energies

MDPI

Article

Assessment of Social Acceptance for Autonomous Vehicles in Southeastern Poland

Agnieszka Dudziak [1], Monika Stoma [1,*], Andrzej Kuranc [1] and Jacek Caban [2]

[1] Faculty of Production Engineering, University of Life Sciences in Lublin, 20-612 Lublin, Poland; agnieszka.dudziak@up.lublin.pl (A.D.); andrzej.kuranc@up.lublin.pl (A.K.)
[2] Faculty of Mechanical Engineering, Lublin University of Technology, 20-618 Lublin, Poland; j.caban@pollub.pl
* Correspondence: monika.stoma@up.lublin.pl

Abstract: New technologies reaching out for meeting the needs of an aging population in developed countries have given rise to the development and gradual implementation of the concept of an autonomous vehicle (AV) and have even made it a necessity and an important business paradigm. However, in parallel, there is a discussion about consumer preferences and the willingness to pay for new car technologies and intelligent vehicle options. The main aim of the study was to analyze the impact of selected factors on the perception of the future of autonomous cars by respondents from the area of Southeastern Poland in terms of a comparison with traditional cars, with particular emphasis on the advantages and disadvantages of this concept. The research presented in this study was conducted in 2019 among a group of 579 respondents. Data analysis made it possible to identify potential advantages and disadvantages of the concept of introducing autonomous cars. A positive result of the survey is that 68% of respondents stated that AV will be gradually introduced to our market, which confirms the high acceptance of this technology by Poles. The obtained research results may be valuable information for governmental and local authorities, but also for car manufacturers and their future users. It is an important issue in the area of shaping the strategy of actions concerning further directions of development on the automotive market.

Keywords: autonomous technology; road vehicles; road traffic; survey study

Citation: Dudziak, A.; Stoma, M.; Kuranc, A.; Caban, J. Assessment of Social Acceptance for Autonomous Vehicles in Southeastern Poland. *Energies* **2021**, *14*, 5778. https://doi.org/10.3390/en14185778

Academic Editors: Guzek Marek, Rafał Jurecki and Wojciech Wach

Received: 31 July 2021
Accepted: 11 September 2021
Published: 14 September 2021

1. Introduction

In the last decade, many modern technologies, solutions, products, etc., have been introduced in various areas of modern man's life, which is, among others things, an implication of implementing the assumptions of the Economy 4.0 project. All of these conceptions change lifestyle, preferences and expectations. This revolution also affected the automotive industry and widely understood transport. The automotive industry is currently undergoing a period of dynamic and permanent change. Over the past decade, the automotive and technology industries, supported by the interdisciplinary efforts of numerous research institutes around the world, have made a significant leap in introducing computerization into what has been purely human activity for over a century, i.e., driving. By introducing functions that seem simple or even basic today, such as anti-lock braking systems and traction control, and gradually introducing more complex functions, such as adaptive cruise control and autonomous parking assistance systems, we are moving closer to the era of unmanned vehicles.

Over the past few years, vehicle manufacturers and technology developers have worked to develop advanced automotive and communication technologies [1,2], modern construction materials, smart vehicle options and alternative types of fuels [3–5]. In addition to the development of engines powered by alternative fuels [5], including those powered by natural gas and hydrogen, we distinguish hybrid and electric vehicles [6,7]. Many car manufacturers work with technology vendors to improve the driving experience, especially in terms of safety and comfort aspects [8]. Hence, these technologies, along

with the need to meet the needs of an aging population in developed countries, have given rise to the development and gradual implementation of the AV concept and have even made it a necessity and an important business paradigm [9]. It should be mentioned, however, that the first attempt to create driverless vehicles dates back to the early 1920s [10]; however, this concept gained momentum only in the 1980s, when scientists managed to develop automated highway systems [11]. This makes the way for the connection of semi-autonomous and AV to the road infrastructure, mainly in Germany and the United States in 1980–2000 [9].

Sensor-based intelligent/autonomous driving systems and advanced vehicle functions generate many potential benefits, the most important of which seems to be the reduction of the number and consequences of accidents (some authors even believe that these systems can virtually eliminate human error, which is a major contributor to road accidents [12]). In addition, multimedia platforms in combination with intelligent and autonomous driving systems can make the time spent in the car, on the one hand, more enjoyable, and on the other hand, more productive, as passengers can multitask while traveling [13]. Advanced communication systems embedded in cars can also lead to more efficient vehicle navigation and traffic flow, reducing congestion and eliminating critical bottlenecks [14]. It should also not be forgotten about reducing energy consumption and pollution.

However, in parallel, there is a discussion about consumer preferences and the willingness to pay for new car technologies and intelligent vehicle options. The speed of market penetration by these technologies, functions and solutions largely depends on whether consumers are interested in these technologies and options and, above all, whether they are willing to pay extra for them. It should be noted that although the idea of self-propelled vehicles without the participation of a driver has existed for decades, too high costs have hindered their mass production so far [15]. In addition, as shown by various studies, many potential users of this type of car have some concerns about their introduction and widespread use, pointing to the existence of several disadvantages, especially in the area of the sense of security, controllability and in the area of law, liability, ethics and cybersecurity.

Taking the above into account, the aim of the study is to analyze the impact of selected factors on the perception of the future of AVs by respondents from Southeastern Poland in terms of comparison with traditional cars. The main goal of the study was to identify the basic factors influencing the opinions of respondents about the social acceptance of AV, in particular the advantages and disadvantages of this solution.

The following research questions were formulated for a fuller implementation of the assumed objectives of the study:

1. Do the respondents, according to the gender grouping variable (men and women), express similar opinions about AVs?
2. Do the respondents have similar opinions on AVs due to the age grouping variable?
3. When it comes to autonomous cars, are there advantages over disadvantages in this concept?
4. How, according to the respondents, will the car market develop, and which cars will be the most popular in the near future?

AV technology can and, in principle, should be considered at the meeting point of many disciplines, such as transport sciences, electrical engineering, information technologies, software and hardware engineering, law, and even ethics and philosophy [8].

2. Literature Review

Currently the automotive industry is experiencing a revolution with the advent of advanced automotive technologies, intelligent vehicle options and alternative fuels. However, research into consumer preferences for this type of automotive technology is very limited. The implementation and penetration of advanced automotive technologies on the market and the planning of possible market adoption scenarios requires the collection and analysis of data on consumer preferences related to these new technologies. Hence, the research by Shin et al. [16] aimed to meet this need by offering a detailed analysis of consumer

preferences for alternative fuel types and technological options, using data collected in the reported experiments conducted on a sample of consumers from six metropolitan cities in South Korea. The results indicated that there is significant heterogeneity in consumer preferences for different smart technology options, such as wireless internet, vehicle connectivity and voice command features, but relatively less diversity in preferences for intelligent in-car applications, such as real-time travel information on parking and road conditions [13].

