EasyChair Preprint

№ 14912

Driving Change: Analyzing the Factors Influencing Public Acceptance of Autonomous Vehicles

Mohamed Elmallah and Mona Ali

September 16, 2024

Driving Change: Analyzing the Factors Influencing Public Acceptance of Autonomous Vehicles

Mohamed Kamel El Mallah*
EMS Department
The German University in Cairo
Cairo, Egypt
Mohamedkamel146@gmail.com

Mona Ali Ali
BI Department
The German University in Cairo
Cairo, Egypt
Mona.ali@guc.edu.eg

***Abstract*—This study attempts to explore the significant factors affecting the acceptance of autonomous vehicles in a developing country context. Furthermore, the driving style construct is explored as a moderating variable for acceptance of autonomous vehicles. The AVAM model is taken as a theoretical base. A survey was developed and tested for both reliability and validity. A sample of 71 respondents in Cairo, Egypt was collected. The results revealed that Performance Expectancy, Perceived Safety and Social Influence have significant effects on respondent Behavioral Intentions to accept autonomous vehicles. There was no evidence of significant moderation for the driving style construct, yet further analysis using simple slope method revealed some interesting outcomes.**

Keywords—Autonomous vehicle, Acceptance, Adoption, Driving styles, Developing countries

I. INTRODUCTION

Autonomous vehicles have great potential to transform the transportation industry [1]. According to Garidis et al. (2020), autonomous driving, a key technology of the fourth Industrial revolution, is poised to emerge as the automotive industry's next significant digital transformation [2]. The positive effects associated from the adoption of autonomous vehicles are numerous. Some of these effects are encompassed in enhancements in safety [3], environmental advantages, and increased mobility access for individuals with limited mobility [4]. While automobiles are indispensable in today's society, they present challenges such as congestion, noise pollution, and traffic accidents (Banister, 2005). According to the World Health Organization (WHO) report in 2018, the global fatalities

resulting from traffic accidents amounted to 1.35 million deaths [5]. Autonomous vehicles emerge as a potential solution addressing the many issues faced by conventional vehicles.

Although the market potential for autonomous vehicles is substantial, there exist lingering doubts among people regarding the adoption of this emerging technology [6] [7]. Before autonomous vehicles could be fully integrated into operational use, significant efforts are required to understand how AV will influence and be influenced by society. Enhancing the reliability and safety of autonomous driving technology, as well as promptly establishing relevant laws and regulations, stand out as crucial priorities as well [8]. Moreover, public acceptance will play a direct role in determining the ridership and overall success of autonomous buses [9] [10] [11]. Consequently, it is imperative to investigate public opinions and acceptance towards autonomous vehicles. This study is an answer to the call for exploring acceptance of AVs in different geographical and cultural contexts, especially where citizens are more skeptical towards new technologies [7]. Additionally, this study is a continuation of the research stream required to explore moderators which attempt to understand the differences between users in reference to AV acceptance.

II. LITERATURE REVIEW

In this section, the current research about acceptance of autonomous vehicles is explained. Moreover, the main constructs, theories, and items relevant to adoption of autonomous vehicles are presented.

a. Adoption of autonomous vehicles

Adoption of autonomous vehicles (Cars and buses) have been extensively researched in the past few years. Many factors affecting the adoption of autonomous vehicles have been explored and tested. [12] used the Autonomous Vehicle Acceptance Model (AVAM) to examine how performance expectancy, effort expectancy, attitude, social influence, self-efficacy, anxiety, and perceived safety affected the acceptance of autonomous vehicles. Based on a 26-item survey, the results of 187 responds were recorded. The findings indicated that users were not very receptive to high levels of autonomy and exhibited a significantly reduced inclination to use highly autonomous vehicles. Furthermore, the result of the study provides evidence of noticeable surge in anxiety as autonomy levels increased, paralleled by a decrease in the perceived level of safety. Additional research was conducted on the view of public perception. In 2020, Wang et al. explored how theories of identity threat, identity control and innovation diffusion are synthesized to examine the impact of technology identity concerns on consumers acceptance of AV technology. 353 consumers were interviewed, and the results showed that technology anxiety and self-identity are the two factors mostly affecting consumers resistance to adopt AV technology [13]. Additionally, a study conducted in China to determine factors for the public's acceptance of autonomous busses performed an online survey filled by 401 people who used the autonomous vehicle [14]. Based on the technology acceptance model, The results showed that behavioral intention is influenced

