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The Role of Self-Driving Vehicles in Sustainability and Road Safety from a Generation-Specific Perspective

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ABSTRACT

A key milestone in technological development, self-driving vehicles are at the heart of the study, a solution that will significantly transform the future of transport. Consumer perceptions of self-driving vehicles are examined from a generation-specific perspective. We seek to answer the question of which of the generations, which differ significantly in terms of values, consumer habits and preferences, should be considered the most potential target market for self-driving cars. In a primary research project, we investigated the perception of self-driving cars by each generation in relation to the individual and the relation between traffic safety and conditions of use.

The research used a quantitative method of random sampling to analyse 8663 evaluable responses. Based on the results, we were able to identify and statistically verify generational differences in consumer opinions on self-driving cars and to characterise distinct consumer segments based on the purchase criteria for self-driving cars.

1. Theoretical Overview

Self-driving vehicles (AVs) are one of the most exciting developments in modern technology that are reshaping the future of transport. They could radically change the way we think about driving, road safety and urban planning. Below we detail the operation, benefits, challenges and future prospects of self-driving vehicles.

1.1 How Self-Driving Vehicles Work

Self-driving vehicles use a set of technologies and algorithms that allow the vehicle to navigate its environment without human intervention. These vehicles use sensors, radars, LIDAR systems and

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cameras to collect data about their environment, which is processed by a central processing unit. This unit uses the data to make decisions about steering, acceleration and braking, allowing the vehicle to travel safely on the road [25].

The technological revolution in self-driving vehicles (AVs) has the potential to transform not only the way we travel, but also to have profound economic and social impacts [26]. These changes are particularly important for mobility and sustainability, as well as for the labour market. These aspects of AV technology will be discussed in detail below, with a particular focus on urban areas and the transport-logistics sector.

The development of self-driving vehicle technology has opened a new era in the world of transport. The levels of vehicle automation can be understood through the five levels defined by SAE International (formerly Society of Automotive Engineers), which illustrate the gradual handover between the human driver and machine intelligence in driving tasks [39]. In this detailed overview, we will examine the levels of self-driving to better understand how these technologies are changing the way we drive [48].

Level 0 - No Automation

At this level, the vehicle is entirely under the control of the human driver, with all driving tasks, including steering, accelerating and braking, performed by the human. There is no automation technology here, except for some basic assistance systems such as ABS (anti-lock braking system).

Level 1 - Assisted Driving

Level 1 means support for the driver in one or more specific driving tasks, such as adaptive cruise control or lane keeping assist. In this case, the driver must be constantly aware of the environment and ready to take control at any time.

Level 2 - Partial Automation

At this level, the vehicle can perform several driving tasks at once, such as steering and speed control, automatically, but the driver still needs to be aware of the environment and ready to intervene. Examples of Level 2 automation include systems such as advanced cruise control, which adjusts its own speed to the speed of the vehicle in front.

Level 3 - Transition Automation

Level 3 means a significant degree of autonomy. The vehicle is able to fully take over driving tasks in certain circumstances, such as motorway driving. In this case the driver does not need to be constantly aware of the surroundings, but must be ready to take back control if necessary.

Level 4 - High Automation

Level 4 self-driving vehicles are able to drive fully autonomously in certain predefined areas or conditions, such as in urban environments or dedicated lanes. Human intervention is no longer required in these areas and the vehicle can handle all types of driving situations that may occur in these areas.

Level 5 - Full Automation

Level 5 represents the pinnacle of self-driving technology, where the vehicle is capable of fully autonomous driving in any environment and under any conditions. No human driver or driver

intervention is required; the vehicle can navigate in all situations, including extreme weather conditions and unexpected road conditions.

An overview of the levels of self-driving highlights the complex process by which vehicles are increasingly taking control from human drivers. This path of technological development is not only intended to improve the safety and efficiency of transport, but also presents new challenges in terms of legal regulation, ethics and social acceptance. As we move forward on the path of self-driving vehicle development, it is important to monitor these changes and proactively address the issues that arise as the technology becomes more widely adopted [35].