The use of AVs, as suggested by many authors and experts not only from the automotive industry, generates many different potential benefits, both in an individual aspect-for users of this type of vehicle, as well as social and economic benefits. In relation to the first area, special attention is paid to the fact that AV have the ability to improve passenger comfort by eliminating the need to perform certain tasks related to driving. It is known that the process of driving a car is complex; in fact, several motor and cognitive tasks must be performed, sometimes in quick succession and sometimes simultaneously, with which drivers need to interact; they must also react to different vehicle parameters, driver and pedestrian behavior, all under different weather, lighting and road conditions [17].

In addition, they provide new mobility opportunities for groups of people who, until now, have been partially or completely excluded from participation in public life due to mobility restrictions (e.g., the elderly or disabled) [16,18,19]. The possibility of using AV does not require drivers to have a driving license. It should be added that the lack of the need to drive a vehicle and focus on the conditions and other road users means for some "drivers" more time to work, which in turn is beneficial for the economy.

Taking into account the area of social benefits, it should be emphasized that autonomous driving does not lead to a loss of safety or efficiency of road transport, but rather improves them [20]. It may also result in new business models, as driverless cars will enable car sharing at much higher levels than is currently the case; in the vast majority of cases, it will be cheaper to use these shared cars than your own, without the financial burden and hassle of owning a private car (frozen capital, taxes, insurance, repairs and parking difficulties) [21,22]. The appropriate and adequate information about the number of free places, their location, etc., can reduce even by 30% the traffic volume in some cases [23]. Sharing cars also means a significant reduction in the number of vehicles on the road, as well as less space and infrastructure needed for transport, which in turn means less money spent on it [24,25]. Shared autonomous vehicles (SAV) allow for a shorter travel time and better use of vehicles (reducing their number on roads) and the available urban infrastructure [26]. As shown in Reference [27], the travelers are exposed to a reduction in travel time once conventional transport modes are replaced by AVs. One SAV (shared autonomous vehicle) can replace eight conventional vehicles with acceptable average waiting time ranging from 7 to 10 min and usage of four seats (shared trip) [28].

Ball [29] emphasizes that the benefits of the widespread introduction of AV can be found in two schools [15,30–34]. In the first school, particular attention is paid to the potential of AV to stimulate additional travel. Without the need for a driver, vehicle passengers would have much more freedom to engage in other activities during the journey, which in turn would reduce travel costs and facilitate urban growth. AV would also increase the mobility of younger people (without a driving license), the elderly, the sick or the disabled. It is also emphasized that AV can generate more demand by increasing road capacity, as lanes could be narrowed and cars could come closer together [29].

In turn, the second school emphasizes the potential of AVs to reduce travel/mobility costs. Part of this may be due to the shift from private car ownership towards "mobility as a service" [33]. By replacing the fixed costs of owning a car with fees for access (time and mileage) to a fleet of shared AVs, the final cost of the vehicle's journey would consequently decrease. Moreover, since AVs would not require a parking space close to the destination, this would allow for the further development and filling of the former parking lots [35].

The introduction of AVs would also make it possible to increase road capacity by up to five times [36] and reduce road congestion (and, consequently, fuel consumption and

environmental pollution [37,38]), as cars on the network would communicate with each other and local infrastructure to smoothly respond to changes in traffic and flexibly adapt to them [39–42]. Some estimates show that this would save the average commuter 42 h a year [43].

As shown by numerous studies and forecasts, AVs can cause the most intense transformation in urban transport systems and the greatest revolution in the practice of transport planning (proper design of parking lots, streets, networks of transit and paratransit services), since the appearance of the motor car over a hundred years ago [29]. However, attention should also be paid to the strategic implications for other road users-especially for pedestrians. In a risky situation, an AV slows down and gives way to pedestrians—this applies even to unmarked pedestrian crossings. Safer AVs also trigger a rational response from pedestrians and other road users. Pedestrians can pass with impunity with the certainty that the car will stop. The situation is slightly different from the point of view of a passenger in an automated car; as Ball [29] puts it, it would be "like driving a street full of five-year-old unaccompanied children".

No less important is the issue of road safety, which is reflected in the number of road accidents and collisions [15]. It is estimated that AVs can significantly reduce the number of accidents caused by human error, which currently account for over 90% of all road accidents (i.e., driving distracted, e.g., by a mobile phone, speeding, driving under the influence of alcohol/drugs, fatigue and spontaneous decision-making) [44], and consequently drastically reduce the number of fatalities, as well as accelerate emergency response. AVs communicate with each other better than drivers and can more effectively sense the presence of other road users and predict their behavior, as well as prevent them from falling asleep at the wheel [29]. Consequently, self-propelled vehicles can help save lives thanks to advanced avoidance and crash-response technologies. This is because AVs are able to detect the traffic environment, navigate through the software algorithm and control the movement of the vehicle without the driver's decisions and actions [45]. According to data from the World Health Organization (WHO), AVs can eliminate over 1.25 million fatalities from road accidents worldwide [46]. This is all the more important because, according to the WHO, over 1.2 million people die each year as a result of road accidents around the world, and this has a huge impact on health and development [47]. It should be added that road accidents and collisions generate various cost burdens with long-term consequences, affecting productivity, healthcare costs, legal and court costs, losses at the workplace, costs of emergency services, burdens related to congestion, costs of insurance and damaged property.

Moreover, other benefits in the social area include the following [48]:

- More effective real-time navigation and dynamic routing;
- More accessible, reliable and flexible carpooling in passenger transport;
- More efficient infrastructure through better vehicle control and coordinated actions;
- Greater savings of resources needed for infrastructure, including the construction of parking lots and roadways;
- More environmentally friendly vehicles and infrastructure (AVs have great potential to reduce energy consumption per mile [30]);
- Lower insurance costs.

Attention should also be paid to the potential impact on companies operating directly in the automotive industry, such as taxi services, new car dealerships and repair shops, which will evolve and adapt to the latest technologies. In the study of Berlin by Bischoff et al. [49], the authors examined the replacement of conventional taxis by autonomous taxis; they showed that one autonomous vehicle might replace 10 conventional taxis if the rides are shared, and six if the rides are not shared. From the point of view of the aftermarket, a greater number of AVs may also lead to an increased interest in accessories, such as, for example, advanced video technology providing entertainment to passengers, which in turn will affect the development of companies producing them.

Advanced systems, used in AVs, can also record and share driver data with insurance companies, thus helping to manage claims, estimate insurance premiums and reduce costs. These vehicles can also generate savings in the construction, transportation and logistics industries by providing information on vehicle downtime and cargo status, providing fleet managers with greater operational transparency [50].

Automation of vehicles, despite many potential advantages, may also generate some disadvantages. They can be, among others, issues related to the mentality of the society, such as user's resilience to giving up driving control, loss of situational awareness, loss of driving skills and privacy issues. Equally important are also technical and technological issues, i.e., increased vulnerability to software and hardware defects, as well as the possibility of cybercrime and greater terrorism potential.

Potential users of AVs also point to some understatements in the area of ethics and possible liability for damages; with the advent of the AV concept, a new ethical paradigm appears for man–machine, due to automated risk allocation during collisions.

Other negative aspects of the large-scale introduction of AV technology also include the need to build a completely new legal framework, the need to formulate different approaches to road control and enforcement, the loss of jobs focused on driving, the car navigation system's susceptibility to different types of weather, problems with communication with non-autonomous vehicles in mixed road traffic and the need to make large investments in the current road infrastructure to adapt to the new fully computerized requirements [51].