positively by attitudes, while attitudes are positively influenced by both trust and perceived usefulness. Additionally, perceived ease of use and perceived comfort also have positive effects on perceived usefulness and trust. On the other hand, perceived risk is negatively associated with trust.

b. Real time acceptance of AVs

Furthermore, to investigate real time autonomous vehicle acceptance, [15] examined variables to further understand people's perceptions on autonomous vehicles. They used both surveys and interviews conducted in Norway before and after establishment of autonomous busses in certain areas. The results concluded that people were willing to use autonomous busses before and after riding them. The major factor that most affected their decision was safety which was present in the autonomous busses. Even with considerable technological advancements in autonomous vehicles, there remains a limited comprehension of how users perceive and experience these large, mass transit buses in real-life traffic environments [16]. In 2022, a study analyzing the acceptance of autonomous buses in real life traffic environment, used discrete choice analyses on a pilot project in Spain. The results indicated that individuals who are more open to new technologies and environmentally conscious show a greater willingness to adopt autonomous buses. Moreover, older passengers, women, employed individuals, private vehicle users, and those with environmental consciousness and openness to new technologies report higher levels of satisfaction while on board the autonomous buses. It has also been found that there was a large barrier found relating to the safety of an autonomous vehicle. Safety directly correlates (depending on user's socio-demo-graphic characteristics and personality) with the likelihood of a person to use autonomous vehicle. The acceptance of a new technology increases when individuals gain first-hand experience with its implementation, and their initial concerns turn out to be unfounded. Familiarity with the new technology plays a crucial role in fostering acceptance. On the other hand, fatal accidents have a detrimental effect on the acceptance of the technology, leading to decreased trust and reluctance to embrace it. [17]. Wicki's study involved an examination of people's acceptance towards autonomous buses in Switzerland before and after using them. The results yielded that the public expressed safety concerns and affected their opinion on the autonomous busses. However, people's experience has not affected the acceptance on the vehicles.

c. AV acceptance in developing countries

While the global dialog on autonomous vehicles AVs often overlooks Africa, a closer examination exposes a compelling need for exploring their potential adaptation to the continent's unique context. Away from simply replicating Western models, investigating AVs in Africa demands a context-specific approach that addresses existing challenges and leverages unique opportunities. This is due to many factors such as underdeveloped infrastructure, unpredictable driving behavior and limited internet access. Exploring the

context of Africa is of high importance because of the continents high levels of road accident casualties. AVs could be the solution to one of Africa's most demanding problems.A study in 2020 conduct an international comparison study on public perceptions of AVs. Their results show that individuals of the developed and developing countries have significantly different perceptions on AVs. The authors argue that respondents from the developed countries tend to have greater awareness of AVs but are more pessimistic about their present and future safety while those of the developing countries are more optimistic in this regard [18].

In 2023, the results of a study exploring the differences between developed and developing countries towards AV adoption intentions implied that individuals in developed and developing countries who feel positively toward AVs are more likely to intend to use them. This positive feeling toward AVs in developed countries is formed through the individuals' perceived benefits (i.e., performance expectancy), perceived enjoyment (i.e., hedonic motivation), social influence, and the trust in AV and its technology. In developing countries, however, the most significant determinant of the attitude is the trust in PAV, followed by hedonic motivation, performance expectancy, and effort expectancy [19].