1.2 Mobility and Sustainability

AVs can significantly improve mobility and sustainability, especially in densely populated urban environments [40]. These benefits are highlighted in the following sections:

Transport Efficiency: optimised routing of AVs and elimination of human error can reduce congestion, allowing faster and smoother journeys. This means less time spent on the road, which improves quality of life and increases labour market productivity [15, 10].

Environmental Footprint: more efficient operation of self-driving vehicles can reduce fossil fuel consumption and greenhouse gas emissions. The uptake of electric AVs can further enhance this effect, contributing to greener and more sustainable urban environments [17].

Access to Mobility: AV technology can increase the mobility of people with reduced mobility, elderly people and people who cannot or do not want to drive. This can improve social inclusiveness and the quality of daily life [50].

Social and health impacts: AVs can reduce the number of road accidents, which often cause serious injuries and deaths. In addition, spending less time behind the wheel can reduce stress and improve overall well-being [2].

1.3 Impact of Self-Driving Vehicles

The spread of AVs could bring fundamental changes to the labour market, especially in the transport and logistics sectors. Workers in the transport and logistics sectors, such as truck drivers, taxi drivers and couriers, may face the reality that some or all of their work will be taken over by AV technologies [4]. This may cause temporary labour market dislocation. However, AV technologies may also create new jobs and occupations, such as vehicle installation engineers, data analysts, and system administrators [16]. New skills are also needed to maintain, upgrade and monitor AVs. The key to managing the technology transition will be retraining the workforce and teaching new skills. Governments, educational institutions and industry must work together to provide workers with the resources and training needed to ease the transition [43, 41].

As well as addressing labour market changes, it is important to consider regulatory and ethical issues such as workers' rights and the social impact of technological developments.

The economic and social impacts of self-driving vehicles are wide-ranging and complex. In addition to the benefits in terms of mobility and sustainability, the impacts on the labour market require significant attention [3]. As the technology advances, it is important to proactively address the challenges of integrating AV technologies into society and to ensure that technological progress benefits all [7, 6]. Re-education, the development of regulatory frameworks and the promotion of

social discourse are key steps for the successful and sustainable integration of self-driving vehicles into society [24].

In the case of self-driving vehicles, it is also important to mention their additional impact and benefits. One of these is safety, improving road safety. A significant proportion of road accidents are caused by human error, so by eliminating the human factor, self-driving vehicles can reduce the number of accidents. In addition, efficiency: AVs can optimise route planning and reduce congestion, thus increasing transport efficiency. In terms of their environmental impact, self-driving vehicles have the potential to reduce emissions by making vehicles more efficient and promoting the uptake of electric vehicles [46]. In addition, AVs enable disabled and elderly people to travel independently, thus improving their quality of life [2].

At the same time, we cannot forget the concerns and reservations about self-driving technology. Although AVs are designed to increase safety, the novelty of the technology and potential system failures can cause concern among consumers. [32] In addition, people's distrust of new technologies is relevant, and the loss of the experience of driving a car is also an experiential risk that could be a barrier to the uptake of the technology [29, 30].

Legal and regulatory issues cannot be ignored. The widespread introduction of AVs requires a new legal and regulatory framework that addresses the specific issues raised by such vehicles. As well as the scope for data protection, the volume and sensitivity of the data collected by AVs raises privacy concerns [44].

Continued research and development in the field of self-driving vehicles is expected to address current challenges and further refine the technology. The market penetration of AVs is expected to increase in the coming decades as the technology matures, consumer confidence grows and the legal framework adapts to the new technological environment [20].

In addition to the paradigm shift in transport, AV technology can also have a significant economic and social impact, creating new business models and job opportunities while transforming urban areas and infrastructure. As the technology evolves, it will be important to engage all segments of society in the debate and decision-making to ensure a positive and inclusive future for self-driving vehicles [22].

Self-driving vehicles offer a promising future where transport is safer, more efficient and more inclusive [21]. As we move forward on this journey, a balance of technological innovation and social adaptation will be key to successfully integrating self-driving vehicles into our daily lives. [28, 34].

1.4 Technology Adoption and Consumer Attitudes

When adopting a new technology, it is important to know and understand the impact mechanisms relevant to the end user, the consumer side [11]. According to Rogers' theory, the adoption of innovations depends on the innovative attributes of individuals and the perceptual attributes of the technology [38]. In the case of self-driving vehicles, this includes perceived usefulness, compatibility, observability, trialability and complexity [37].

