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Original Research

AUTONOMOUS SYSTEMS ON THE BATTLEFIELD: THE MILITARY POTENTIAL AND RISKS OF SELF-DRIVING VEHICLES

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Abstract: The technological development of self-driving cars offers new opportunities for both civil and military applications. In the military domain, the development and application of autonomous vehicles deserves particular attention as it raises new challenges and risks, including cyber security, ethical issues and national security. This research aims to explore the societal acceptance of, and fears and concerns about, the use of autonomous vehicles in combat applications. The study analyses the views of different demographic groups, taking into account confidence in technological developments, transport safety, and ethical and legal issues related to military applications. The results show that the acceptance of military autonomous systems is closely related to public confidence in technology and concerns about the safety of technology. The research will contribute to future research investigating the integration of self-driving vehicles in military environments.

Keywords: autonomous vehicles, military applications, cybersecurity, ethical dilemmas

1. INTRODUCTION

Self-driving cars represent one of the most controversial areas of technological development, as they raise a number of social, legal and ethical issues. The operation of self-driving vehicles is based on different levels of automation, as defined by SAE International (2021) (SAE International, 2021). In the EU, there are legal barriers to their introduction, as the Vienna Convention requires all vehicles to have a human driver. In contrast, in the United States, technology adoption is moving faster, while in China, the government is providing significant support for R&D (Bai et al., 2025). One of the biggest challenges for autonomous vehicles is gaining public trust. Research has shown that people's attitudes are significantly influenced by age, gender, education and attitudes towards the technology (Kyriakidis et al., 2015; Kettles & Van Belle, 2019; Lee et al.,2025). For manufacturers, rapid adoption of the

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technology is key, but various strategic steps are needed to build user confidence, such as demonstration programmes and education campaigns (Howard & Dai, 2014; Servin et al., 2023). However, the public is sceptical about the reliability and pricing of self-driving cars, and many people do not feel ready to use fully autonomous vehicles (Kyriakidis et al., 2015; Schoettle & Sivak, 2016).

2. LITERATURE REVIEW

The development of self-driving vehicles is one of the biggest challenges of modern technology, offering new opportunities in terms of road safety, efficiency and environmental protection. At the same time, this development also raises a number of new risks and problems, particularly for military and combat applications, which cannot be ignored by future transport systems. Key issues include communication security, cyber threats, ethical issues and social acceptance. Combat applications, such as military autonomous vehicles, carry a particular responsibility, as proper decision making can directly affect not only transport security but also national security ().

The safety of the various communication systems, in particular vehicle-to-vehicle communication (V2V), which plays a critical role in maintaining road safety, is essential for the operation of self-driving vehicles. Research shows that the development of V2V communication has not yet reached the desired level and that cybersecurity threats to self-driving cars, such as hacker attacks and system failures, remain a major challenge. The potential for group attacks, which will increase with the interconnection of autonomous systems, underscores the importance of new authentication protocols and key agreement schemes that minimize the risk of eavesdropping and replay while requiring low computational overhead (Bai et al, 2025; Bo, 2024; Dehler & Buchholz, 2025; Gál et al.,2024; Gogoll & Müller, 2017; Goodall, 2014; Kettles & Van Belle, 2019; Kovács et al., 2021; Moller et al., 2025; Perger, 2022; Servin et al., 2023; Tang et al., 2025; Viktor & Fodor, 2024; Zheng et al., 2025).

Protecting data exchanges between vehicles can be particularly important in military applications where combat situations require rapid decision-making. For military autonomous vehicles and drones performing responsible tasks such as transport or reconnaissance, it is vital that communications are not compromised. The risk of cyberterrorism and cyberattacks for military purposes, which can also manifest themselves in attacks against physical assets such as drones and self-driving vehicles, can affect not only the security of technology but also global relations between warring parties (Borenstein et al., 2019; Cavoli et al., 2017; Chougule et al., 2023; Howard & Dai, 2014; König & Neumayr, 2017; Kyriakidis et al, 2015; Li et al., 2022; McCarthy, 2017; Othman, 2023; Szatmáry & Lazányi, 2022; Woollard, 2023).