Other disadvantages of introducing AVs also include their potential negative impact on some enterprises and economies based on public transport, vehicle insurance and services. Insurance companies see the danger of AVs disrupting their business model. Moreover, it was indicated in Reference [38] that reducing the costs of driving a vehicle may increase traffic intensity.

3. Method

Consumer behavior on the market is a variable category and depends on many factors influencing the decision to choose products and their purchase. One of the most reliable methods of obtaining information on consumer behavior on the market are surveys. The research used in this study was conducted in 2019, among a group of 579 respondents, via the Internet. The original questionnaire was used, with the use of a deliberate sample, as the research concerned only respondents who are drivers or intend to become drivers in the future. The questionnaire used in the research consisted of two parts: the substantive part and the metric questions. The questions contained in the first part concerned many different aspects of the autonomous vehicle market, including the issues of knowledge and acceptance of autonomous vehicles, and opinions on the prospects of their development compared to other types of vehicles, as well as the benefits, disadvantages and barriers and challenges resulting from the introduction of this technology. In turn, the second part, i.e., metric, contained questions enabling the sociodemographic characteristics of the respondents according to various grouping variables (e.g., gender, age, place of residence and driving experience period). The questions in the survey were closed questions: single or multiple choice. In the case of some questions, it was also possible to provide your own answer (if none of the proposed variants of the answer reflected the attitudes of the respondent); however, it was always clearly indicated in the survey.

The results were prepared by taking into account the division of the respondents into four age groups: 19–25 (48% of respondents), 26–40 (24% of respondents), 41–60 (24% of respondents) and over 60 (4% of respondents). They came from the countryside (34% of the respondents) and from cities of various numbers: up to 100,000 (20% of respondents), 100,000–300,000 (10% of respondents) and over 300,000 inhabitants, 35% of respondents). Of the study participants, 38% were women and 62% were men.

In order to achieve the assumed goals, as well as to answer the research questions, the results obtained in the own questionnaire research were statistically analyzed. A correspondence analysis was used, thanks to which it was indicated how the vehicle

market will develop in the near future in the opinion of the respondents, in terms of age and gender, i.e., how respondents from Southeastern Poland perceive the future of AVs in comparison with standard vehicles (SVs). Moreover, the results of research referring to the potential benefits and advantages, as well as disadvantages of introducing AVs onto Polish roads are presented; in order to be able to fully answer the research questions, two variables grouping respondents were used in the analyses, namely gender and age.

The research sample came from the area of Southeastern Poland; this region was selected due to two factors. Firstly, it is an area less prosperous than the western territories and is characterized by a less developed communication infrastructure that can be developed for the use of AVs. Secondly, due to the less developed road infrastructure, it was expected that the social distance to such solutions might be large.

Data analyses were carried out on the basis of the statistical processing software Statistica 13.3 and Excel 2007. In this work, the correspondence analysis method was used. It is a descriptive and exploratory technique for analyzing two-way and multi-way tables, containing certain measures that characterize the relationship between columns and rows. The obtained results provide information similar in nature to the results obtained in the case of factor analysis techniques and allow for the analysis of the structure of the qualitative variables that make up the table. The most common table of this type is the two-dimensional contingency table. In correspondence analysis, the frequencies in the contingency table are first standardized such that the relative frequencies are computed and, when summed across all fields (cells) of the table, they give 1.0. One way to show the goals of a typical analysis is to express relative frequencies in terms of the distance between individual rows or columns in a space with a small number of dimensions.

In addition, the study also used the Spearman rank-order correlation analysis. Spearman's rank correlation coefficient is used to describe the strength of the correlation of two features when features are qualitative, allowing for ordering according to the strength of this feature, or when features are quantitative, but their number is small. In the study, the ranks of the X and Y features were assigned in descending order. If some units of a feature have the same value, then these units are assigned identical ranks, calculating the arithmetic mean of the ranks for the same units.

4. Results

On the basis of the information obtained from the respondents, in the initial phase of the research procedure, an analysis of correspondence between three groups of characteristics was carried out, i.e., car type (five groups of answers), age of respondents (four groups of answers) and gender (two groups). Respondents were asked about the expected type of the most popular vehicles in Poland in the near future. The following vehicles are included: SV, hybrid vehicle (HV), electric vehicle (EV), AV and standard vehicle supported by autonomous solutions (SV+). In this questionnaire, the respondents did not distinguish between the driving method according to its propulsion (SV petrol or diesel, EV or HV), so vehicles marked as SV, EV, HV and SV+ are considered human-driven vehicles, and an AV is understood as a self-steering vehicle. In order to present the configuration of points representing the input data, a two-dimensional factor space was chosen. The first factor allows us to reproduce 63.01% of input data variation (i.e., total inertia), and the second factor 24.77% (see Table 1).

The largest contribution to the creation of the two-dimensional factor space by the type of vehicle was played by SV+ and SV-coordinate I, and EV and AV-coordinate II. On the other hand, women over 60 years of age (dimension I) and women aged 26–40 (dimension II) had the largest share in the creation of the two-dimensional factor space by age and gender (Figure 1).

Table 1. Information resources' factors.

Number of Dimensions	Eigenvalues and Inertia, Total Inertia = 0.15719 χ^2 = 90.067 df = 28 p = 0.00001				
	Singular Value	Eigenvalues	Percentage of Inertia	Cumulative Percentage	χ^2
1	0.314710	0.099043	63.01026	63.0103	56.75147
2	0.197308	0.038930	24.76721	87.7775	22.30709
3	0.111603	0.012455	7.92396	95.7014	7.13687
4	0.082199	0.006757	4.29857	100.0000	3.87159