In our view, consumer trust is of paramount importance for self-driving technology [42, 13]. To increase consumer trust, it may also be necessary to strengthen the legal and regulatory frameworks that ensure the responsible adoption and use of AV technology. [18] Clear definition of and compliance with government and industry standards and safety regulations are essential to enhance consumer confidence. Overall, consumer confidence in self-driving technologies can only be effectively built if safety concerns are taken seriously and proactively addressed. Alongside technological innovation, building and maintaining consumer trust is also key to the long-term

success and social acceptance of self-driving vehicles [27], [9]. This is why the focus of our primary research was also on the examination of consumer acceptance and the analysis of how consumer trust is established [12], [5].

The adoption of innovation is also very much influenced by the consumer generation [19]. Younger generations tend to be more open to new technologies, while older generations may be more resistant [1, 45, 14]. For this reason, we analysed the issue of consumer adoption of self-driving technology from a generation-specific perspective in our primary research [51]. With this in mind, we consider it important to briefly review the main characteristics of each generation to see the salient consumer, value differentials that may determine consumer attitudes towards such a new technology [47].

1.4.1 Generational differences

Generational theories and differences play an important role in understanding social dynamics, including the adoption of technological innovations. The unique characteristics, values and experiences of each generation have a significant impact on how they respond to new technologies. Below, we examine the characteristics and attitudes of the most well-known generations - Baby Boomers, Generation X, Generation Y (also known as Millennials) and Generation Z - in the context of technological innovation.

The Baby Boomer generation is often described as having achieved their goals through hard work and sacrifice. This generation grew up in the age of television and witnessed the first human spaceflight, which gave them a fundamental optimism about technological advances. At the same time, their receptivity to digital technologies varies; some are actively engaged in the digital world, while others find it harder to adapt to new technologies. As a result, the adoption of AVs and other new technologies among this group tends to be slower, with reliability and security being their priorities.

Generation X are often seen as the bridge to the digital transition: they were not exposed to digital technologies as children, but as adults they have witnessed and actively participated in the dawn of the digital age. This generation appreciates the potential of technology, but is more critical of innovation and places greater emphasis on privacy and security. Generation X approaches the adoption of AV technology with cautious optimism, appreciating the potential benefits of new technologies but may be sceptical of their risks.

Millennials are the first truly digital natives for whom the internet, mobile technologies and social media are a natural part of everyday life. This generation is extremely open to new technologies and adapts quickly to them. Millennials value innovation, especially when it improves quality of life or offers sustainable solutions. Their interest in AVs is high as they see the potential of these technologies in terms of convenience, efficiency and reduction of ecological footprint [49].

Generation Z, already born into a fully digital world, is even more committed to new technologies and innovation. For Generation Z, smartphones and tablets are part of everyday life from an early age. For this generation, AVs and other advanced technologies are not only acceptable, they are desirable and necessary because of the efficiency, environmental awareness and innovation they represent. Generation Z is particularly interested in technologies that offer personalised experiences and high levels of network connectivity.

The relationship between Generation Alpha and self-driving cars is particularly noteworthy in terms of technological adaptation and future mobility trends. They are born with digital technology and innovation as a natural part of their environment, so for them the use of autonomous vehicles can be intuitive and self-evident. This generation is growing up with the knowledge that driving a car

does not necessarily require human intervention, which could fundamentally change their attitude towards transport and mobility. [31] Members of Generation Alpha are getting used to the presence of AI in their lives at an early age, whether it is smart devices, smart home applications or personalised digital assistants. This kind of technological convenience and integration prepares them for the adoption of self-driving cars, which they may see as a natural and logical development in technological progress. For Generation Alpha, safety and sustainability could be key factors. The potential of self-driving cars to reduce traffic accidents and optimise the energy efficiency of vehicles is in line with the values that their parents and educational systems emphasise. The ability of autonomous vehicles to offer less polluting, more efficient transport solutions could be attractive to them. Members of Generation Alpha are likely to think in terms of new mobility paradigms, where personal ownership of cars is replaced by shared and service-based transport solutions. In this context, the integration of self-driving vehicles may not only drive technological advances, but also transform transport habits and urban planning [33]. As Generation Alpha becomes comfortable in the digital space, the role of parents and educators will be crucial in teaching them the importance of digital ethics and privacy. The issues of data collection and processing that arise when using self-driving cars can be critical points to pay attention to early on [8].