III. METHODOLOGY

a. Hypotheses and theoretical framework

Human acceptance may be affected by elements other than those identified by the TAM or UTAUT. Therefore, the various elements that affect the acceptance of autonomous driving must be defined and evaluated [20]. The AVAM (Autonomous Vehicle Acceptance Model) is a modified version of the UTAUT (Unified Theory of Acceptance and Use of Technology) and CTAM (Contextual Technology Acceptance Model) specifically tailored for autonomous vehicle technologies. It includes all eight key factors from the UTAUT, namely Performance Expectancy, Effort Expectancy, Attitude Towards Technology, Social Influence, facilitating conditions, Self-Efficacy, Anxiety, and Behavioral Intention (to use the system). Additionally, the AVAM incorporates one factor introduced by the CTAM, which is Perceived Safety. [12]. To some extent, an individual's behavior can be predicted based on their behavioral intentions. Furthermore, external factors play a role in influencing the individual's perception of the system's usefulness (PU) and ease of use (PEOU). These perceptions, in turn, impact the individual's attitude (ATT) towards the system, ultimately influencing their behavior towards using it. [14]

The suggested model includes the following constructs: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), perceived safety (PS), and Anxiety (A) to be directly related to Behavioral Intentions (BI). Adopted from [12]. The study excluded attitude and self-efficacy since they are more complex variable, which need to be tested using sub variable or second and first order variables. The six hypotheses tested in this study are as follows:

- Hypothesis 1: Performance Expectancy of AVs significantly affects citizens Intentions to accept AVs (BI)
- Hypothesis 2: Effort Expectancy to use AVs significantly affects citizens Intentions to accept AVs (BI)
- Hypothesis 3: Social Influence (SI) of AVs significantly affects citizens Intentions to accept AVs (BI)
- Hypothesis 4: Perceived Safety (PS) of AVs significantly affects citizens Intentions to accept AVs (BI)
- Hypothesis 5: Anxiety (AX) of AVs significantly affects citizens Intentions to accept AVs (BI)
- Hypothesis 6: Driving Behavior (DB), AGE, Driving License possession (DL), and Education (ED) moderate the relationship between factors of AV acceptance (PE,EE,SI,PS,AX) and Intention to accept AV (BI)

The model tested is provided in Figure 1.

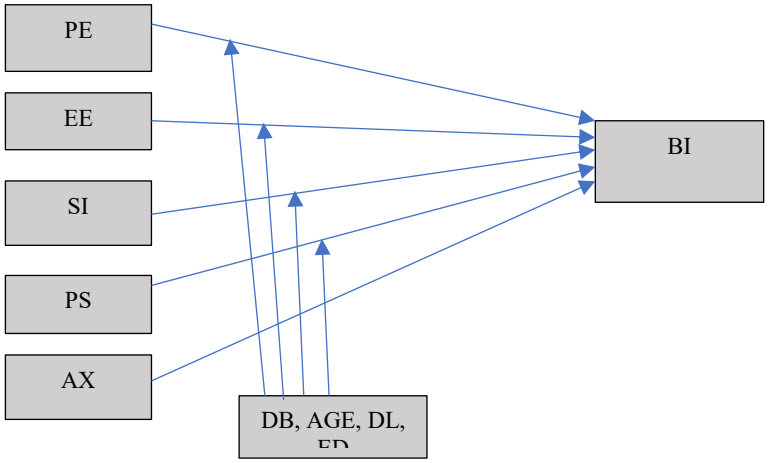

Fig. 1 Tested model based on AVAM [12]

b. Questionnaire development

The questions for the items included in the survey are adopted from previous studies as shown in table 1.

