analysis chapter presents the results of the survey by applying the descriptive statistical analysis methods and includes charts composed in MS Excel to help visualize the results. Second part of the chapter focuses on discussing the results, including comparison of the results to other related research, comparison of answers between male and female respondents as well as correlations between some of the answers to statements in the survey.

3.1. Results and analysis

The first question in the main part of the survey was meant to observe the awareness level that the respondents had of self-driving vehicles by asking them directly their own assessment of the familiarity they had with the concept. As seen in Figure 6 below, the knowledge level on the subject was relatively high according to respondents own assessment as 43 of respondents stated that they were at least moderately familiar with the concept and every participant had some knowledge of the concept. Answers between male (n=30) and female (n=39) respondents were also compared which revealed higher awareness levels amongst male respondents as most of them were moderately familiar with the concept while most popular answer for females was slightly familiar. Of the 69 respondents 6 had had the possibility to test self-driving vehicles in person.

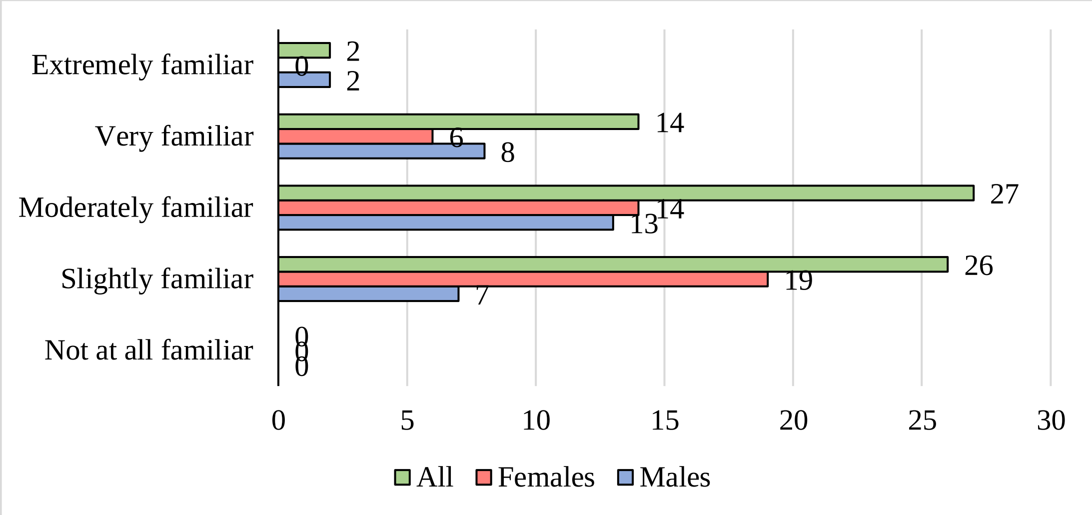

Figure 6. Respondents familiarity with the concept of self-driving vehicles, n=69
Source: Composed by author

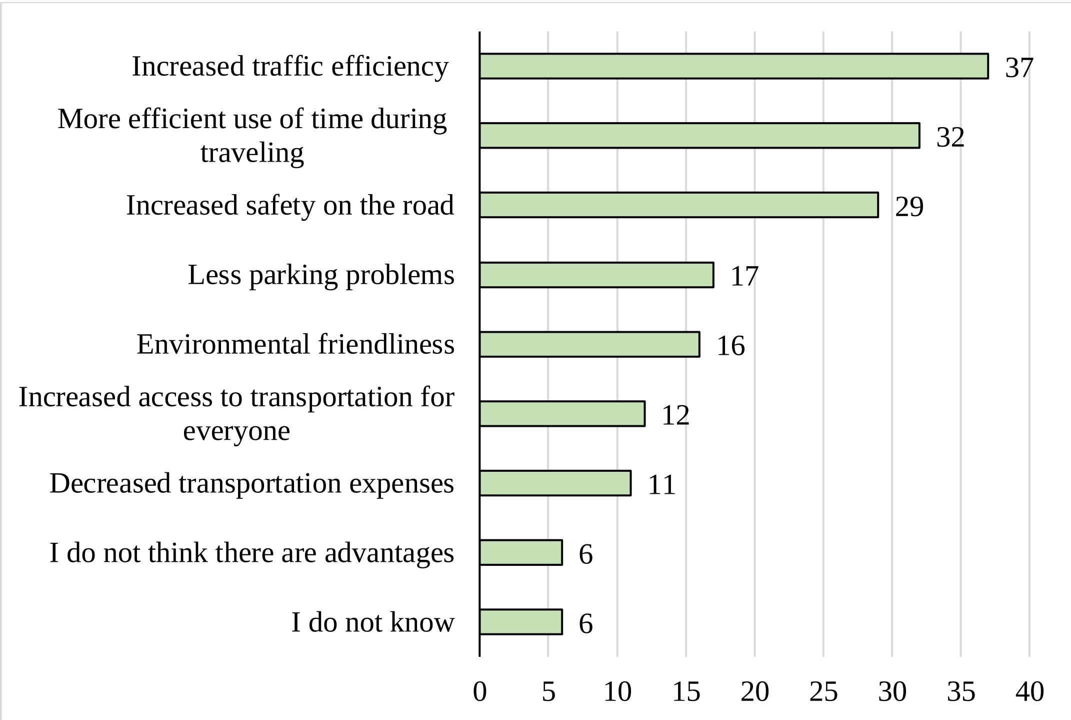

Figure 7. Advantages associated with self-driving vehicles, n=166
Source: Composed by author

The respondents were asked to assess the biggest advantages that could be achieved with the use of self-driving vehicles by choosing from a list with the advantages most commonly associated with the technology and the result can be inspected from Figure 7 above. The respondents were asked to choose up to two options that they associated the most with self-driving vehicles, but some of the respondents chose more than two bringing the total number of answers to 166. The most commonly associated advantage with self-driving vehicles was increased traffic efficiency with 37 answers, followed by more efficient use of time during travelling (32 answers) and increased safety on the road (29 answers). Less parking problems and environmental friendliness got 17 and 16 answers and decreased transportation expenses and increased access to transportation were the least chosen advantages with 12 and 11 answers. 6 of the respondents thought self-driving vehicles have no advantages and 6 could not answer.