The characteristics and attitudes of different generations have a significant impact on the adoption of technological innovations, including autonomous vehicles. Baby Boomers and Generation X are more cautious, while Generations Y and Z are more open and receptive to new technologies. Understanding and addressing the needs and concerns of different generational groups is key to the successful introduction and adoption of AV technology. Bridging the gap between generations and facilitating cross-generational communication could be the key to widespread adoption of autonomous vehicles. Generation Alpha, as the first true "indigenous" users of self-driving cars, can have a profound impact on how future transport systems evolve. Their adaptive capacity and their openness and acceptance of new technologies will be a key factor in the further development and widespread adoption of self-driving technology. The attitudes and behaviours of Generation Alpha will be key to how society integrates and uses autonomous vehicles in the near future [24].

2. Material and method

In this paper, we present the results of our primary research in addition to a systematic review of the relevant national and international literature. In the framework of primary data collection, we conducted quantitative research in the form of a pre-tested, standardised online questionnaire.

Subjects were recruited using an arbitrary sampling procedure, resulting in 8663 assessable questionnaires.

The research tool included two open-ended questions to test free association, the others were closed questions at nominal measurement level-one and multiple-choice selective questions-and Likert and semantic differential scales to analyse consumer attitudes and preferences. Scale questions were asked using a scale of 1 to 4. One reason for this is the individual scale preference of Hungarian respondents: due to the school grading system, they are most stable in interpreting a scale up to five as opposed to scales 1-7, 1-9 or 1-10.

The odd scale was chosen because the middle value (3) for the odd (1-5) scale is an escape route for respondents. In the analysis of attitudes, those who chose the middle value do not tip the scales in either direction, resulting in an excessive proportion of "indifferent" consumers, making it difficult

to segment them in a statistically and professionally meaningful way. Excluding the middle value leads the respondent to take a more rigorous stance, thus contributing more to conducting a successful segmentation [33].

The themes of the research tool were developed as a result of relevant secondary data analysis. Each response alternative - the pre-testing of the research tool - was finalised in the light of the qualitative results. As part of this qualitative research phase, 20 mini-focus group interviews were conducted using a semi-structured interview schedule. Qualitative sampling was also carried out using the snowball method. The mini-focuses were guided group discussions with 3-4 participants each, with a heterogeneous composition in terms of gender and age. The main objective of the qualitative research was to establish the quantitative research, finalise the standardised questionnaire and outline the research hypotheses. The themes of the quantitative research tool finalised as a result of the qualitative phase were: transport habits, perceptions of self-driving technology, consumer perceptions of self-driving cars, sociodemographic data. In this paper we focus on the partial results of the quantitative phase of our research project. Within this, we have also focused on generation-specific perceptions of self-driving cars.

To test the research hypotheses, the existence of correlations between non-metric questions was assessed using Pearson's Chi-square significance, while the absolute values of the Adjusted Residual (Adj.R) were used to establish and analyse internal correlations.

To examine the correlation between the nominal and metric scale results, the analysis of variance method was used, including the one-way ANOVA method for comparing multiple sample means. The mean of a metric dependent variable was compared between more than two groups. The post-hoc test was used to determine which pairs of groups were significantly different. In doing so, significance values were used to determine the existence of correlations (sig<= 0.05). Internal correlations were analysed along the comparison of group means using the F-statistic, i.e. the coefficient of variance of the means within samples. [23]. In the first step of segmentation based on the expectations of self-driving technology, we performed a factor analysis on the elements of the preference system, deciding on the final factor structure based on the KMO value, the total variance value and the professional explanatory power. The procedure involved Principal Component Analysis and varimax rotation. And for segmentation, we used the K-means clustering procedure for the sample element number reason.