TABLE I. SURVEY ITEMS

Construct	Questions	Source
PE	I think that using an autonomous vehicle would enable me to reach my destination quickly.	Hewitt
	I think that using the autonomous vehicle would enable me to reach my destination cost efficiently.	
	I think that using the autonomous vehicle would enable me to reach my destination safely	

EE	I think that I would find the autonomous vehicle easy to use	Hewitt
	I think that interaction with the autonomous vehicle would be clear and understandable.	
	I think using an autonomous vehicle would be easy for me to learn.	
SI	I would be proud to show the the autonomous vehicle to people who are close to me	Hewitt
	I would feel more inclined to use the autonomous vehicle if it was widely used by others.	
	I would prefer to use the autonomous vehicle with other passengers.	
AX	I would have concerns about using autonomous vehicles	Hewitt
	I think using the autobmous vehicle would be somewhat frightening to me	
	I am afraid that I would'nt understand how to operate the autobmous vehicle.	
PS	I believe that using the autonomous vehicle would be dangerous.	Hewitt
	I would feel safe while using the autonomous vehicle.	
	I would trust the autonomous vehicle.	
BI	I would use an autonomous vehicle as soon as it is available on the market	Garidis, Ulbricht, Rossmann, & Schmäh, 2020
	I would like to own an autonomous vehicle	
	I can imagine the use of an autonomous vehicle-sharing service	
	I would trust the driving skills of an autonomous vehicle more than my own.	

As for the DB Construct the items were adopted from [21]. The survey included three sections, the first section asked questions about the demographics of the respondents. The first section included questions about gender, age, level of education and driving license acquisition. The second section included 19 questions about the six constructs in the proposed model. The third section included 8 questions about the driving styles of the respondents.

c. Data collection

Convenience sampling method was adopted for this study. An online channel was used to collect data from respondents. Citizens of Egypt were targeted. The survey link was sent via, email, LinkedIn, and other online channels. The collection process took two weeks from July 1st, 2023, to July 15th, 2023. 71 responses were collected and analyzed using SmartPLS 4.0.

IV. RESULTS:

a. Sample description

A descriptive analysis was performed on the first section to reveal the different types of the respondents. Table 2 summarizes the results.

TABLE II. SAMPLE DESCRIPTION

Gender	45% male			55% female	
Age	2% under 18	39 % aged 18-25	14% aged 26-35	29% aged 36-45	16% age above 45
Education	5% vocational	14% Highschool	50% Bachelors	20% Masters	11% PhD
Driving license possession	90 % yes			10% no	

b. Testing the reliability and validity of the survey (Outer model)

The reliability and validity of the instrument are tested by calculating the Cronbach alpha, composite reliabilities rho_a and rho_b, as well as the AVE. Table 3 demonstrates the results as provided by SmartPLS 4.0. Also the weights for all items were found to be above 0.63.

TABLE III. RELIABILITY AND VALIDITY OUTPUT

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
Anxiety	0.67	0.688	0.857	0.75
Behavioural intentions	0.814	0.837	0.881	0.654
Effort Expectancy	0.844	0.894	0.905	0.761
Percieved Safey	0.833	0.906	0.899	0.751
Performance Expectancy	0.751	0.805	0.853	0.66
Social Influence	0.733	0.856	0.846	0.65

c. Testing the paths (Inner model)

Bootstrapping is first performed to assess the significance of the relationships between the factors leading to acceptance and behavioral intentions. Table 4 demonstrates the P values as calculated by SmartPLS 4.0.

TABLE IV. HYPOTESIS TEST OUTPUT

	Origl. sample (O)	Sample mean (M)	(STDEV)	T stat	P values
Anxiety -> Behavioural intentions	0.138	0.141	0.095	1.452	0.146
Effort Expectancy -> Behavioural intentions	0.221	0.211	0.094	2.352	0.019
Percieved Safey -> Behavioural intentions	0.301	0.306	0.137	2.207	0.027
Performance Expectancy -> Behavioural intentions	0.153	0.16	0.104	1.478	0.14
Social Influence -> Behavioural intentions	0.264	0.257	0.107	2.471	0.014

d. Testing the moderators

Bootsrapping was performed to obtain the P values for all proposed moderators. The P-Values calculated by SmartPLS 4.0 indicated no significance for all moderators as since the P-Values were all above 0.05. further investigation was performed using simple slope analysis to explore the moderators further. The results which show some possible moderation are provided in Figures 2-6.