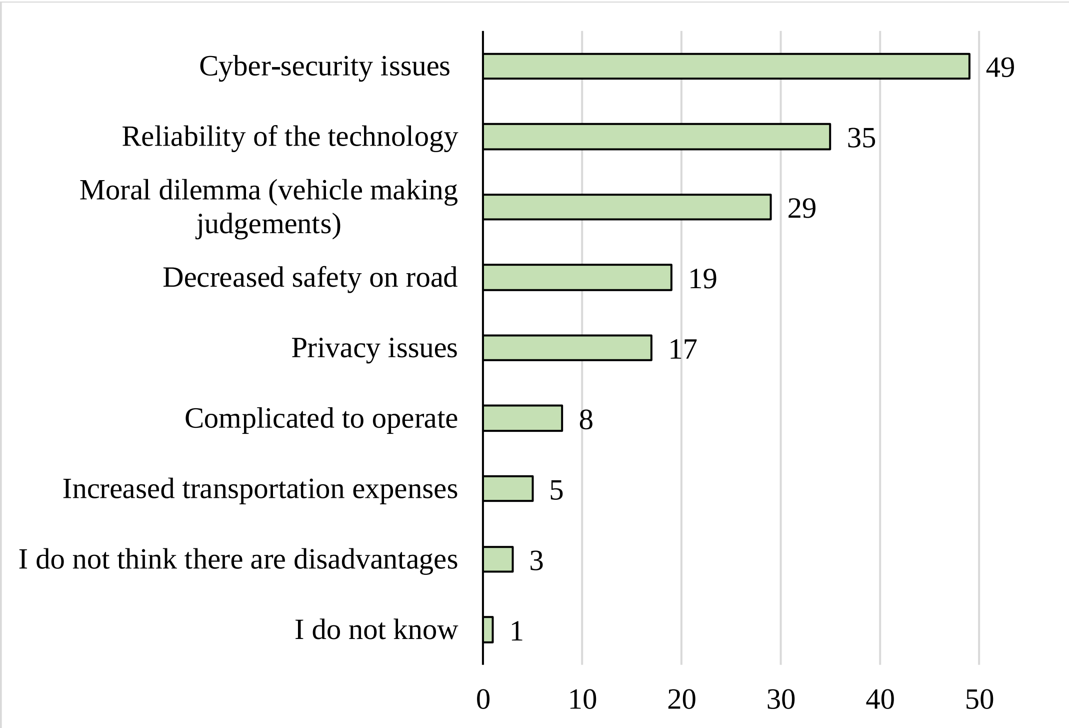

Figure 8. Disadvantages associated with self-driving vehicles, n=166
Source: Composed by author

The perceived disadvantages were asked with the same type of question as in the previous question and respondents were again asked to choose two options that seemed most fitting to them (total number of answers again 166). The data presented in Figure 8 shows that respondents were most concerned about cyber-security issues with 49 answers, reliability of the technology with 35 answers and with the moral dilemma of vehicle making judgements in difficult situations (29 answers). Decreased safety on road represented gathered 19 answers and privacy issues 17 answers with ease of use and increased transportation being the least chosen options with 8 and 5 answers. Only 3 answers were that there are no disadvantages associated with self-driving vehicles and 1 respondent did not know how to answer.

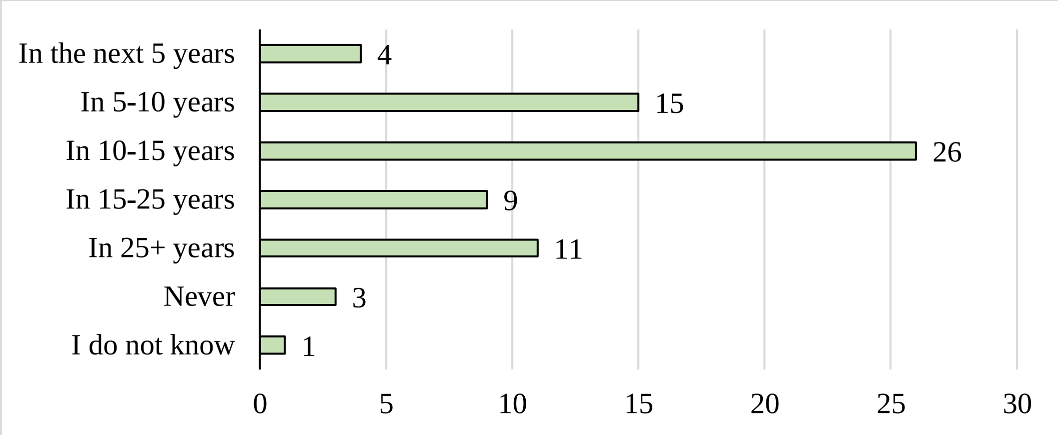

Figure 9. Respondents estimation of when self-driving vehicles will reach mass adoption, n=69
Source: Composed by author

In Figure 9 we can see how long the respondents expected that the mass adoption of self-driving vehicles will take. Most popular answer for this question was 10-15 years with 26 answers, followed by 5-10 years with 15 and over 25 years with 11 of the answers. Nine respondents predicted the mass adoption to happen in 15 to 25 years, four in the next 5 years, 3 believed they will never see mass adoption and one respondent did not know how to answer.