Legal and ethical challenges become particularly acute in military applications, where decision-making affects people's lives. The classic "trolley problem" - which asks how an autonomous vehicle should make decisions when faced with an unavoidable accident - is also raised here, but requires a new, more responsible approach. Programmers must take into account not only traffic rules, but also the law of war and international humanitarian law in the case of military applications. For military autonomous systems, ethical protocols are needed that can handle the reconciliation of human morality and the decision-making capabilities of machines. In addition, international regulation and cooperation between states are essential for global security. As the organisation responsible for global security, NATO can play a key role in standardising cybersecurity protocols and regulating the safe operation of autonomous vehicles. In the case of combat applications of autonomous systems, security measures require closer coordination, as advances in technology open up opportunities for new types of attacks that target the vulnerabilities of self-driving systems (Kumar & SM, 2019; McCarthy, 2017; Perger, 2022; Viktor & Fodor, 2024).

The social acceptance of self-driving vehicles is closely linked to technological progress, human factors and the management of safety issues. Although the convenience and safety benefits of self-driving vehicles, particularly in reducing road accidents, are increasingly recognised, adoption is still hampered by cyber security risks, concerns about loss of control and liability issues. To increase social acceptance, a gradual deployment strategy is needed that takes into account the security fears of the population and the different attitudes of different demographic groups (Cavoli et al., 2017; Howard & Dai, 2014; Jaradat et al., 2020; Kettles & Van Belle, 2019; König & Neumayr, 2017; Kovács et al., 2021; Kyriakidis et al., 2015; Li et al., 2022; Othman, 2023).

A safe and ethical implementation of autonomous transport requires a complex, systemic approach. Development strategies need to take into account the social and technological context, as well as the various ethical dilemmas that will determine not only the operation of the technology, but also its future legal and military applications. Continuous development and proactive risk management are essential for the societal acceptance and safe operation of self-driving systems. In parallel with the development of new technologies, the role of human judgement and global cooperation is becoming increasingly important (Bo, 2024; Borenstein et al., 2019; Gogoll & Müller, 2017; Goodall, 2014; Perger, 2022; Servin et al., 2023; Szatmáry & Lazányi, 2022; Woollard, 2023).

3. DATA AND METHODOLOGY

Data was collected through an anonymous online questionnaire, which allowed respondents to express their opinions honestly, thus increasing statistical reliability. The online questionnaire format provided a quick and convenient way to collect and analyse the data. The questionnaire was completed on a voluntary basis, which also contributed to obtaining real, personal opinions. While the voluntary nature of the respondents and the convenience sampling method do not guarantee a fully representative sample, the large number of respondents (1 840) already provides a strong basis for the reliability of the survey results and helps to ensure that the conclusions are valid for a wider audience.

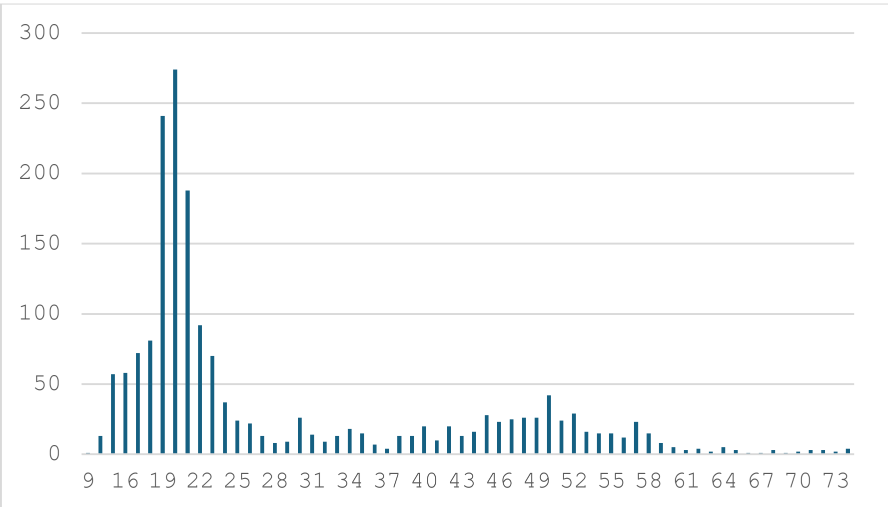

Figure 1. Age distribution of respondents (n=1840)

The aim of the research was to investigate the social acceptance of self-driving cars in particular. The results will contribute to a better understanding of the topic and may provide useful guidance for future research. The age of the respondents ranges from 9 to 75 years, with a mean age of 28.49 years and a median of 21 years, and a standard deviation of 13.819. The mean age is higher than the median, suggesting that more respondents were younger, but the wide age distribution shows that the questionnaire addressed several age groups, allowing a detailed analysis of different aspects of social acceptance.