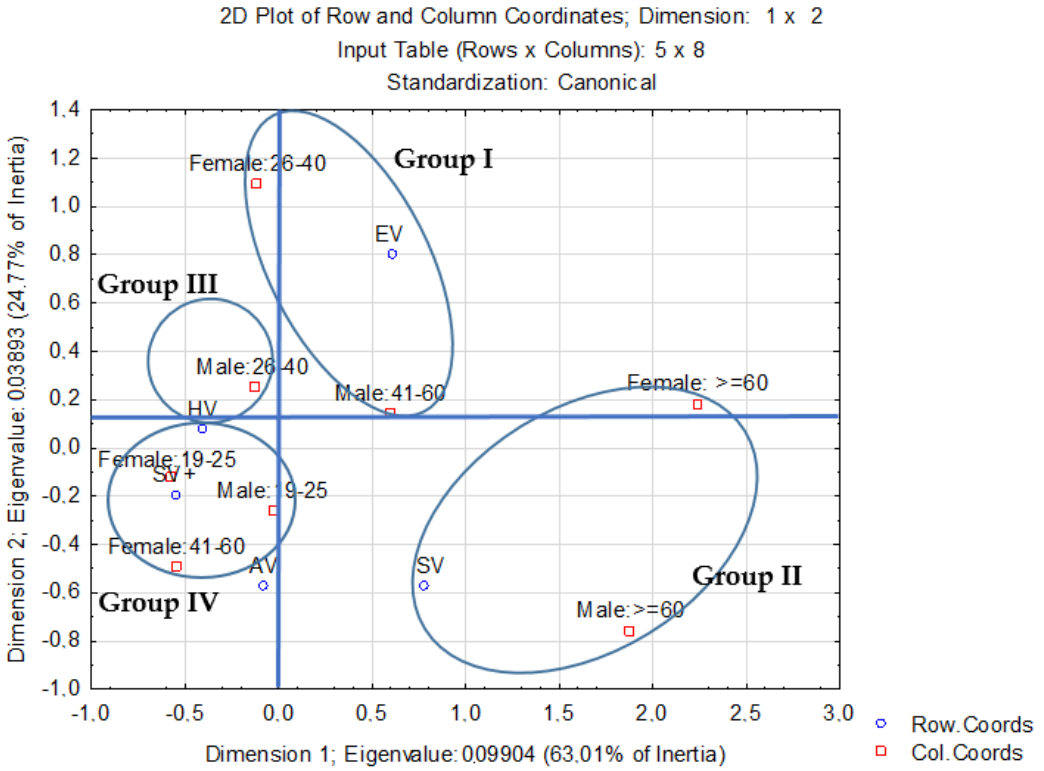

Figure 1. Correspondence analysis results between three groups of characteristics—vehicle type, age of respondents and gender.

There are four clear groups of vehicle types with the structure of indicators depending on the sex and age of the respondents (Figure 1), the first is made of EV, the second is SV, the third, with the most average structure, are HV, while the fourth is AV and SV+.

The greatest connection is between men aged 19–25 with SV+ and AV, it is a relatively strong link. Due to the value of the indicator-i.e., the age and sex of the respondents, the group in question differs from other preferred types of vehicle. An equally large link can be noticed between women aged 19–25 and SV+.

SV, on the other hand, correspond best with the group of women and men aged over 60. The age index of these respondents distinguishes this group of cars from the rest.

Another quite strong connection is between women aged 26–40 and men aged 41–60 with the group of EV.

At a later stage of the research procedure, we focused on the analysis of the benefits and advantages and-on the other hand-the disadvantages of using AV in the opinion of their potential users, using two grouping variables-gender and age, in order to identify possible differences in the perception of positive and negative aspects of the AV on Polish roads by women and men in different age groups.

Safer driving is one of the main driving forces in the development of AV and would be a prerequisite for their implementation on public roads in the future. In the research carried out using the proprietary questionnaire, 44% of respondents indicated that if they used AV,

they would feel safer. However, most people surveyed are concerned about cybersecurity and the privacy of data about the internet technologies or services they currently use.

Besides safety, the introduction of AV can generate a number of other benefits. Hence, the respondents were asked to indicate other advantages related to this solution. The proposed answers included, among others: comfort (the ability to work and rest while driving, e.g., napping, receiving and writing e-mails, reading a book, etc.), more efficient use of time, greater safety (less accidents and collisions), less stress while driving a car, saving on operating costs, reducing road congestion, a solution for people who do not like driving a car, greater mobility (e.g., disabled, elderly), greater independence (e.g., disabled, elderly or unable to drive), enabling better access to services and more.

The conducted own research indicated gender differences and those resulting from the age of respondents. The results of this analysis are shown for women in Figure 2a and for men in Figure 2b.

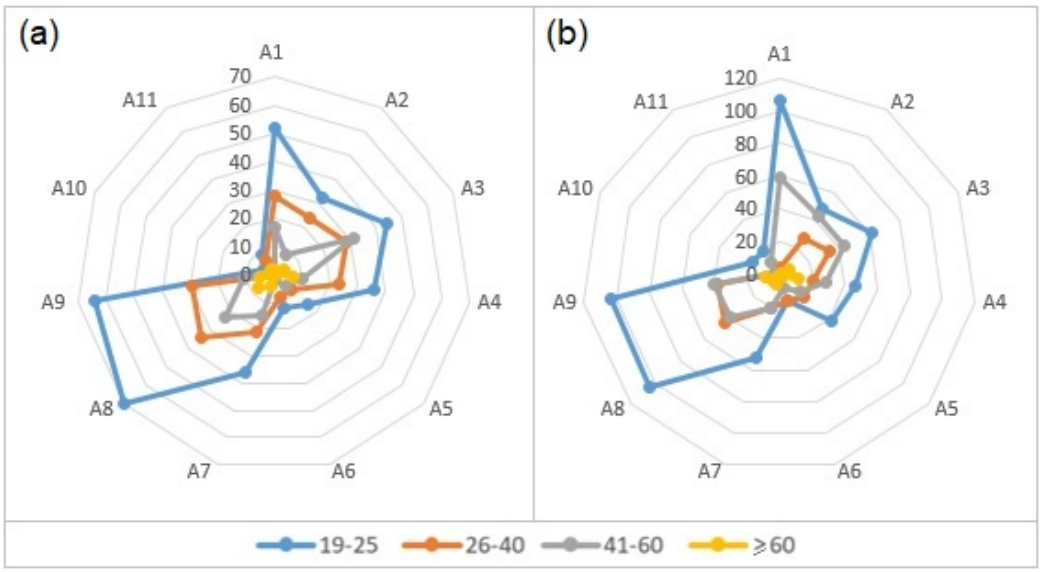

Figure 2. The advantages of the AV concept in the opinion of women (**a**) and men (**b**), A1—convenient solution, A2—efficient use of time, A3—safety, A4—less stress, A5—economy, A6—less congestion on the road, A7—solution for people who do not like driving a car, A8—mobility and A9—independence.

Young women aged 19–25 most often pointed to the benefits of mobility, independence and comfort; women aged 26–40, apart from mobility and independence, also pointed to the issue of comfort, but also safety (Figure 2a). On the other hand, women aged 41–60 paid attention primarily to safety, but also mobility. In turn, women over 60 years of age clearly indicated less stress while driving and, similarly to other groups, mobility, which can also be understood as greater independence. Interestingly, in all age groups, the least problem, according to the respondents, is access to services and the issue related to the reduction of parking spaces and less congestion on the road.

Compared to women, among the most frequently mentioned benefits related to AV, young men more often perceived comfort, independence and mobility, but also safety (group of men aged 19–25) (Figure 2b). On the other hand, men aged 26–40 most often indicated comfort, mobility and independence; men aged 41–60, apart from the issue of comfort, indicated the issue of effective use of time and safety. On the other hand, men over 60 indicated, similarly to women in this age group, less stress while driving and independence.

Table 2 presents the potential disadvantages of the AV concept perceived by women and men of different age groups. After analyzing the available literature, the proposed answers included boredom while driving; no pleasure in driving; unnecessary driving course; no driving habits; no control over electronics; elimination of many professions,

e.g., taxi driver, professional driver, etc.; the threat of cybercrime in the area of vehicles; and others.

Table 2. Potential disadvantages of the AV concept in the opinion of women and men.