The main socio-demographic characteristics of the sample show that there was an equal gender split (50-50%) between male and female respondents. In terms of generational distribution, respondents of different ages were almost equally represented: 23% were the youngest, Generation Alpha respondents; 20% were Generation Z respondents; 22% of the respondents were Generation Y; 16% were Generation X; and 19% of the sample were Baby Boomers. 62% of the sample drive a car regularly.

In the framework of quantitative research, our main objective was to analyse the perception of self-driving cars generation-specifically. Within this, a comprehensive analysis of consumer perceptions of self-driving cars and self-driving systems, their confidence, safety perception and use in a generational context. The aim of our research was to analyse the use of consumer perceptions of self-driving cars as segmentation cognitions. In light of these objectives, we focused on testing the following hypotheses:

- H1: Perceptions of self-driving systems are related to the generation of the individual in terms of perceptions of the future of the technology (H1/a), road safety (H1/b), safety of the occupant (H1/c) and use of the technology (H1/d).
- H2: the conditions for buying self-driving cars have generation-specific elements.
- H3: Consumer preferences towards the use of self-driving cars can be used as segmentation knowledge.

3. Results

For the first time, we analysed opinions on self-driving cars across the whole sample. Most people consider it an immature technology and unreliable - the third most cited adjective. However, many see it as the car of the future. And while more people consider it expensive, almost as many say it is a trendy technology.

Table 1
Consumer perceptions of the future of self-driving cars

the self-driving car	%
will be the car of the future	**19.4**
not reliable	**10.9**
technology not yet mature	**25.0**
safe	5.4
convenient	9.6
dear	*10.5*
accident risk	8.2
trendy	*10.1*
you don't know	0.9
Total	100.0

Source: own research, 2023. N=8663 persons

It was also clear from the differentiated responses that the respondents' opinions on self-driving cars were far from uniform.

Table 2
Consumer opinions on self-driving car users

the driver of the self-driving car,	Valid Percent
who trusts technology more than himself	**19.2**
who likes to try new things	**28.1**
who likes to do several things at once	11.7
who can't drive well	14.2
who don't want to miss out on technological innovations	**15.1**
who work too much and can't concentrate on driving	11.6
Total	100.0

Source: own research, 2023. N=8663 persons

According to most respondents, people who drive a self-driving car are innovative and like to try new things and new technologies. This suggests that most people do not see self-driving cars as a substitute for traditional driving, but as the answers to the previous question suggest, they see a

fashion-conscious person who keeps up with innovations and does not want to be left behind by technological innovations behind the wheel of a self-driving car.

However, it is also true that most respondents say that the most likely adopters of such technology are those who are more confident in it than in their own abilities. This also confirms that the self-driving car user is perceived as someone who follows technological innovations, is open to innovation and has a positive attitude towards technology.

We also looked at general perceptions of self-driving cars by generation. The Pearson's Chi-square test for significance (sig = 0.000) showed that the two variables are not independent of each other (H1/a confirmed).R), we found that the youngest generation, Alpha, is the generation most likely to see it as the car of the future, and that this generation also had a higher than expected proportion of those who considered self-driving technology trendy and safe, but expensive.

Among Baby Boomers, there was a higher than expected proportion of sceptics, who said it was unreliable, and even if it was a convenient solution, it was a distinctly accident-prone and expensive one.

A higher than expected proportion of Generation Y members considered self-driving cars to be an immature technology, suggesting that there are still doubts and fears about self-driving vehicles among this generation.