The results of the survey, although not representative, can provide important insights into the evolution of public opinion and contribute to a better understanding of the social acceptance of future self-driving vehicles.

The research explored attitudes towards self-driving technologies along eight targeted questions covering perceived challenges, risks and potential uses of autonomous vehicles. The dimensions surveyed provide a comprehensive picture of respondents' views on both civilian and military applications. The following variables formed the basis of the analysis:

- Biggest technological challenge: The question aims to find out what respondents consider to be the biggest technological challenge in the development and deployment of self-driving vehicles. The responses will help identify the main barriers limiting technological adoption.
- Cybersecurity of self-driving cars: This question explores concerns about the cybersecurity risks of self-driving vehicles. The answers provide an indication of the extent to which respondents feel vulnerable to hacking and unauthorised access.
- Communication between drivers and pedestrians: This question measures the importance respondents attach to the establishment of effective communication between self-driving vehicles and human road users. This issue is particularly relevant in the context of urban transport, where implicit human interaction is common.
- The need for regulation: This question addresses the need for a regulatory framework for autonomous vehicles. Respondents express their views on the importance for them of regulating responsibility, ethics and safety at the level of legislation.
- Most challenging traffic environment: This question asks respondents which traffic environment (e.g. city, motorway, extreme weather) they consider most challenging for self-driving systems. The results highlight socially perceived technological barriers.
- Combat use of self-driving military vehicles: This question explores societal attitudes towards the use of autonomous vehicles for combat purposes in the military. It focuses on the acceptability of military decision-making without human intervention.
- Most suitable military tasks for self-driving vehicles: This question explores which military tasks (e.g. logistics, reconnaissance, surveillance, combat) respondents consider most suitable for autonomous vehicles. The results contribute to the societal perception of autonomous military technology developments.
- Likelihood of terrorist use: This question assesses the extent to which respondents fear that self-driving vehicles could be used for malicious purposes, such as terrorist attacks. The answers reflect societal perceptions of the technological threat.

4. RESULTS AND DISCUSSION

Table 1. Spearman's correlations between the variables (n=1840)