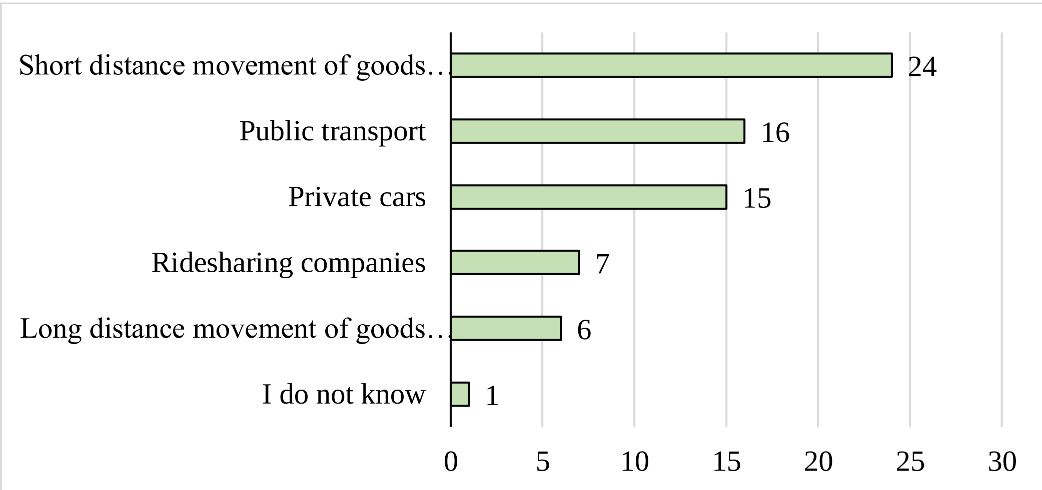

Figure 10. Expected first field of transport to adopt self-driving vehicles, n=69
Source: Composed by author

The respondents were also asked what field of transport will be the first to extensively adopt self-driving vehicles in their opinion. Figure 10 shows that short distance movement of goods (last mile) is considered as the first field to adopt self-driving vehicles by biggest group of respondents with 24 answers. Public transport (16 answers) and private cars (15 answers) were next options and ridesharing companies and truck transportation gathered 7 and 6 answers respectively.

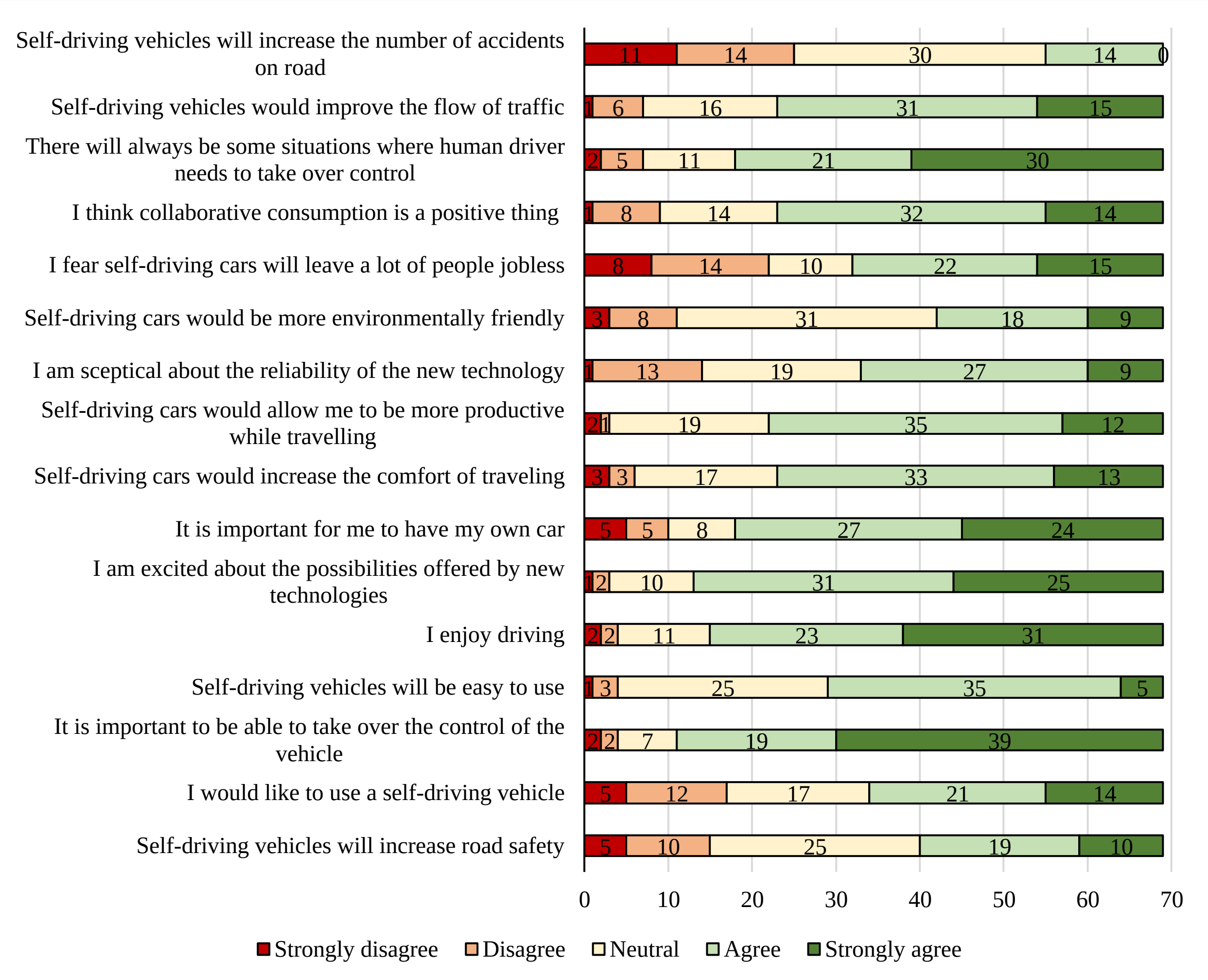

Figure 11. Respondents agreement levels regarding Self-driving vehicle statements, n=69
Source: Composed by author

The respondent's attitudes towards self-driving vehicles were measured by gathering data on the agreement level the respondents had with the statements presented in Figure 11. A five-point Likert scale was used for the option choices including strongly disagree, disagree, neutral, agree and strongly agree. The respondents mostly agreed with the statements about the advantages of self-driving vehicles, e.g., only 7 respondents disagreed or strongly disagreed with the statement that self-driving vehicles would improve the flow of traffic and 46 respondents agreed or strongly agreed that self-driving cars would increase the comfort of traveling. Most respondents felt that there will always be situations where human driver needs to take over control as 51 agreed or strongly agreed with the statement and most of the respondents agreed that it is important to have the possibility to take over control in a self-driving vehicle (58 respondents). Many respondents were also sceptical about the reliability of the new technology which partly explains the previous answers. Majority of respondents agreed with the statement that private car ownership is important to them (51 respondents) and even larger portion stated that they enjoy driving (54).