Table 3
Generation-specific analysis of the future of self-driving cars

			Generations					**Total**
			Alpha	Generation X	Generation Y	Generation Z	baby boomer	
self-driving car according to you	will be the car of the future	Count	425	346	386	315	209	1681
		line%	25.3%	20.6%	23.0%	18.7%	12.4%	100.0%
		Adj.R	**2.6**	1.6	0.7	-0.8	-4.6	
	not reliable	Count	169	228	148	177	221	943
		line%	17.9%	24.2%	15.7%	18.8%	23.4%	100.0%
		Adj.R	-3.8	4.1	-5.2	-0.6	**6.4**	
	technology not yet mature	Count	343	462	623	482	257	2167
		line%	15.8%	21.3%	28.7%	22,2%	11.9%	100.0%
		Adj.R	-9.0	2.9	**8.3**	3.8	-6.3	
	safe	Count	127	94	99	73	77	470
		line%	270%	20.0%	21.1%	15.5%	16.4%	100.0%
		Adj.R	**2.2**	0,4	-0.7	-2.2	0.1	
	convenient	Count	203	186	142	136	161	828
		line%	24.5%	22.5%	17.1%	16.4%	19.4%	100.0%
		Adj.R	1.2	**2.5**	-3.7	-2.3	**2.7**	
	dear	Count	250	114	225	149	174	912
		line%	27.4%	12.5%	24.7%	16.3%	19.1%	100.0%
		Adj.R	**3.5**	-5.5	1.8	-2.5	2.5	
	accident risk	Count	117	96	153	154	192	712
		line%	16.4%	13.5%	21.5%	21.6%	27.0%	100.0%
		Adj.R	-4.3	-4.1	-0.5	1.5	**8.2**	
	trendy	Count	329	114	143	187	98	871
		line%	37.8%	13.1%	16.4%	21.5%	11.3%	100.0%
		Adj.R	**11.1**	-4.8	-4.4	1.6	-4.1	
	you don't know	Count	16	25	12	13	9	75
		line%	21.3%	33.3%	16,0%	17.3%	12.0%	100.0%
		Adj.R	-0.3	3.1	-1.3	-0.5	-1.0	

Source: own research, 2023. N=8663 persons

We also looked at the relative confidence of each generation in such a technology. A correlation test between the metric and non-metric scales (One-Way Anova sig value =0.000) showed that the statistical correlation between the two variables is confirmed (H1/b is confirmed). The results show that the youngest generation, Alpha, would be the most confident in this technology and Baby Boomers are the most distrustful.

Table 4
Confidence in self-driving systems in a generational context

Confidence in the self-driving system (where, 1=not at all 4= completely trust it)				
	N	**Mean**	**Std. deviation**	**sig**
Baby Boom	1398	2.73	1.362	0.000
Generation X	1665	2.77	1.347	
Generation Y	1931	2.90	1.359	
Generation Z	1686	2.85	1.358	
Alpha	1982	**2.95**	1.369	
Total	8662	2.85	1.361	

Source: own research, 2023. N=8663 persons, One-Way ANOVA, sig=0.000

The extent to which people would feel safe in a self-driving vehicle was also examined using analysis of variance across different generations. Due to sig = 0.000, the statistical correlation between the two variables was verified (H1/c confirmed) and in this case, the Alpa generation was the most positive, while Baby Boomers were also the most sceptical and distrustful.

Table 5
Perception of safety of self-driving cars in a generational context

Feeling safe in a self-driving car (1=I don't feel safe at all, 4=I feel very safe)				
	N	**Mean**	**Std. deviation**	**sig**
Baby Boom	1398	2.79	1.409	0,010
Generation X	1665	2.78	1.368	
Generation Y	1931	2.80	1.361	
Generation Z	1686	2.86	1.337	
Alpha	1982	**2.92**	1.353	
Total	8662	2.83	1.365	

Source: own research, 2023. N=8663 persons,

Consumer perceptions of self-driving car use were also analysed in a generational context, with Pearson's sig value (<=0.05) indicating that the correlation between the two variables was statistically valid (H1/d). The analysis of internal correlations showed that the proportion of those who would use such technology was higher than expected among Generation Alpha and Generation X, while among those who would not, this was true for Baby Boomers. Generations Y and Z appeared hesitant to use it, despite the fact that their answers to the previous questions did not indicate a negative attitude.