		Biggest technological challenge	Cybersecurity of self-driving cars	Communication between drivers and pedestrians	Need for legal regulation of self-driving cars?	Most challenging transport environment	Combat applications of self-driving military vehicles?	The most suitable military tasks for self-driving vehicles	Likelihood of terrorist use of self-driving vehicles
Hackers hack into car systems	Correlation Coefficient	,076**	-,269**	,164**	,184**	-0,028	-0,034	-0,032	,209**
	Sig. (2-tailed)	0,001	0,000	0,000	0,000	0,238	0,139	0,167	0,000
The self-driving car breaks down	Correlation Coefficient	-0,004	-,250**	,246**	,263**	-,057*	-,111**	-0,034	,164**
	Sig. (2-tailed)	0,865	0,000	0,000	0,000	0,014	0,000	0,144	0,000
The car does not decide/respond the way we want it to	Correlation Coefficient	,046*	-,269**	,232**	,265**	-,082**	-,089**	-0,029	,160**
	Sig. (2-tailed)	0,048	0,000	0,000	0,000	0,000	0,000	0,209	0,000
Fear of new technology	Correlation Coefficient	,106**	-,256**	,099**	,068**	-0,022	-,115**	-0,034	,108**
	Sig. (2-tailed)	0,000	0,000	0,000	0,003	0,350	0,000	0,141	0,000
People lose their jobs because of it (e.g. taxi drivers)	Correlation Coefficient	0,032	-,241**	,123**	,098**	-0,022	-,106**	-,053*	,085**
	Sig. (2-tailed)	0,174	0,000	0,000	0,000	0,342	0,000	0,023	0,000
Control cannot be taken back.	Correlation Coefficient	,051*	-,259**	,187**	,214**	-0,013	-,086**	-,055*	,139**
	Sig. (2-tailed)	0,029	0,000	0,000	0,000	0,578	0,000	0,017	0,000
Too expensive	Correlation Coefficient	0,043	-,091**	,102**	,097**	-,071**	0,005	0,031	,091**
	Sig. (2-tailed)	0,066	0,000	0,000	0,000	0,002	0,815	0,179	0,000
The driving experience is lost	Correlation Coefficient	,049*	-,184**	,099**	,146**	-0,026	-0,011	-,069**	0,041
	Sig. (2-tailed)	0,034	0,000	0,000	0,000	0,264	0,635	0,003	0,078
Lack of security of personal data	Correlation Coefficient	,056*	-,306**	,129**	,165**	-0,022	-0,032	-,064**	,160**
	Sig. (2-tailed)	0,017	0,000	0,000	0,000	0,339	0,167	0,006	0,000
Gender	Correlation Coefficient	0,023	-,204**	,094**	,079**	-0,028	-,118**	-,079**	,050*
	Sig. (2-tailed)	0,317	0,000	0,000	0,001	0,222	0,000	0,001	0,033
Age	Correlation Coefficient	,099**	-,135**	,095**	,140**	-,163**	,047*	0,031	,243**
	Sig. (2-tailed)	0,000	0,000	0,000	0,000	0,000	0,042	0,186	0,000
Place of residence	Correlation Coefficient	0,002	,079**	-,047*	-0,023	-0,035	-0,005	0,022	-0,040
	Sig. (2-tailed)	0,921	0,001	0,044	0,325	0,130	0,834	0,354	0,090
Level of education	Correlation Coefficient	,091**	-,102**	,052*	,114**	-,103**	,051*	,059*	,170**
	Sig. (2-tailed)	0,000	0,000	0,025	0,000	0,000	0,029	0,012	0,000
Level of study	Correlation Coefficient	-,073*	0,021	0,053	,111**	-0,050	,100**	,063*	,092**
	Sig. (2-tailed)	0,013	0,466	0,069	0,000	0,085	0,001	0,031	0,002
In Education	Correlation Coefficient	-,109**	,138**	-,050*	-,068**	,158**	-0,046	0,014	-,157**
	Sig. (2-tailed)	0,000	0,000	0,032	0,004	0,000	0,051	0,560	0,000
Work	Correlation Coefficient	0,036	-,083**	,065**	,066**	-,102**	,049*	0,009	,125**
	Sig. (2-tailed)	0,125	0,000	0,005	0,005	0,000	0,037	0,708	0,000
Driving licence	Correlation Coefficient	0,034	-0,021	,076**	,090**	-,054*	,059*	0,018	,098**
	Sig. (2-tailed)	0,146	0,369	0,001	0,000	0,020	0,012	0,446	0,000