Gender	Women				Men			
Age	19–25	26–40	41–60	over 60	19–25	26–40	41–60	over 60
Boredom	22	10	10	2	62	12	32	5
No driving pleasure	46	28	25	6	112	34	55	6
Redundant driving course	26	10	8	0	22	14	16	2
Being used to driving a car	50	27	24	5	66	35	30	4
No control over electronics	70	44	28	5	110	56	48	5
Elimination of professions	62	32	12	4	106	30	26	4
Cybercrimes	50	28	16	2	106	44	48	0
Other	6	0	0	0	6	4	2	0

The conducted research shows (Table 2) that women in the group 19–25 indicated primarily no control over electronics, the potential elimination of professions (e.g., taxi drivers) and the possibility of cybercrimes. Women aged 26–40 spoke in a similar formula, pointing to no control over electronics and the elimination of professions, but at a similar level indicated the risk of cybercrime and the no pleasure in driving a car. On the other hand, women aged 41–60 declared no control over electronics, no driving pleasure, but also the risk of getting used to driving a vehicle. On the other hand, women over 60, among the biggest disadvantages, indicated the lack of driving pleasure, lack of control over electronics and the habit of driving a vehicle.

The research shows that men in the 19–25 age group indicated no pleasure in driving a car and no control over electronics, as well as the potential elimination of professions (e.g., taxi drivers) and the possibility of the so-called cybercrimes. Men aged 26–40 spoke in a similar formula, pointing to the no control over electronics and the risk of cybercrimes. In turn, men aged 41–60 declared no driving pleasure and no control over electronics, but also cybercrimes. On the other hand, men over 60, among the biggest disadvantages, indicated the no driving pleasure and no control over electronics, but also possible boredom while driving a car.

AVs seem to be an interesting solution for many respondents, but not entirely realistic. Table 3 below presents the analysis of the correlation of various variables with regard to associations relating to this type of solution. The performed Spearman correlation, as an analysis, allows us to correlate the variables on the ordinal scale. This is a kind of nonparametric correlation that is based on rank.

Table 3. Spearman rank-order correlations MD pairwise deleted marked correlations are significant at $p < 0.05$.

Variable	x_1	x_2	x_3	x_4	x_5	x_6	x_7
x_1	1.000000	0.248955	0.116724	0.167230	0.173011	−0.307904	**−0.372148**
x_2	0.248955	1.000000	−0.083286	**0.336166**	0.107645	**−0.345075**	−0.227059
x_3	0.116724	−0.083286	1.000000	−0.147148	0.175057	0.100478	0.056061
x_4	0.167230	**0.336166**	−0.147148	1.000000	−0.024476	−0.247382	−0.307910
x_5	0.173011	0.107645	0.175057	−0.024476	1.000000	0.011198	−0.076679
x_6	−0.307904	**−0.345075**	0.100478	−0.247382	0.011198	1.000000	**0.485749**
x_7	**−0.372148**	−0.227059	0.056061	−0.307910	−0.076679	**0.485749**	1.000000

Variables: x_1, innovative solution; x_2, more AV on the road in the future; x_3, many different barriers; x_4, more positive than negative sides; x_5, they still need to be refined; x_6, AV is a utopia; x_7, not an interesting concept.

The analysis shows that the correlation of the variables related to the fact that AVs are not interesting (x_7), and at the same time, utopia (x_6) is of great importance; the second quite strong correlation concerned the relationship between the statement that AVs, despite being an innovative solution (x_1), are not interesting for the respondents (x_7). Another

correlation is the relationship between more AVs in the future on roads (x_2) and more positive sides than negative (x_4) and the fact that, although AVs are often treated as utopia (x_6), on roads, there will likely be more and more of them on the near future (x_2).

Figure 3 shows the approach to the correlation of individual variables presented in Table 3.

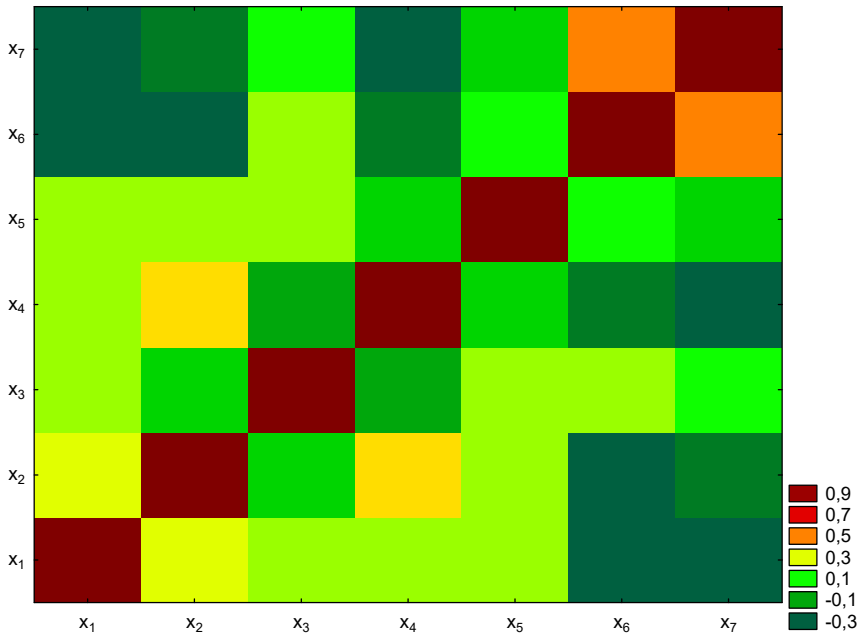

Figure 3. Three-dimensional sequential graph Spearman rank-order correlations in Workbook1 7v*7c.

The analysis shows that the respondents are quite cautious in making their judgments about this concept; they are quite skeptical about it, but they are aware that AV will enter the market, and, according to the analyses, most likely not so quickly. As it seems, the AV concept is realistic in the future, but, still, in relation to other types of vehicles traveling on Polish roads, it differs significantly from them in terms of its assumptions, infrastructure preparation and, above all, the mentality and culture of the society.

5. Discussion

AVs show great potential to radically change both the structure of cities and the dynamics of transport systems. Technologies such as advanced driver assistance systems (ADAS), e.g., lane keeping and adaptive cruise control, are already available on new vehicle models, and there is likely to be a gradual shift towards autonomy in the coming years.

The research results described in this paper show that changes to vehicle autonomy are generally well perceived by respondents and are only a matter of time. Similar statements can be found in the literature. Levinson and Krizek [32] suggest that full automation may be required in all new US vehicles by 2030 and that "human drivers will eventually be banned from public roads".

One of the most cited studies on AV adoption is the Litman study [25], which predicted that automated driving would become a standard feature of most new vehicles by 2050 and that AV would account for around 40–60% of vehicles, 80–100% of vehicle sales and 50–80% of vehicle travel. Litman also predicted that the beneficial effects of AV in increasing road safety and reducing traffic congestion would probably appear between 2040 and 2060. Bansal and Kockelman [39] predict that, by 2045, 24.8–87.2% of vehicle fleets will be accepted by self-propelled cars (SAE level 5). Their findings further revealed that AVs were viewed as a form of "somewhat low-risk" transport, and while there were concerns, there was little opposition to the prospect of their use on public roads.