The average agreement levels for statements above were also calculated for all responses and separately for male and female responses using the following scale: 1- strongly disagree, 2- disagree, 3- neutral, 4- agree and 5- strongly agree (Appendix 3). Respondents showed highest agreement levels for the statements saying that it is important to be able to take control over the vehicle, that they are excited about possibilities offered by new technologies and that they enjoy driving. For differences between male and female responses, female respondents were more concerned about the safety risks, employment effects and reliability of self-driving vehicles and perceived collaborative consumption more positively while males on average enjoyed driving more than females.

Correlations between answers for the statements were analysed by using IBM SPSS software which revealed some moderate correlation between the statement answers (Appendix 2). The answers to statement about willingness to use self-driving vehicles were found to correlate positively with answers to statements about easy usability of self-driving cars, excitement about possibilities offered by new technology and positive environmental impact of self-driving vehicles. Significant correlation was also observed between statements about driving enjoyment and private car ownership as well as between statements stating that it is important to be able to take over the control of the vehicle and that human override will always be needed in certain situations. The first and last statements were both related to safety of self-driving vehicles but were formed as a positive statement for the other and negative for the other and had significant negative correlation, which shows that respondents were mainly attentive when filling out the survey.

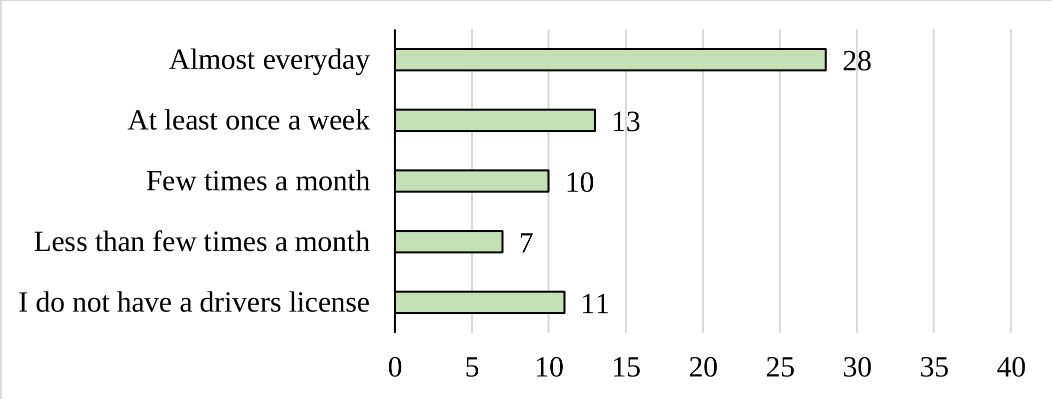

Figure 12. Driving frequency of respondents, n=69
Source: Composed by author

The respondents driving habits were measured by asking how often they drive a car in normal conditions and not taking into account covid restrictions. Figure 12 reveals that 28 out of 69 respondents drive a car almost every day, while 13 drive at least once a week, 10 few times a month and 7 respondents less than few times a month. 11 of the respondents did not have a driver's license and therefore presumably did not drive a car at all. A majority of 36 respondents owned a private car.

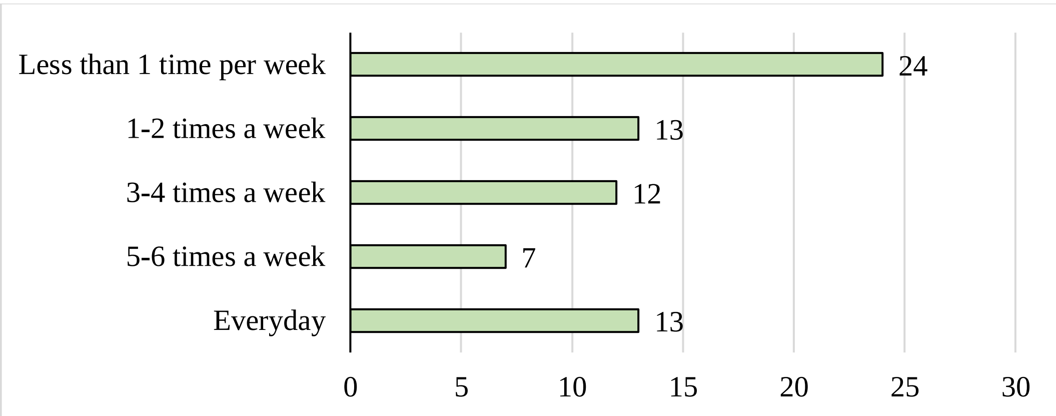

Figure 13. Respondents need to commute during current remote work/study scenario, n=69
Source: Composed by author

In relation to the current situation with covid the respondents were asked how often they need to commute at current times, as the current circumstances might provide a picture of our future commuting needs even after the restrictions. In Figure 13 it is seen that 13 out of 69 respondents commuted every day, 7 respondents 5-6 times a week, 12 respondents 3-4 times a week, 13 respondents 1-2 times a week and the biggest group of 24 respondents only less than 1 time per week.