Table 6
Analysis of self-driving car use in a generational context

Self-driving car use and the intergenerational link								
			baby boomer	Generation X	Generation Y	Generation Z	generations Alpha	Total
Would you use a self-driving car	yes	Count	438	644	534	399	687	2702
		% within Would use a self-driving car	16.2%	23.8%	19.8%	14.8%	25.4%	100.0 %
		Adjusted Residual	-10.0	**7.3**	-3.8	-7.4	**15.8**	
	not	Count	199	109	108	103	111	630
		% within Would use a self-driving car	31.6%	17.3%	17.1%	16.3%	17.6%	100.0 %
		Adjusted Residual	**5.4**	-1.3	-3.2	-2.0	1.0	
	perhaps	Count	669	529	733	723	350	3004
		% within Would use a self-driving car	22.3%	17.6%	24.4%	24.1%	11.7%	100.0 %
		Adjusted Residual	-1.0	-2.8	**3.4**	**7.9**	-8.3	
	I don't know	Count	677	383	556	461	250	2327
		% within Would use a self-driving car	29.1%	16.5%	23.9%	19.8%	10.7%	100.0 %
		Adjusted Residual	**8.3**	-4.0	2.2	0.5	-8.3	
	Total	Count	1983	1665	1931	1686	1398	8663
		% within Would use a self-driving car	22.9%	19.2%	22.3%	19.5%	16.1%	100.0 %

Source: own research, 2023. N=8663 persons,

We then looked at the conditions for buying a self-driving car in relation to generational affiliation. The results showed that the statistical correlation between the two variables was confirmed (sig<=0.05; H2 confirmed). For Baby Boomers, the most important criterion was cheapness, Generation Alpha expects self-driving cars to be faster and the value of the cars to be higher. In other words, the technology itself is a value-adding factor in their eyes.

For Generation Y, the simplification of driving and for Generation X, the impact on traffic and passenger safety were the most important aspects.

Table 7
Generation-specific analysis of the conditions for buying a self-driving car

Conditions for buying a self-driving car		N	Mean	Std. deviation	sig
Self-driving system should be cheap	Alpha	1983	2.58	1.098	0.000
	Generation X	1665	2.59	1.048	
	Generation Y	1931	2.43	1.067	
	Generation Z	1686	2.44	1.053	
	baby boomer	**1398**	**2.67**	1.111	
	Total	8663	2.54	1.079	
Self-driving system to simplify driving	Alpha	1983	3.07	0.869	0.000
	Generation X	1665	3.15	0.850	
	Generation Y	1931	**3.22**	0.828	
	Generation Z	1686	3.11	0.839	
	baby boomer	1398	3.12	0.935	
	Total	8663	3.14	0.863	
A self-driving system to make transport faster	**Alpha**	1983	**2.95**	0.965	0.000
	Generation X	1665	2.80	1.011	
	Generation Y	1931	2.83	0,970	
	Generation Z	1686	2.85	0.948	
	baby boomer	1398	2.81	1.059	
	Total	8663	2.85	0.989	
Self-driving system to increase road safety	Alpha	1983	3.34	0.829	0.000
	Generation X	1665	**3.51**	0.775	
	Generation Y	1931	3.49	0.771	
	Generation Z	1686	3.34	0.889	
	baby boomer	1398	3.48	0.810	
	Total	8663	3.43	0.819	
Self-driving system to increase the value of your car	**Alpha**	1983	**2.51**	1.085	0.000
	Generation X	1665	2.44	1.103	
	Generation Y	1931	2.41	1.097	
	Generation Z	1686	2.34	1.087	
	baby boomer	1398	**2.57**	1.093	
	Total	8663	2.45	1.095	
Self-driving system to increase passenger safety	Alpha	1983	3.44	0.783	0.001
	Generation X	1665	**3.50**	0.805	
	Generation Y	1931	3.45	0.825	
	Generation Z	1686	3.38	0.812	
	baby boomer	1398	3.46	0.860	
	Total	8663	3.45	0.816	

Source: own research, 2023. N=8663 persons,

A further aim of our research was to examine whether these consumer segments can be defined on the basis of expectations of self-driving cars.

To this end, for the first time, we conducted a factor analysis of the factors we investigated for self-driving cars.

This resulted in three groups of factors:

The 'Safety Factor', which includes factors such as the safety enhancing role of the system, passenger safety and overall transport safety.

The "Value-Adding Factors Group", which includes the additive, positive impact on the value of cars, their speed, and the ease of driving.

The "Cheapness factor group", which includes the cheapness criterion.