The results obtained in the presented study regarding security as the main advantage of the possibility of using AV are similar to those achieved by Kyriakidis et al. [52], who

found that gaining end-user trust in the issues of data security, protection and privacy will be critical to the widespread implementation of AV in the future.

Payre et al. [53] conducted a survey among 421 people. Automated driving in this group was unconditionally accepted by 68.1%, with higher acceptance depending on the type of driving, including motorway driving, driving in the presence of traffic congestion and automatic parking. Similar results were obtained in a study by Howard and Dai [54], in Berkeley, California. People in this study were most attracted to the potential benefits of safety, parking and multitasking [55], which is also reflected in the results of the research presented in this paper. In our survey, 68% of respondents (396 people) confirmed that AV will be gradually introduced to our market, which confirms the high acceptance of this technology by Poles.

Own research also showed that AVs are generally viewed in a positive light; in terms of qualitative risk perception, they have been assessed relatively well compared to the existing modes of transport, and there has been little opposition to them. It would therefore seem that the idea of AV on public roads is already accepted by many people. However, further findings indicate that considerable efforts are still needed to encourage public acceptance. As in the research by Hulse et al. [17], despite an obvious low negative, concerns were expressed not only relating to road safety issues. Moreover, significant associations have been found between perceived risk assessments or attitudes and various factors, including road user populations, gender and age, meaning that AV perceptions vary, something that was also reflected in our own findings.

Furthermore, Hohenberger et al. [56] found that emotions and affective responses to AV indicate gender differences in the willingness to use automated vehicles. In particular, men were found to be more likely to predict pleasure than anxiety about wanting to use AV. Similar conclusions were also given in Reference [17], which showed that, compared to cars operated by people, AVs were perceived differently depending on gender and age-men, and younger adults showed greater acceptance of them.

It should be emphasized that the respondents participating in the research conducted by the authors of this article also pointed to numerous negative views on the problem of functioning in the AV space. This corresponds to the results of the research by Schoettle and Sivak [57], wherein respondents similarly also revealed numerous concerns about AV travel. The greatest concerns were system or hardware failures with security implications. Moreover, participants were very concerned about the fact that the AVs did not give the option to take control of the vehicle, and they thought about the fact that other types of road vehicles are also autonomous. While there were some differences in the survey responses depending on the age of the participant (e.g., older participants were more likely than younger participants to say they would not drive AV), gender differences were detected in nearly all questions, with women being less convinced of AV than men. It should be added that References [10,57] present research of a more global nature, i.e., among the inhabitants of China, India, Japan, the United States, Great Britain and Australia. As can be seen, such fears and positions indicated in the own research among Polish respondents do not only occur locally, but show global trends. It can therefore be said that there are similar social concerns with regard to AV technology regardless of where you live.

In other studies that are available in the literature on the subject, respondents also stated that they could not afford the additional costs. It also took into account the risk context when unknown entities can gain access to data, i.e., through hacking; therefore, many participants in many studies conducted so far had clear concerns about privacy policy [58], which is also consistent with the results of own research.

At present, autonomous vehicles are still in the trial phase and have not yet been introduced into regular operation in any country. Scientific publications discussing organizational issues related to the functioning of transport systems, in which autonomous vehicles are present, are still mainly based on theoretical assumptions.

One of the problems in implementing of technology AV is the interaction between autonomous vehicles and other road users [59], including non-motorized ones, i.e., cyclists and pedestrians, who cannot easily be controlled by traffic control systems.

The sustainable development policy should primarily aim at eliminating the negative effects of motorization, such as congestion in cities, air pollution, the lack or unequal accessibility of transport, as well as the increasing costs of infrastructure maintenance. National governments should initiate close cooperation between vehicle manufacturers and local authorities in terms of strategies for implementing available technological solutions. However, the lack of precise visions of the technical and organizational model of automation means that local and regional authorities do not want to make specific planning decisions in this area yet. This is because of the high risk due to the many unknowns and sometimes because of more urgent investment needs [60]. The obtained results of our own and other social research may be helpful in developing assumptions for further development of urbanized areas and autonomous means of transport.

It should be assumed that the safety and reliability of AV will continue to increase with the progress of civilization and technology. Public infrastructure will begin to evolve to support AV. New business models will be created. Intelligent mobility will become a reality as cities become "smarter" and cars become autonomous. Companies and car manufacturers are ready for AV, while the biggest unknown is whether our society is ready for such a solution. Indeed, the trend of vehicle automation technology by major vehicle manufacturing industries is expected to move closer to highly automated or fully autonomous vehicles through technological advances in the robotics and artificial intelligence sectors. This is because, as also shown in our own research, AVs have great potential to increase mobility. In some cases, this situation may indicate the need to change from the existing infrastructure solutions to the habits of drivers, and it will certainly be a big revolution on the automotive market.

6. Conclusions

As a result of the research and analysis of their results, the following observations and conclusions were formulated.

Firstly, the analysis of the correspondence found that young people are most favorable to the concept of AV, and this applies to both women and men. EVs are in second place, dominating among women in the 26–40 age group and among men in the 41–60 age group. It was also noted that there are advantages over disadvantages to AV. Moreover, due to their age, the participants of the study had similar opinions on AV. Over 40% of respondents indicated that if AV was widely used, they would feel safer. On the other hand, most of the people interviewed are concerned about cybersecurity and privacy related to the technologies used. Among the benefits of using AV vehicles, the respondents indicated mainly comfort, more efficient use of time, greater safety and less stress related to driving. The issues of greater mobility and independence of people with disabilities, the elderly or those unable to drive a car turned out to be very important. The respondents paid less attention to access to services, savings in parking spaces or lower transport congestion.

Our own conducted research indicated some gender differences and those resulting from the age of the respondents. However, it is worth emphasizing that women aged 41–60 paid attention primarily to safety and mobility; in turn, women over 60 years of age clearly indicated less stress while driving. Among the disadvantages, women most often indicated the no control over electronics and control systems, while men, as well as the no control over the system, indicated the no pleasure in driving and the fear of becoming weaned from driving and the loss of this ability. Both women and men also noticed the social effect of eliminating the profession of taxi driver. Moreover, it was found that the local perception of the AV concept is positive and consistent with global trends in this area.

Author Contributions: Conceptualization, A.D., M.S. and J.C.; methodology, A.D. and M.S.; software, A.D.; validation, M.S., J.C. and A.K.; formal analysis, A.D. and J.C.; investigation, A.D., M.S. and J.C.; resources, A.D., M.S., A.K. and J.C.; data curation, A.D.; writing—original draft preparation, M.S., A.D., J.C. and A.K.; writing—review and editing, A.D., M.S. and J.C.; visualization, A.D. and A.K.; supervision, M.S. and A.D.; project administration, A.D. All authors have read and agreed to the published version of the manuscript.