The first interesting relationship is observed between Combat applications of self-driving military vehicles? and Too expensive, with a weak negative relationship (correlation coefficient: -0.071; p: 0.002). Those who are more in favour of military applications of driverless cars do not consider such technology expensive. This suggests that those interested in combat applications are less concerned about the cost and more likely to see the useful military benefits that the technology can offer. The next correlation is between Combat applications of self-driving military vehicles? and People lose their jobs because of it (e.g. taxi drivers), where a weak positive relationship is observed (correlation coefficient: 0.085; p: 0.000). Those who are more concerned about losing jobs are more inclined to support combat applications of driverless cars. This suggests that potential social impacts of technology, such as job losses, do not necessarily affect confidence in military applications. The relationship between Control cannot be taken back and Combat applications of self-driving military vehicles? is weakly negative (correlation coefficient: -0.055; p: 0.017), indicating that those who fear that they cannot regain control in an emergency are less likely to support military applications of driverless cars. This is an important reminder that gaining and regaining control is a key factor in military applications, which may be perceived by the public. The correlation between Fear of new technology and Combat applications of self-driving military vehicles? has a stronger negative direction (correlation coefficient: -0.089; p: 0.000), suggesting that those who are more fearful of new technologies are less supportive of combat applications of driverless cars. Fear of technology may therefore reduce confidence in combat applications, as the introduction of new technologies may also raise concerns in the military sector. There is also a negative relationship between The self-driving car breaks down and Combat applications of self-driving military vehicles? (correlation coefficient: -0.111; p: 0.000). Those who are more concerned about driverless cars breaking down are less supportive of their combat applications. This suggests that reliability is a key issue, especially when it comes to the application of the technology in a military environment. There is a weak negative relationship between Lack of security of personal data and Combat applications of self-driving military vehicles? (correlation coefficient: -0.032; p: 0.167), suggesting that those who are concerned about the security of personal data are less likely to support the use of driverless cars for military purposes. There is therefore a degree of tension between privacy and military applications, where the issue of personal data security may reduce confidence in military developments. A weak negative relationship is observed between The driving experience is lost and Combat applications of self-driving military vehicles? (correlation coefficient: -0.069; p: 0.003), suggesting that those who feel that the driving experience is lost are less willing to support military applications of driverless cars. Personal experiences, such as the pleasure of driving, may also influence perceptions of military applications of the technology. There is a weak negative relationship between Age and Combat applications of self-driving military vehicles? (correlation coefficient: -0.163; p: 0.000), suggesting that older people are less likely to support combat applications of driverless cars. Age is therefore an important factor, as older generations may be less willing to adopt new technological innovations, especially in a military context. A positive relationship between Level of education and Combat applications of self-driving military vehicles? is also observed (correlation coefficient: 0.059; p: 0.012), suggesting that people with higher levels of education are more likely to support military applications of driverless cars. Education is therefore an important factor that can increase confidence in technology, especially in combat applications. There is also a positive relationship between Work and Combat applications of self-driving military vehicles? (correlation coefficient: 0.125; p: 0.000), suggesting that workers who are up-to-date with technological developments are more likely to support military applications of driverless cars. Thus, the interplay between employee background and openness to technology reinforces confidence in the development of combat-oriented technologies. Finally, there is also a strong relationship between Driving licence and Combat applications of self-driving military vehicles? (correlation coefficient: 0.098; p: 0.000), indicating that those who have a driving licence are more likely to support the military applications of driverless cars. Driving experience and openness to military applications may therefore be closely related.

The analysis shows that those who are more in favour of combat applications of driverless cars do not consider the technology expensive and are more inclined to consider its use for military purposes. At the same time, those who fear new technologies, worry about job losses, or lack confidence in the reliability and privacy of the technology are less likely to support military applications. Higher educational attainment, employment background and management experience can all help to encourage the adoption of combat-oriented developments

A t-test analysis was conducted to see if there is a significant difference between respondents who hold different views on self-driving cars. The results show that in several cases significant differences were observed between the more distrustful and the more confident groups, confirming the previous correlation analysis.

Based on the results of the t-test, the following findings can be made: Fear of new technologies: those who are less confident in self-driving cars show a higher degree of fear of the risks of new technologies ($M = 3.22$) than those who are more confident ($M = 2.32$). The difference is significant ($t = 2.502$; $p = 0.019$). Ability to take back control in case of emergency: those who are more distrustful of self-driving cars ($M = 4.12$) are more concerned that they will not be able to take back control in case of an emergency than those who are more trustful ($M = 3.09$). The difference is significant ($t = 3.977$; $p < 0.001$). Use of self-driving military vehicles in combat situations: those who are less confident in self-driving cars ($M = 2.57$) are less likely to consider the use of self-driving military vehicles in combat situations acceptable than those who are more confident in technological advances ($M = 3.05$). The difference is significant ($t = -2.166$; $p = 0.032$). Risk of terrorist attacks: more distrustful respondents ($M = 2.92$) are less likely to believe that terrorists could use self-driving vehicles for attacks than those who are more confident in the security of the technology ($M = 3.36$). The difference is significant ($t = -2.633$; $p = 0.013$).

The results suggest that respondents who are distrustful are more fearful of new technologies, technological failures and loss of control, while those who are more confident are more open to the use of self-driving systems but more sensitive to the possibility of potential misuse. This research helps to understand that attitudes towards self-driving cars can vary and that trust and fear are important factors in the social acceptance of the technology.