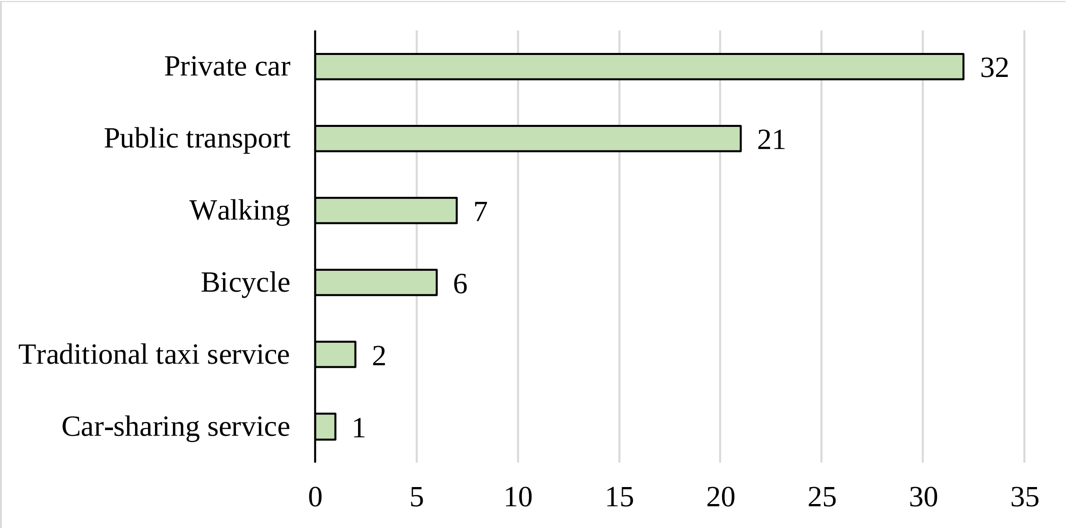

Figure 14. Respondents most commonly used travel mode to school/work, n=69
Source: Composed by author

The travel mode mostly used by respondents was also researched with the results displayed in Figure 14 above. Private car was the most popular option with 32 responses out of 69, followed by public transport with 21 responses, walking with 7, bicycle with 6, traditional taxi service with 2 and ridesharing service with 1 response.

3.2. Discussion of results

A large portion of the respondents were familiar with the topic, with 27 respondents out of 69 being moderately familiar and 14 respondents very familiar according to the respondents own answers although only 6 respondents had actually tested a self-driving vehicle in real life (Figure 6). The relatively high knowledge level can partly be explained by the fact that even though Estonia is quite a small country, there are relatively many self-driving vehicle projects being developed which are visible in the national media as well as even on the streets of some of the cities. It has to be also noted that the target group of university students used in this research do not represent the whole population reliably as previous studies have identified that factors like higher education and younger age that describe university students increase self-driving vehicle adoption (Acheampong, Cugurullo 2019).

The mostly common advantages linked to self-driving vehicles by the respondents were increased traffic efficiency with 37 answers out of 166 and more efficient use of time during traveling with 32 answers (Figure 7). This supports the observation that the knowledge levels respondents had about self-driving cars were high as they could identify the commonly regarded benefits of AVs that could be achieved with the technology. The most chosen answers also show that time is a valuable asset to the respondents as not only could transportation times be cut by improving the traffic efficiency, but the time could also be spent more effectively in a self-driving vehicle on for example work tasks. These attitudes were supported by the second part of the questionnaire (Figure 11), where 46 out of 69 respondents agreed with the statement that AVs would improve the flow of traffic with only 7 disagreeing and 47 respondents agreeing with the statement that AVs would improve productivity during traveling with only 3 disagreeing.

With disadvantages associated with self-driving vehicles, cyber-security issues were noticeably the most commonly chosen option with 49 answers out of 166, followed by reliability of the technology with 35 answers (Figure 8). The security issues with self-driving vehicles are a widely discussed topic and a priority for many companies and other organizations involved in the field for a good reason as a security breach with a fully autonomous vehicle could have very serious consequences. The reliability issue was also confirmed in the other part of the survey where 27 of respondents agreed and 9 fully agreed with the statement that they are sceptical about the reliability of the new technology (Figure 11). The main concerns found in this study were mostly in line with previous findings and are something that policymakers and manufacturers should focus on especially as media coverage of accidents involving self-driving vehicles has been shown to have significant negative effect towards user’s acceptation of the technology (Othman 2021).

The observations between male and female respondents’ answers revealed that men on average had higher awareness levels regarding self-driving vehicles, at least according to their own assessment (Figure 6). This could be explained by men generally showing higher interest towards vehicles and technology. When observing the answers to statements about self-driving vehicles (Appendix 3), it is also concluded that female respondents were more concerned about the risks associated with self-driving vehicles than males, which is consistent with some of the previous studies (Othman 2021). Therefore, it may be benefitable for policymakers and other entities involved to distinguish differences in perceptions of demographic groups and target their actions to smaller groups accordingly. This kind of strategy could help in improving attitudes and therefore adoption of self-driving vehicles, although it has also been found that social influence, also included in the UTAUT model, has significant effect on people’s attitudes meaning that people’s acceptance of self-driving vehicles increases when they see others using them (Acheampong, Cugurullo 2019).

Concerns about trusting self-driving vehicles to take total control without override possibility and moral dilemmas related to crash algorithms that have been present in other studies (Liljamo *et al.* 2018) were also observed. The moral dilemma of the vehicle making judgements in accident situation was the third most popular disadvantage associated with self-driving vehicles (Figure 8) and respondents agreed most with the statement that it should be possible to take control of the self-driving vehicle in Figure 11. This could be explained with the fact that very often when self-driving vehicle related news are presented in the media, they are about accidents involving them. Actual experience of self-driving vehicles has been found to decrease these concerns and improve attitudes towards them (Othman 2021), but even in a country like Estonia where self-driving projects are relatively present, only a small part of respondents had had an experience with them (6 out of 69 respondents). Concerning moral behaviour of self-driving vehicles and the liability issues related to the topic, the governing bodies of the world should agree on common standards, as the current situation of unclear guidelines and rules on the topic hinders the development and adoption of self-driving vehicles and has a negative effect on the public perception of them.

The correlation analysis performed on items in Figure 11 shows that especially the perceived ease of use correlates positively with intention to use self-driving technology (Appendix 2), which is in line with the TAM model presented by Davis (1986) that states that perceived usefulness and perceived ease of use form the behavioural intention to use a technology which in turn affects actual use. The assumptions of the model have been proven in previous studies (Nastjuk *et al.* 2020), showing that attitudes are a significant predictor of actual use and therefore a relevant topic to study. The perceived usefulness of self-driving vehicles showed a bit weaker correlation with usage willingness, which might indicate that respondents could be better informed about the advantages that self-driving vehicles could introduce. Positive attitudes towards environment and technology also correlated positively with eagerness to use self-driving vehicles as has been found in previous studies (Acheampong, Cugurullo 2019). This might indicate that they are perceived to be environmentally friendlier than traditional vehicles and that people more interest and open towards new technologies will adopt them faster than others.