Funding: Funded from the "Excellent science" program of the Ministry of Science and Higher Education as a part of the contract no. DNK/SP/465641/2020 "The role of the agricultural engineering and environmental engineering in the sustainable agriculture development".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jia, D.; Ngoduy, D.; Vu, H.L. A multiclass microscopic model for heterogeneous platoon with vehicle-to-vehicle communication. *Transp. B Transp. Dyn.* **2019**, *7*, 311–335. [CrossRef]
2. Tucki, K.; Orynycz, O.; Świć, A.; Mitoraj-Wojtanek, M. The Development of Electromobility in Poland and EU States as a Tool for Management of CO_2 Emissions. *Energies* **2019**, *12*, 2942. [CrossRef]
3. Papis, M.; Jastrzębski, D.; Kopyt, A.; Matyjewski, M.; Mirosław, M. Driver reliability and behavior study based on a car simulator station tests in ACC system scenarios. *Ekspolatacja Niezawodn. Maint. Reliab.* **2019**, *21*, 511–521. [CrossRef]
4. Pauer, G.; Török, Á. Static System Optimum of Linear Traffic Distribution Problem Assuming an Intelligent and Autonomous Transportation System. *Period. Polytech. Transp. Eng.* **2018**, *47*, 64–67. [CrossRef]
5. Rimkus, A.; Žaglinskis, J.; Stravinskas, S.; Rapalis, P.; Matijošius, J.; Bereczky, Á. Research on the Combustion, Energy and Emission Parameters of Various Concentration Blends of Hydrotreated Vegetable Oil Biofuel and Diesel Fuel in a Compression-Ignition Engine. *Energies* **2019**, *12*, 2978. [CrossRef]
6. Šarkan, B.; Gnap, J.; Kiktova, M. The importance of hybrid vehicle in urban traffic in terms of environmental impact. *Arch. Automot. Eng. Arch. Motoryz.* **2019**, *85*, 115–122. [CrossRef]
7. Geca, M.; Wendeker, M.; Grabowski, L. A City Bus Electrification Supported by the Photovoltaic Power Modules. SAE Technical Paper, 2014-01-2898. Available online: https://saemobilus.sae.org/content/2014-01-2898/ (accessed on 8 August 2021).
8. Kirk, B. Connected Vehicles: An Executive Overview of the Status and Trends. *Globis Consulting*, 21 November 2011.
9. Bagloee, S.A.; Tavana, M.; Asadi, M.; Oliver, T. Autonomous vehicles: Challenges, opportunities, and future implications for transportation policies. *J. Mod. Transp.* **2016**, *24*, 284–303. [CrossRef]
10. Schoettle, B.; Sivak, M. *A Survey of Public Opinion About Autonomous and Self-Driving Vehicles in the US, the UK, and Australia*; University of Michigan Transportation Research Institute: Ann Arbor, MI, USA, 2014.
11. Ioannou, P. *Automated Highway Systems*; Springer Science & Business Media: New York, NY, USA, 2013.
12. Nelson, S.P. Challenges and Technologies: The Human Friendly Vehicle in 2030 and Beyond. Freescale Semiconductor Inc. 2014. Available online: http://www.freescale.com/files/training_pdf/VFTF09_AA106.pdf (accessed on 4 August 2021).
13. Shariff, A.; Bonnefon, J.-F.; Rahwan, I. Psychological roadblocks to the adoption of self-driving vehicles. *Nat. Hum. Behav.* **2017**, *1*, 694–696. [CrossRef]
14. Kraan, M.; Mahmassani, H.S.; Huynh, N. Traveler Responses to Advanced Traveler Information Systems for Shopping Trips: Interactive Survey Approach. *Transp. Res. Rec. J. Transp. Res. Board* **2000**, *1725*, 116–123. [CrossRef]
15. Fagnant, D.J.; Kockelman, K. Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transp. Res. Part A Policy Pract.* **2015**, *77*, 167–181. [CrossRef]
16. Shin, J.; Bhat, C.R.; You, D.; Garikapati, V.M.; Pendyala, R.M. Consumer preferences and willingness to pay for advanced vehicle technology options and fuel types. *Transp. Res. Part C Emerg. Technol.* **2015**, *60*, 511–524. [CrossRef]
17. Hulse, L.M.; Xie, H.; Galea, E.R. Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Saf. Sci.* **2018**, *102*, 1–13. [CrossRef]
18. Becker, F.; Axhausen, K.W. Literature review on surveys investigating the acceptance of automated vehicles. *Transportation* **2017**, *44*, 1293–1306. [CrossRef]
19. Meyer, J.; Becker, H.; Bösch, P.M.; Axhausen, K.W. Autonomous vehicles: The next jump in accessibilities? *Res. Transp. Econ.* **2017**, *62*, 80–91. [CrossRef]
20. Friedrich, B. The effect of autonomous vehicles on traffic. In *Autonomous Driving*; Springer: Berlin/Heidelberg, Germany, 2016; pp. 317–334. [CrossRef]