Based on the results of the K-means clustering, the three clusters that emerged reflect the different attitudes towards machine learning technology. According to the numbers in the first table, the largest group is the "Sceptics" (843 people), while the "Neutrals" and "Cautious Optimists" are smaller groups, with 576 and 421 people respectively. In the analysis, respondents rated the advantages and disadvantages associated with automated driving, as well as the safety of the technology and potential risks.

The "Neutral" group showed mixed attitudes, with moderate opinions on the pros and cons of automated driving, while the "Sceptics" are highly distrustful of the technology, especially in relation to potential security risks such as hacking and malfunctions. They are also most concerned about the social and economic impacts of new technology, such as unemployment and excessive costs. In contrast, the group of "Cautious Optimists" tend to emphasize the benefits of automated driving, while remaining cautious and showing lower scores on fears and risks.

Overall, the different attitudes of the clusters clearly show that attitudes towards machine learning are not homogeneous and that perceptions of benefits and drawbacks, as well as fears and concerns about them, play a key role in the attitudes of each group. The "Sceptics" group is the largest, as they are the most distrustful, while the "Cautious Optimists" are the most open to the benefits of technology, but still cautious.

Table 2. ANOVA Summary Table (n=1840)

	Cluster		Error		F	Sig.
	Mean square	df	Mean square	df		
Self-driving cars will have a positive impact on emissions	227,785	2	1,087	1837	209,565	0,000
Self-driving cars will have a positive impact on society	308,296	2	1,008	1837	305,783	0,000
Self-driving cars reduce car accidents	353,777	2	1,222	1837	289,480	0,000
Hackers are hacking into your car's system.	703,394	2	1,403	1837	501,251	0,000
The self-driving car breaks down	562,394	2	0,902	1837	623,220	0,000
The car does not decide/respond the way we want it to	637,414	2	0,884	1837	721,199	0,000
Fear of new technology	547,354	2	1,374	1837	398,487	0,000
People lose their jobs because of it (e.g. taxi drivers)]	634,621	2	1,369	1837	463,705	0,000
Control cannot be taken back	775,813	2	0,972	1837	798,508	0,000
Too expensive.	290,775	2	1,646	1837	176,679	0,000
The experience of driving is lost.	432,457	2	1,492	1837	289,840	0,000
Lack of security of personal data.	655,956	2	1,183	1837	554,430	0,000
The F tests should be used only for descriptive purposes because the clusters have been chosen to maximize the differences among cases in different clusters. The observed significance levels are not corrected for this and thus cannot be interpreted as tests of the hypothesis that the cluster means are equal.						

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Based on the results of the t-tests conducted between the Neutrals, Skeptics and Cautious Optimists clusters, Levene's test showed that for most of the variables tested, there was no significant difference in the within-cluster variances, thus the condition of equal variance was met. This was the case for the following variables: communication between drivers and pedestrians ($F = 1.866$; $p = 0.172$), the need for legal regulation of self-driving cars ($F = 15.063$; $p < 0.001$), the likelihood of self-driving cars being used for terrorist purposes ($F = 18.020$; $p < 0.001$) and the level of education ($F = 14.738$; $p < 0.001$). This suggests that for these factors, although the opinions of the three clusters may have differed in content, they showed a similar distribution in terms of variance, i.e. the variance of responses did not differ significantly.

However, significant differences were found for the variable "cybersecurity of self-driving cars" ($F = 10.932$; $p = 0.001$) and for the variable "biggest technological challenge" ($F = 0.380$; $p = 0.538$). For these questions, the variance of responses differed significantly within clusters, which may suggest that the three groups perceive the importance of cybersecurity and the weight of technological challenges differently. In particular, the Sceptics and Cautious Optimists clusters showed the largest differences.

Differences were also found for the following variables: age ($F = 36.332$; $p < 0.001$), location ($F = 0.161$; $p = 0.688$), and educational attainment ($F = 50.512$; $p < 0.001$). Significant differences were found between clusters for age and educational attainment, while no such differences were found for the location variable. Age and education level indicate that different patterns in the distribution of responses were observed for the Neutral and Cautious Optimist clusters.