The observed commuting habits and car ownership of the respondents were somewhat surprising especially given that it can be presumed that most of the university students in Estonia live near their university which are located in the bigger cities. Private car was the most popular travel mode (32 answers from 69) by a significant difference to the second most popular option of public transport (21 responses) (Figure 14). A Majority of respondents also owned a car (36 out of 69) with 28 out of 69 respondents stating that they drive almost every day under normal conditions (Figure 12). Even though Estonia has relatively effective and low-cost public transportation system in cities like Tallinn and Tartu, cost of car ownership with the included expenses (service, insurance, parking etc.) is also significantly lower than in many other European nations which partly explains the high number of private car ownership. Many respondents also state that they enjoy driving and a majority agree with the statement that it is important for them to have their own car (Figure 11), which might indicate that private cars are also seen as a status symbol in the society. Infrastructure in the cities focused more on motor vehicles rather than for bicycles and pedestrians and harsher climate conditions likely also have a negative impact on the use of more environmentally friendly travel modes like walking or biking (Figure 14).

As self-driving vehicles have the possible impact of increasing congestion in cities by attracting even more people to use cars through increased efficiency and comfort and decreased costs, addressing the issue of city transport should be a top priority for the Estonian government. Increasing the efficiency and availability of public transport with the help of self-driving vehicles, promoting shared mobility as an alternative for private cars and changing the direction of city planning to a less car centred one are some of the means that could be used (Alonso Raposo *et al.* 2019). The current pandemic could also help identify and adopt work models that are less dependent on physical location and therefore help reduce unnecessary travel. These kinds of effects can be observed from the respondent's answers in Figure 13, as 24 out of the 69 respondents stated that they needed to commute less than one time per week under the remote work and study scenarios.

CONCLUSION

As the Estonian government along with many other countries aims to make transportation safer, more efficient and accessible in the future while at the same time reducing carbon emissions, the self-driving technology is a big part of obtaining those goals. A few companies that focus on self-driving vehicles also operate in Estonia, but still there is very little research done on the public's perception towards them. As the potential users' attitudes towards the technology have been argued to have an even greater effect on their adoption than technological advancements in the field, timely data about the topic can be a valuable asset for promoting the technology and guiding future research. The aim of the study was therefore to gather recent information on the awareness level and attitudes that Estonian university students have with regards to self-driving vehicles. The target group chosen for the study was university students studying in Estonia, as they were identified as likely being one of the first adopters of the technology and therefore the ones to lead the way to a wider adoption of self-driving vehicles.

The following research questions were established to help reach the aim of the research:

RQ1: What is the level of awareness Estonian university students have at the moment regarding self-driving vehicles?
RQ2: What are the prevailing attitudes Estonian university students have towards self-driving vehicles?
RQ3: What are the expectations that Estonian university students associate in regard to self-driving vehicles?

To answer these questions the author opted to use the quantitative research method and set out to create an online survey using Google Forms to gather the needed data. Convenience sampling was used to gather the sample and the survey was distributed through online channels resulting in 73 responses. The final sample of 69 respondents was analysed using Microsoft Excel and IBM SPSS software.

The awareness level that the respondents had about self-driving vehicles was relatively high, as all of them were at least slightly familiar with the topic and 43 out of 69 at least moderately familiar, although it was observed that males were somewhat more familiar with the topic than females. The biggest advantages associated with self-driving vehicles were increased traffic efficiency and increased productivity during traveling while biggest perceived disadvantages were cyber-security issues and reliability concerns. Leaving people in the transportation sector jobless as well as the effect on road safety were also concerns people associated with autonomous vehicles. Female respondents were also found to be more concerned about the risks associated with self-driving vehicles than men.

Of all the respondents 41 out of 69 expected the mass adoption of self-driving vehicles to happen in the next 5-15 years with short distance movement of goods seen as the first field of transportation to adopt them in large numbers. The respondents felt very strongly that it is important to be able to take over the control in a self-driving vehicle, as they thought that they would not be able to handle every situation autonomously. Perceived ease of use together with positive attitudes towards technology and environment were found to correlate positively with the intention to use self-driving vehicles. Collaborative consumption was perceived as a positive phenomenon by most, but the majority of respondents still stated that it is important for them to have their own car. Although respondents generally perceived that self-driving vehicles have a lot of advantages over traditional vehicles only about half of the respondents agreed with the statement that they would like to use a self-driving vehicle.

Even though this research was intended to be used mainly as an exploratory study to gain initial understanding of the situation and to help guide future research efforts, some recommendations are also provided that could be useful for policymakers and businesses involved with the technology. The biggest perceived disadvantages observed should be addressed in order to decrease people’s concerns about the technology. Cyber-security issues were the number one worry for people and efforts should be made to guarantee that the technology is secure. Reliability and safety of the technology could be promoted with the help of statistical data of autonomous projects, which shows that autonomous vehicles generally have less accidents than human controlled. Introducing real projects to people and demonstrating them in real life has also been proven to be one of the most effective ways to positively affect people’s perceptions about the technology especially as only a small per cent of people have actually experienced them. The societal impact and change in transportation habits that could be introduced by self-driving vehicles is also something that should definitely be addressed, mostly by the government bodies, in order to manage the potential risks and to create a more sustainable, efficient and accessible future of transportation.

The biggest limitation of the research is the fact that non-probability sampling was used to form the sample, which means that the results cannot be reliably generalized to the wider population. Additionally, people with interest in the topic may be more inclined to answer the questionnaire, which could lead to untruthful picture of the target audiences' perceptions. With online questionnaire there are also little means of confirming that the respondents answer truthfully to the questions. It has to be also kept in mind that due to the demographic factors of the target group the observed awareness levels are most likely higher and attitudes more positive regarding self-driving vehicles than the general publics.

For future research efforts in the field, some suggestions are made with the target population of Estonians especially in mind. As the sample size of the research was relatively small and concentrated on a small target group, a similar study using random sampling with a larger sample and wider population might be beneficial as further research for validating and comparing the results. It may also be useful to focus on more narrow topics e.g., self-driving busses or autonomous parcel robots in future research to gain a more precise picture concerning the different types of self-driving vehicles. One possible direction for future study would be to investigate the channels of information that affect the formation of perceptions about self-driving vehicles in order to improve the communication about them. A qualitative method could also be used to study the same topic to gain more in-depth insights about the attitudes and their formation process associated with the given topic.