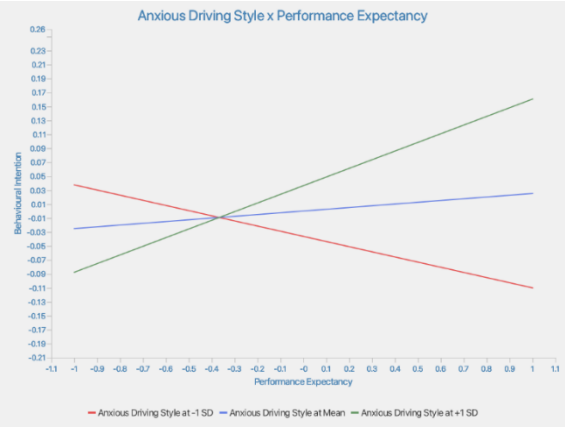

Fig. 3 Anxious driving style X Performance Expectancy

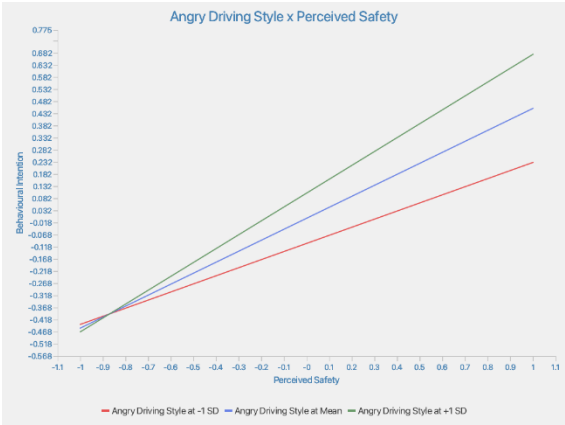

Fig. 2 Angry driving style X Perceived safety

Fig. 5 Anxious driving style X Perceived Safety

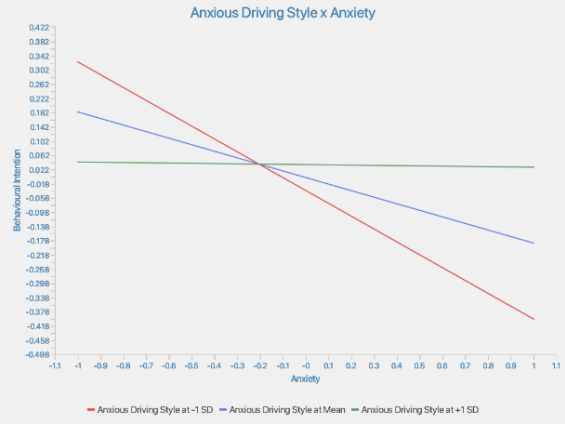

Fig. 4 Anxious driving style X Anxiety

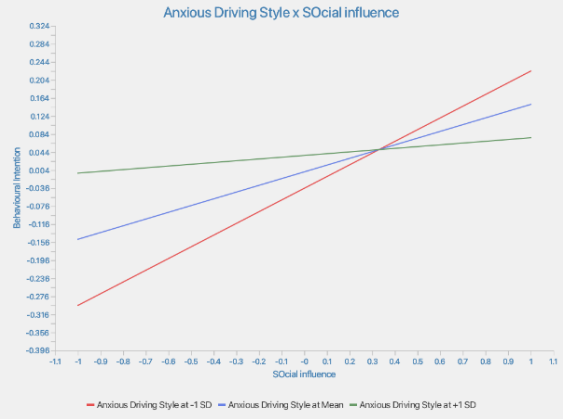

Fig. 6 Anxious driving style X Social Influence

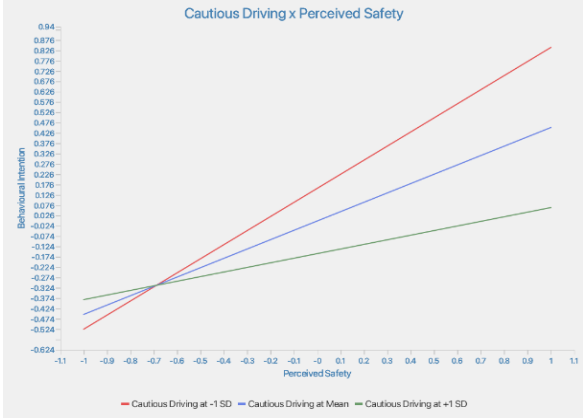

Fig. 7 Cautious driving style X Perceived Safety

V. Discussion

a. Factors affecting AV acceptance

This study attempted to explore the factors leading to the adoption of AVs in a developing country. A total of 71 responses were gathered in a time range of two weeks in 2023. The results provide significant evidence that the instrument developed is both valid and reliable. Furthermore, the results provide significant evidence that effort expectancy, perceived safety and social influence are correlated with behavioral intentions to accept Avs. This result emphasizes the effect of EE, PS, and SI on the AVs acceptance of developing countries citizens. The significance of the relationship between effort expectancy and BI for AV acceptance is in accordance with [19]. The significance of the relationship between PS and BI for AV acceptance is in accordance with [12]; [13]; [8]; [16] [18]; [17]. The significance of the relationship between SI and BI for AV acceptance is in accordance with the results of the developed countries as provided by [19]. The insignificance of both AX and PE is in opposition to the results provided by [12]; [13].

b. Moderation effect of driving behavior

Although there was no significant evidence for the moderation effect the simple slope analysis provide some insights which could be further investigated. For respondents with an anxious driving style, it is proposed that the behavioral intentions of respondents with higher anxious driving styles will depend more on PE, PS, and AX. Additionally, for the same driving style, Behavioral intentions of respondents with higher anxious driving styles will depend less on social influence. For respondents with an angry driving style, it is proposed that behavioral intentions of respondents with