21. Johnson, B. *Disruptive Mobility—A Scenario for 2040*; Barclays Investment Bank: London, UK, 2015. Available online: https://www.investmentbank.barclays.com/content/dam/barclaysmicrosites/ibpublic/documents/investment-bank/global-insights/barclays-disruptive-mobility-pdf-120115-459kb.pdf (accessed on 20 May 2021).
22. Bartuska, L.; Labudzki, R. Research of basic issues of autonomous mobility. LOGI 2019-Horizons of Autonomous Mobility in Europe. *Transp. Res. Procedia* **2020**, *44*, 356–360. [CrossRef]
23. Škultéty, F.; Beňová, D.; Gnap, J. City Logistics as an Imperative Smart City Mechanism: Scrutiny of Clustered EU27 Capitals. *Sustainability* **2021**, *13*, 3641. [CrossRef]
24. Krueger, R.; Rashidi, T.H.; Rose, J.M. Preferences for shared autonomous vehicles. *Transp. Res. Part C Emerg. Technol.* **2016**, *69*, 343–355. [CrossRef]
25. Litman, T. Autonomous Vehicle Implementation Predictions: Implications for Transport Planning. Victoria Transport Policy Institute. 2021. Available online: https://www.vtpi.org/avip.pdf (accessed on 15 June 2021).
26. Duarte, F.; Ratti, C. The Impact of Autonomous Vehicles on Cities: A Review. *J. Urban Technol.* **2018**, *25*, 3–18. [CrossRef]
27. Hamadneh, J.; Esztergár-Kiss, D. The Influence of Introducing Autonomous Vehicles on Conventional Transport Modes and Travel Time. *Energies* **2021**, *14*, 4163. [CrossRef]
28. Hamadneh, J.; Esztergar-Kiss, D. Impacts of Shared Autonomous Vehicles on the Travelers' Mobility. In Proceedings of the 2019 6th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), Cracow, Poland, 5–7 June 2019; pp. 1–9. [CrossRef]
29. Millard-Ball, A. Pedestrians, Autonomous Vehicles, and Cities. *J. Plan. Educ. Res.* **2016**, *38*, 6–12. [CrossRef]
30. Guerra, E. Planning for Cars That Drive Themselves: Metropolitan Planning Organizations, Regional Transportation Plans, and Autonomous Vehicles. *J. Plan. Educ. Res.* **2016**, *36*, 210–224. [CrossRef]
31. Heinrichs, D.; Cyganski, R. Automated Driving: How It Could Enter Our Cities and How This Might Affect Our Mobility Decisions. *disP Plan. Rev.* **2015**, *51*, 74–79. [CrossRef]
32. Levinson, D.; Krizek, K. The End of Traffic and the Future of Transport, 3rd ed.; Network Design Lab: 2015. Available online: http://www.princeton.edu/~{}alaink/Orf467F15/TheEndOfTraffic.pdf (accessed on 8 August 2021).
33. Milakis, D.; van Arem, B.; van Wee, B. *Policy and Society Related Implications of Automated Driving: A Review of Literature and Directions for Future Research*; Working Paper; Delft University of Technology: Delf, The Netherlands, 2015.
34. Xu, Z.; Wang, M.; Zhang, F.; Jin, S.; Zhang, J.; Zhao, X. PaTAVTT: A Hardware-in-the-Loop Scaled Platform for Testing Autonomous Vehicle Trajectory Tracking. *J. Adv. Transp.* **2017**, *2017*, 9203251. [CrossRef]
35. Nikitas, A. Automated cars: A critical review of the potential advantages and disadvantages of driverless technologies. In Proceedings of the First International Workshop on Smart Urban Mobility, Edinburgh, UK, 26–27 November 2015.
36. Fernandes, P.; Nunes, U.J.C. Platooning With IVC-Enabled Autonomous Vehicles: Strategies to Mitigate Communication Delays, Improve Safety and Traffic Flow. *IEEE Trans. Intell. Transp. Syst.* **2012**, *13*, 91–106. [CrossRef]
37. Greenough, J. 10 Million Self-Driving Cars Will Be on the Road by 2020. June 2016. Available online: http://uk.businessinsider.com/report-10-million-self-driving-cars-will-be-on-the-road-by-2020-2015-5-6?r=US&IR=T (accessed on 1 August 2021).
38. Krasniqi, X.; Hajrizi, E. Use of IoT Technology to Drive the Automotive Industry from Connected to Full Autonomous Vehicles. *IFAC-PapersOnLine* **2016**, *49*, 269–274. [CrossRef]
39. Bansal, P.; Kockelman, K.M. Forecasting Americans' long-term adoption of connected and autonomous vehicle technologies. *Transp. Res. Part A Policy Pract.* **2017**, *95*, 49–63. [CrossRef]
40. Dresner, K.M.; Stone, P. Sharing the Road: Autonomous vehicles meet human drivers. In Proceedings of the 20th International Joint Conference on Artificial Intelligence, Hyderabad, India, 6–12 January 2007; pp. 1263–1268.
41. Fajardo, D.; Au, T.-C.; Waller, S.; Stone, P.; Yang, D. Automated intersection control: Performance of future innovation versus current traffic signal control. *Transp. Res. Rec.* **2011**, *1*, 223–232. [CrossRef]
42. Hengstler, M.; Enkel, E.; Duelli, S. Applied artificial intelligence and trust—The case of autonomous vehicles and medical assistance devices. *Technol. Forecast. Soc. Chang.* **2016**, *105*, 105–120. [CrossRef]
43. Chan, C. Advancements, prospects, and impacts of automated driving systems. *Int. J. Transp. Sci. Technol.* **2017**, *6*, 208–216. [CrossRef]
44. Folsom, T.C. Social ramifications of autonomous urban land vehicles. In Proceedings of the 2011 IEEE International Symposium on Technology and Society (ISTAS), Chicago, IL, USA, 23–25 May 2011.
45. Xu, Z.; Zhang, K.; Min, H.; Wang, Z.; Zhao, X.; Liu, P. What drives people to accept automated vehicles? Findings from a field experiment. *Transp. Res. Part C Emerg. Technol.* **2018**, *95*, 320–334. [CrossRef]
46. World Health Organization. *Global Status Report on Road Safety 2015*; World Health Organization: Geneva, Switzerland, 2015.
47. Weber, M. Where to? A History of Autonomous Vehicles. 2014. Available online: http://www.computerhistory.org/atchm/where-to-ahistory-of-autonomous-vehicles (accessed on 15 July 2021).
48. Sparrow, R.; Howard, M. When human beings are like drunk robots: Driverless vehicles, ethics, and the future of transport. *Transp. Res. Part C Emerg. Technol.* **2017**, *80*, 206–215. [CrossRef]
49. Bischoff, J.; Maciejewski, M. Simulation of City-wide Replacement of Private Cars with Autonomous Taxis in Berlin. *Procedia Comput. Sci.* **2016**, *83*, 237–244. [CrossRef]
50. Nieoczym, A.; Tarkowski, S. The modeling of the assembly line with a technological Automated Guided Vehicle (AGV). *Logforum* **2011**, *7*, 35–42.

51. Nagy, S.; Csiszár, C. The quality of smart mobility: A systematic review. *Sci. J. Sil. Univ. Technol. Ser. Transp.* **2020**, *109*, 117–127. [CrossRef]
52. Kyriakidis, M.; Happee, R.; de Winter, J. Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transp. Res. Part F Traffic Psychol. Behav.* **2015**, *32*, 127–140. [CrossRef]
53. Payre, W.; Cestac, J.; Delhomme, P. Intention to use a fully automated car: Attitudes and a priori acceptability. *Transp. Res. Part F Traffic Psychol. Behav.* **2014**, *27*, 252–263. [CrossRef]
54. Howard, D.; Dai, D. Public perceptions of self-driving cars: The case of Berkeley, California. In Proceedings of the Transportation Research Board 93rd Annual Meeting; TRB 93rd Annual Meeting Compendium of Papers, Washington, DC, USA, 12–16 January 2014.
55. Zhang, W.; Guhathakurta, S.; Fang, J.; Zhang, G. Exploring the impact of shared autonomous vehicles on urban parking demand: An agent-based simulation approach. *Sustain. Cities Soc.* **2015**, *19*, 34–45. [CrossRef]
56. Hohenberger, C.; Spörrle, M.; Welpe, I.M. How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups. *Transp. Res. Part A Policy Pract.* **2016**, *94*, 374–385. [CrossRef]
57. Schoettle, B.; Sivak, M. *Public Opinion about Self-Driving Vehicles in China, India, Japan, the U.S., the U.K., and Australia*; University of Michigan Transportation Research Institute: Ann Arbor, MI, USA, 2014; pp. 1–31.
58. Maddox, J.; Sweatman, P.; Sayer, J. Intelligent vehicles? infrastructure to address transportation problems—A strategic approach. In Proceedings of the 24th International Technical Conference on the Enhanced Safety of Vehicles (ESV), Gothenburg, Sweden, 8–11 June 2015.
59. Moravčík, L. Typové Schválenie Autonómnych (Samojazdiacich) Vozidiel. *Perner's Contacts* **2020**, *15*, 2. [CrossRef]
60. Jaroszyński, M. Autonomous vehicles: Organizational scenarios and their threats and opportunities to transportation sustainability. *WUT J. Transp. Eng.* **2018**, *120*, 133–142. [CrossRef]