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APPENDICES

Appendix 1. Questionnaire with answer distribution

Dear participant,

This survey is part of the authors Bachelor of Business Administration graduation thesis at the Tallinn University of Technology. The thesis aims to identify the knowledge level and attitudes that the Estonian university students have towards self-driving vehicles* to provide current data to be used in the creation of marketing strategies that aim to promote self-driving vehicle technologies in Estonia.

The survey includes multiple choice and scale questions about perceptions related to self-driving vehicles as well as questions about demographics and transportation habits.

The survey will take about 5-10 minutes to fill out and the data gathered is completely confidential and anonymous. Thank you for taking the time to help with this research.

*Self-driving vehicles are able to drive without a human driver by using advanced sensing and communication technology.

Are you currently studying in an Estonian university/applied university? (n=73)

Yes	69
No	4

How familiar are you with the concept of self-driving vehicles? (n=69)

Not at all familiar	0
Slightly familiar	26
Moderately familiar	27
Very familiar	14
Extremely familiar	2

Have you tested a self-driving vehicle yourself? (n=69)

Yes	6
No	63

What do you think are the biggest advantages that could be achieved by using self-driving vehicles? (respondents were asked to choose up to 2 options, n=166*)

Increased safety on the road	29
Decreased transportation expenses	11
Increased traffic efficiency	37
Environmental friendliness	16
More efficient use of time during travelling	32
Increased access to transportation for everyone	12
Less parking problems	17
I do not think there are advantages	6
I do not know	6

What do you think are the biggest disadvantages that self-driving vehicles have? (respondents were asked to choose up to 2 options, n=166*)

Cyber-security issues	49
Decreased safety on road	19
Increased transportation expenses	5
Reliability of the technology	35
Moral dilemma (vehicle making judgements)	29
Complicated to operate	8
Privacy issues	17
I do not think there are disadvantages	3
I do not know	1

*Some people chose more than 2 options

When do you think we will see the mass adoption of self-driving vehicles? (n=69)

In the next 5 years	4
In 5-10 years	15
In 10-15 years	26
in 15-25 years	9
In 25+ years	11
Never	3
I do not know	1

What do you think will be the first field of transportation to see the mass use of self-driving vehicles? (n=69)

Private cars	15
Ridesharing companies	7
Public transport	16
Long distance movement of goods (trucks)	6
Short distance movement of goods (courier robots)	24
I do not know	1

Choose the option that represents how you feel about the statement. (n=69)

Statements:	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Self-driving vehicles will increase road safety	5	10	25	19	10
I would like to use a self-driving vehicle	5	12	17	21	14
It is important to be able to take over the control of the vehicle	2	2	7	19	39
Self-driving vehicles will be easy to use	1	3	25	35	5
I enjoy driving	2	2	11	23	31
I am excited about the possibilities offered by new technologies	1	2	10	31	25
It is important for me to have my own car	5	5	8	27	24
Self-driving cars would increase the comfort of traveling	3	3	17	33	17
Self-driving cars would allow me to be more productive while travelling	2	1	19	35	12
I am sceptical about the reliability of the new technology	1	13	19	27	9
Self-driving cars would be more environmentally friendly	3	8	31	18	9
I fear self-driving cars will leave a lot of people jobless	8	14	10	22	15

Statements:	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I think collaborative consumption is a positive thing (shared use of goods or service, e.g. ridesharing)	1	8	14	32	14
There will always be some situations where human driver needs to take over control	2	5	11	21	30
Self-driving vehicles would improve the flow of traffic	1	6	16	31	15
Self-driving vehicles will increase the number of accidents on road	11	14	30	14	0

What is your gender? (n=69)

Male	30
Female	39

What is your age? (open question)(n=69)

19	1
20	8
21	8
22	10
23	5
24	6
25	7
26	7
27	4
28	3
29	2
30	1
33	2
35	1
41	1
42	1
46	1
No answer	1

What is your nationality? (open question)(n=69)

Estonian	34
Finnish	19
Nigerian	4
Belarussian	2
Ukranian	2
Bangladeshi	1
Canadian	1
Georgian	1
German	1
Moroccan	1
Sri Lankan	1
Do not want to say	2

What is your field of study? (n=69)

Business	44
Social sciences	10
Engineering	7
Science	4
IT	2
Health	1
Do not want to answer	1

How often do you drive a car? (not taking into account covid restrictions)(n=69)

Almost everyday	28
At least once a week	13
Few times a month	10
Less than few times a month	7
I do not have a drivers license	11

Do you own a car? (n=69)

Yes	33
No	36

Under the current remote work and studies scenario, how often do you need to commute? (n=69)

Everyday	13
5-6 times a week	7
3-4 times a week	12
1-2 times a week	13
Less than 1 time per week	24

What is your most common travel mode choice (to school/work)? (n=69)

Private car	32
Public transport	21
Ridesharing service	1
Traditional taxi service	2
Bicycle	6
Walking	7

If you have any questions or feedback concerning this survey you can write them here. (For a reply please leave your contact information and I will get back to you)

A few people wrote that the topic seemed interesting or wished good luck.

End of Appendix 1. Questionnaire with answer distribution

Source: Questionnaire composed by author, answers gathered through Google Forms platform.