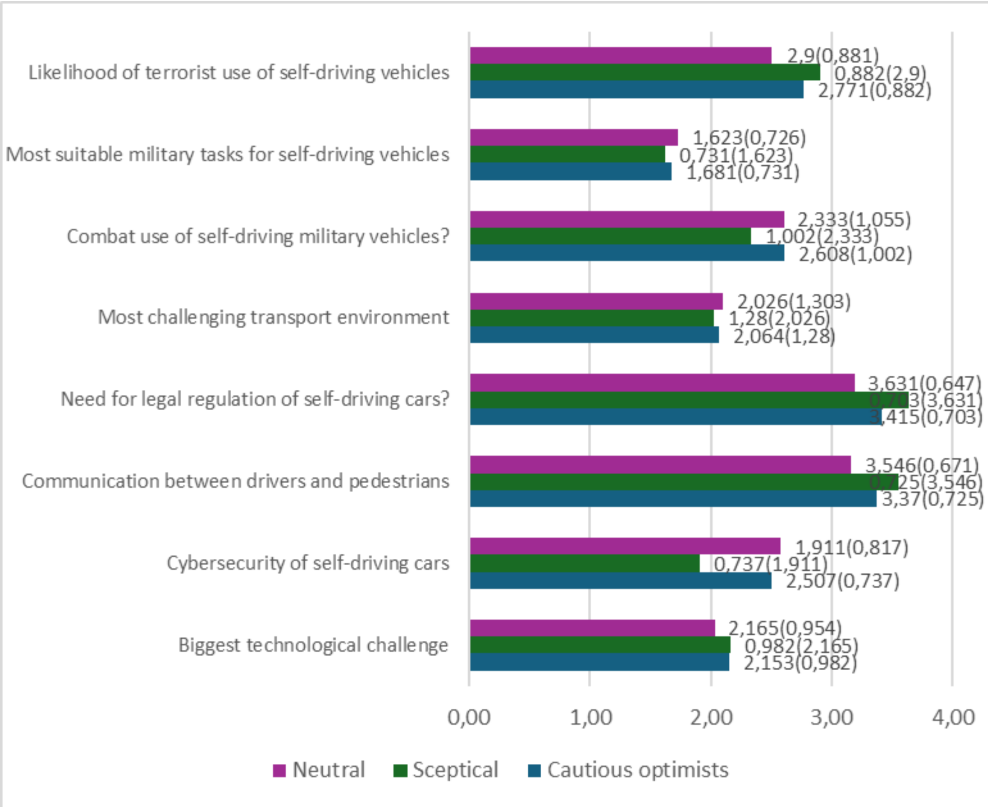

Figure 2. Means and Standard Deviations of Clusters

The aim of my research was to explore the social attitudes towards self-driving vehicles and to compare the three attitude clusters (Neutrals, Sceptics, Cautious Optimists). As a result of the K-Means clustering, I identified three groups: the Neutrals cluster, which does not completely reject self-driving vehicles but does not embrace them; the Skeptics cluster, which rejects new technologies but is sensitive to the risks; and the Cautious Optimists cluster, which is open to self-driving technologies but expresses concerns about the risks. The t-test analyses suggest that there are significant differences between the clusters, especially in terms of cyber security, age and education level. The results suggest that building trust and addressing concerns about risks are key to the adoption of technological innovations.

5. CONCLUSION

As one of the most revolutionary technological advances, self-driving cars are having a major impact not only on the transport industry but also on military applications. Research focuses on the development and application of autonomous vehicles in combat environments, in particular autonomous military vehicles and drones. Cybersecurity threats to autonomous vehicles, communications security and ethical issues in combat applications pose serious challenges that have implications not only for technological development but also for national security. The survey analysed respondents' views on the acceptance of the use of military autonomous vehicles. The responses reveal that different sectors of society have different perceptions of the role of autonomous systems in military applications, especially in combat. Older age groups and groups fearful of technological innovation are less supportive of the introduction of autonomous systems for combat purposes, while younger, more open-minded groups are more accepting of new technologies if they meet safety and ethical standards. The results of this research show that the successful integration of future developments and applications in military systems can be achieved by building on the safe use of new technologies and social acceptance. The introduction of military autonomous systems requires increased public confidence, which requires education, demonstrations and appropriate regulation.

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