higher angry driving styles depends more on PS then those with lower angry driving styles. For the cautious driving style respondents, the behavioral intentions of respondents with higher cautious driving styles will depend less on PS than those with lower cautious styles. This presents the possibility that the marketing for AVs on the notion of safety is only affective for those who claim a more anxious and angry driving style. Furthermore, The marketing of AVS on the notion of performance expectancy and anxiety would be efficient with those who possess and anxious driving style.

VI. Conclusion

This study is a continuation of the research stream in autonomous vehicle adoption/ acceptance. It responds to the call for more research in developing countries. To the authors' best knowledge, this study is the first to inset driving styles as a moderator between factors affecting AV acceptance and BI to accept AVs. Our results can be informative for a better understanding of why people accept or do not accept self-driving cars in a developing country context, and how acceptance can be enhanced through the different driving styles.

VII. Limitations

The main limitation of this study is the sample size. 71 responses is particularly low. The low response rate comes from the fact that there was limitation in both time and funding. This study is ongoing and the number of responses is continuously on the rise. Furthermore, attitude and self-efficacy were removed to minimize the time respondents take to finalize the survey online. Attitude is a more complex variable, which depends on other constructs, which would have made our analysis based on first and second order constructs.

VIII. Future research

Because of both the time and funding limitations, both attitudes and self-efficacy were removed from the initial AVAM model. A more comprehensive study would better accommodate for both attitudes and self-efficacy. Additionally, replicating this study in other developing countries would give a more holistic view on which factors directly affect the acceptance of AVs within such context.

References

[1] C. Olaverri-Monreal, "Promoting trust in self-driving vehicles," *Nature Electronics. Nature Research,* 2020.