Table 8
Expectations of self-driving system by factor group

	Factors		
	Security	**Value added**	**Cheapness**
Self-driving system to increase passenger safety	**0.899**	0.114	0.069
Self-driving system to reduce the number of accidents	**0.884**	0.061	0.078
Self-driving system to increase road safety	**0.850**	0.172	0.048
Self-driving system to increase the value of your car	-0.121	**0.775**	0.224
A self-driving system to make transport faster	0.176	**0.766**	0.095
Self-driving system to simplify driving	0.310	**0.624**	-0.058
Self-driving system should be cheap	0.126	0.161	**0.963**

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.
Source: own research, 2023. N=8663 persons,

Next, a cluster analysis was performed on the results of the tree analysis to see if the sample could be segmented by factor groups.

The results showed that the following significantly different consumer groups could be defined (H/3 confirmed):

The "Seekers of Plus Benefits", for whom the benefits of self-driving systems, such as speed, added value, convenience, are a priority.

The "Safety and Extras Lovers", for whom the safety enhancing role of self-driving systems is the most important consideration, followed by the search for additional benefits.

"Price-sensitive consumers", for whom cheapness is the most important aspect of their expectations of self-driving systems.

Table 9
Consumer segments based on expectations of self-driving systems

	Consumer segments		
Factors influencing expectations of self-driving systems	**Seekers of extra benefits (4136 persons)**	**Safety and extras lovers (1883 people)**	**Price-sensitive consumers (2644 persons)**
Safety factor	0.52905	-1.49306	0.23573
Factor of value-adding factors	-0.02978	-0.26460	0.23504
Cheapness factor	0.60764	0.21040	-1.10037

Source: own research, 2023. N=8663 persons, K-means clustering procedure

4. Summary

The fundamental aim of our research was to provide a generation-specific analysis of self-driving cars and self-driving technology. In terms of results, we found that self-driving technology is mostly seen as a trendy, safe and convenient solution by the younger generation (Alpha), while the older generation (Baby Boomer) was the most sceptical about self-driving systems. Generation Alpha and Generation X were the most open to using this technology. Generations Y and Z were hesitant to use the technology, despite the fact that they did not show any reluctance or negative attitudes towards

it. Thus, we think that the uncertainty is mainly explained by a lack of precise knowledge of the technology, a fear of novelty and reticence. We believe that this can best be mitigated by educational campaigns. The openness of the youngest generation to novelty could, in our opinion, be successfully applied in these campaigns. For Generation Alpha, technological innovation is more natural than for any other older generation. No wonder they have no doubts or fears, because for them these innovative solutions and technological innovations are not the result of a long-term development and evolution, but are their starting point in the world of technology. Whereas a Baby Boomer, who has been socialised in a completely different technological environment, is more sceptical about self-driving systems because for him or her, they are not the natural solution, they are not familiar with them, they have not used them.

The results also showed that consumer segments can be well defined based on the expectations of self-driving cars. The "Plus Benefit Seekers", for whom the speed, added value and convenience aspects of self-driving systems are the most important, and the "Safety and Extras Enthusiasts", for whom the safety enhancing role of self-driving systems is the most important, are potential target markets for this technology. "Price-sensitive consumers", for whom affordability is the main consideration in their expectations of self-driving systems, do not appear to be a potential user group, at least certainly not at the product introduction stage. We consider the first two consumer segments to be the most likely innovator, novelty-accepting, even novelty-seeking and prioritising segments, on whom the market introduction of self-driving cars can be built.

In the continuation of our present research, we plan to conduct a comprehensive analysis and characterisation of each segment in order to better design marketing strategies for the adoption of self-driving cars. The limitation of this research is the lack of characteristics of these segments and the lack of attention to cross-cultural differences. For the latter reason, we plan to implement in the future an international sample to conduct a consumer perception of the technology under study, taking into account the specificities of each culture, which we believe is justified also because it is a global technology.

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Conceptualization, M.G.F.,G.K; methodology M.G.F; software, G.K and M.G.F.; validation, G.K., M.G.F; formal analysis, M.G.F.; investigation, M.G.F., G.K.; writing—original draft preparation, G.F.M,G.K.; writing—review and editing, M.G.F; visualization, G.K.; supervision, M.G.F. ; project administration, M.G.F., G.K.; funding acquisition, M.G.F. All authors have read and agreed to the published version of the manuscript.

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