Appendix 2. Correlations between statements about self-driving vehicles

Spearman's rho		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
Q1	ρ (rho)	--															
	Sig. (2-tailed)																
Q2	ρ (rho)	.308*	--														
	Sig. (2-tailed)	0.010															
Q3	ρ (rho)	-0.088	-0.224	--													
	Sig. (2-tailed)	0.470	0.065														
Q4	ρ (rho)	.314**	.414**	-0.129	--												
	Sig. (2-tailed)	0.009	0.000	0.293													
Q5	ρ (rho)	-0.121	-0.089	0.155	0.100	--											
	Sig. (2-tailed)	0.322	0.465	0.202	0.414												
Q6	ρ (rho)	.390**	.472**	0.125	.319**	0.060	--										
	Sig. (2-tailed)	0.001	0.000	0.305	0.008	0.622											
Q7	ρ (rho)	-0.186	-0.230	.332**	0.038	.575**	0.137	--									
	Sig. (2-tailed)	0.125	0.057	0.005	0.754	0.000	0.261										
Q8	ρ (rho)	.429**	.353**	0.091	.530**	-0.057	.447**	0.074	--								
	Sig. (2-tailed)	0.000	0.003	0.457	0.000	0.643	0.000	0.545									
Q9	ρ (rho)	.411**	.286*	0.065	0.146	-.286*	.276*	-0.151	.553**	--							
	Sig. (2-tailed)	0.000	0.017	0.595	0.231	0.017	0.022	0.216	0.000								

Spearman's rho		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16
Q10	ρ (rho)	-.372**	-.358**	.330**	-.403**	0.130	-0.210	0.191	-.316**	-0.141	--						
	Sig. (2-tailed)	0.002	0.003	0.006	0.001	0.286	0.083	0.115	0.008	0.249							
Q11	ρ (rho)	0.229	.527**	-0.190	.251*	0.036	.290*	-.242*	0.130	0.119	-0.188	--					
	Sig. (2-tailed)	0.058	0.000	0.117	0.038	0.766	0.016	0.045	0.288	0.331	0.122						
Q12	ρ (rho)	-.402**	-0.124	0.117	-0.109	0.141	-.263*	0.190	-0.193	-0.084	.345**	0.050	--				
	Sig. (2-tailed)	0.001	0.311	0.337	0.373	0.247	0.029	0.117	0.112	0.492	0.004	0.682					
Q13	ρ (rho)	0.110	.296*	0.046	.254*	-.286*	.240*	-0.175	.422**	.333**	-0.100	.319**	0.093	--			
	Sig. (2-tailed)	0.368	0.013	0.705	0.035	0.017	0.047	0.149	0.000	0.005	0.414	0.008	0.447				
Q14	ρ (rho)	-.276*	-.304*	.620**	-0.196	.268*	-0.013	.407**	0.120	-0.032	.288*	-0.161	0.161	0.070	--		
	Sig. (2-tailed)	0.022	0.011	0.000	0.107	0.026	0.914	0.001	0.328	0.797	0.016	0.186	0.188	0.569			
Q15	ρ (rho)	.551**	.244*	0.065	.321**	-0.094	.523**	-0.151	.522**	.263*	-.308**	.240*	-.283*	.337**	0.037	--	
	Sig. (2-tailed)	0.000	0.044	0.595	0.007	0.442	0.000	0.216	0.000	0.029	0.010	0.047	0.018	0.005	0.765		
Q16	ρ (rho)	-.632**	-.240*	0.089	-.267*	0.050	-.248*	0.208	-.372**	-0.134	.396**	-0.149	.544**	-0.008	.245*	-.410**	--
	Sig. (2-tailed)	0.000	0.047	0.469	0.027	0.685	0.040	0.086	0.002	0.274	0.001	0.222	0.000	0.946	0.042	0.000	

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

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

Q1	Self-driving vehicles will increase road safety	Q9	Self-driving cars would allow me to be more productive while travelling
Q2	I would like to use a self-driving vehicle	Q10	I am sceptical about the reliability of the new technology
Q3	It is important to be able to take over the control of the vehicle	Q11	Self-driving cars would be more environmentally friendly
Q4	Self-driving vehicles will be easy to use	Q12	I fear self-driving cars will leave a lot of people jobless
Q5	I enjoy driving	Q13	I think collaborative consumption is a positive thing (shared use of goods or service, e.g. ridesharing)
Q6	I am excited about the possibilities offered by new technologies	Q14	There will always be some situations where human driver needs to take over control
Q7	It is important for me to have my own car	Q15	Self-driving vehicles would improve the flow of traffic
Q8	Self-driving cars would increase the comfort of traveling	Q16	Self-driving vehicles will increase the number of accidents on road

End of appendix 2. Correlations between statements about self-driving vehicles

Source: Composed by author using IBM SPSS software

Appendix 3. Average values for statements about self driving vehicles

Question	Average	Female respondents average	Female diffrence from average	Male respondents average	Male difference from average	Diffrence between male and female averages
Self-driving vehicles will increase road safety	3,28	3,26	0,02	3,30	0,02	0,04
I would like to use a self-driving vehicle	3,39	3,46	0,07	3,30	0,09	0,16
It is important to be able to take over the control of the vehicle	4,32	4,41	0,09	4,20	0,12	0,21
Self-driving vehicles will be easy to use	3,58	3,54	0,04	3,63	0,05	0,09
I enjoy driving	4,14	4,03	0,12	4,30	0,16	0,27
I am excited about the possibilities offered by new technologies	4,12	4,13	0,01	4,10	0,02	0,03
It is important for me to have my own car	3,87	3,90	0,03	3,83	0,04	0,06
Self-driving cars would increase the comfort of traveling	3,72	3,79	0,07	3,63	0,09	0,16
Self-driving cars would allow me to be more productive while travelling	3,78	3,90	0,11	3,63	0,15	0,26
I am sceptical about the reliability of the new technology	3,43	3,54	0,10	3,30	0,13	0,24
Self-driving cars would be more environmentally friendly	3,32	3,38	0,07	3,23	0,09	0,15
I fear self-driving cars will leave a lot of people jobless	3,32	3,54	0,22	3,03	0,29	0,51

Question	Average	Female respondents average	Female diffrence from average	Male respondents average	Male difference from average	Diffrence between male and female averages
I think collaborative consumption is a positive thing	3,72	3,87	0,15	3,53	0,19	0,34
There will always be some situations where human driver needs to take over control	4,04	4,13	0,08	3,93	0,11	0,19
Self-driving vehicles would improve the flow of traffic	3,77	3,82	0,05	3,70	0,07	0,12
Self-driving vehicles will increase the number of accidents on road	2,68	2,90	0,22	2,40	0,28	0,50

End of appendix 3. Average values for statements about self driving vehicles

Source: Composed by author using MS Excel

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