[2] K. Garidis, L. Ulbricht, A. Rossmann and M. Schmäh, "Toward a User Acceptance Model of Autonomous Driving," in *Proceedings of the 53rd Hawaii International Conference on System Sciences*, 2020.

[3] W. G. K. J. S. J. D. &. B. J. Najm, "Frequency of target crashes for intellidrive safety systems.," 2010.

[4] S. K. S. M. M. I. &. S. S. Bouton, "Urban mobility at a tipping point.," *Sustainability & Resource Productivity,* 2015.

[5] W. H. O. (WHO), "Global Status Report on Road Safety," 2018.

[6] Roche-Cerasi, "Public acceptance of driverless shuttles in Norway," *Transp. Res. Part F,* 2019.

[7] K. S. V. Mouratidis, "Autonomous buses: Intentions to use, passenger experiences, and suggestions for improvement.," *Transp. Res. Part F Traffic Psychol,* 2021.

[8] M. e. a. Azad, "Fully autonomous buses: A literature review and future research directions," *J. Adv. Transp.,* 2019.

[9] G. e. a. Papadima, "Investigation of acceptance of driverless buses in the city of Trikala and optimization of the service using Conjoint Analysis.," *Util. Policy,* 2020.

[10] C. Chen, "Factors affecting the decision to use autonomous shuttle services:Evidence from a scooter-dominant urban context," *Transp. Res. Part F,* 2019.

[11] S. e. a. Nordhoff, "User acceptance of automated shuttles in BerlinSchöneberg: A questionnaire study.," *Transp. Res. Part F Psychol,* 2018.

[12] C. Hewitt, T. Amanatidis, I. Politis and A. Sarkar, "Assessing Public Perception of Self-Driving Cars: the Autonomous Vehicle Acceptance Model," in *Proceedings of the 24th International Conference on Intelligent User Interfaces*, 2019.

[13] X. Wang, Y. D. Wong, K. X. Li and K. F. Yuen, "This is not me! Technology-identity concerns in consumers' acceptance of autonomous vehicle technology," *This is not me! Technology-identity concerns in consumers' acceptance of autonomous vehicle technology,* vol. 74, pp. 345-360, 2020.

[14] Z. Wu, H. Zhou, H. Xi and N. Wu, "Analysing public acceptance of autonomous buses based on an extended TAM model," *IET Intelligent Transport Systems,* vol. 10.1049, 2020.

[15] K. Mouratidis and V. C. Serrano, "Autonomous buses: Intentions to use, passenger experiences, and suggestions for improvement," *Transportation Research Part F,* vol. 76, 2021.

[16] A. Ariza-Álvarez, M. E. López-Lambas and u. A. Soria-Lara, "Analysing the acceptance of autonomous buses in real-lifetraffic environments: pilot project with tourists in Malaga,Spain," *Transportation Planning and Technology,* vol. 46.

[17] M. Wicki, "How do familiarity and fatal accidents affect acceptance of self-driving vehicles?," *Transportation Research Part F,* vol. 83, 2021.

[18] J. Moody, N. Bailey and J. Zhao, "Public perceptions of autonomous vehicle safety: An international comparison," *Safety Science,* vol. 121, pp. 634-650, 2020.

[19] M. M. Zefreh, B. Edries, D. Esztergár-Kiss and A. Torok, "Intention to use private autonomous vehicles in developed and developing countries: What are the differences among the influential factors, mediators, and moderators?," *Travel Behaviour and Society,* vol. 32, 2023.

[20] J.-G. Shin, I.-S. Heo, J.-H. Yae and S.-H. Kim, "Kano model of autonomous driving user acceptance according to driver characteristics: A survey study," *Transportation Research Part F: Psychology and Behaviour,* vol. 91, pp. 73-86, 2022.

[21] O. Taubman-Ben-Ari, M. Mikulincer and O. Gillath, "The multidimensional driving style inventory—scale construct and validation," *ELSEVIER,* vol. 36, 2004.