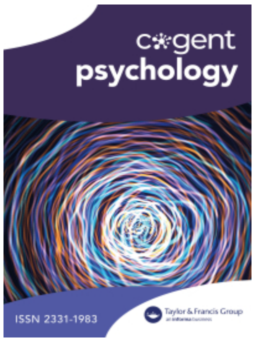

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Preferred level of vehicle automation: How technology adoption, knowledge, and personality affect automation preference in Türkiye and Sweden

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ABSTRACT

The acceptance of automated vehicles and advanced vehicle technologies by users is subject to different human factors variables. Personality, technology adoption, and prior previous knowledge about the systems have been significant determinants of people's attitudes toward new technologies across different settings. The present study examined the effects of technology adoption, knowledge of vehicle automation, and personality on the preferred level of vehicle automation in Türkiye and Sweden. The study was conducted with 297 drivers from Türkiye (age: $M=22.47$, $SD=2.83$) and 332 drivers from Sweden (age: $M=30.06$, $SD=10.48$). Participants completed a questionnaire regarding technology adoption, knowledge and preference of vehicle automation, and the Basic Personality Traits Inventory (BPTI). The findings indicated that high technology adoption was associated with preferring higher levels of automation. Furthermore, drivers from Türkiye, in comparison to drivers from Sweden, and drivers with previous knowledge of high or full automation, compared to those who have not heard of these systems in the two countries, expressed a preference toward higher levels of automation. High extraversion and openness to change were associated with high technology adoption, leading to preferring vehicles with higher levels of automation. Overall, the results indicated that drivers' knowledge of automated vehicles and general traits, such as personality and technology adoption, play a role in vehicle preference. The study analyzed the factors that affect user acceptance of automated vehicles and offered insights into their interrelationships across two countries with differing levels of road safety.

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From level 0 to level 5 (SAE International, 2019), automation technologies for vehicles facilitate a wider spectrum of driving sub-tasks and enable vehicles to operate under different driving environments. In essence, while drivers remain for all driving tasks without automation, vehicle systems gradually improve their ability to assist certain driving functions (*driver assistance*) or even perform accelerating/decelerating and steering automatically (*partial automation*). As the automated system becomes more advanced, the vehicle can operate without the driver monitoring the surroundings. However, with certain levels of automation, the automated system may require the driver to manually control the vehicle (*conditional automation*), or the vehicle can execute all driving functions in specific situations while also offering the option for the driver to drive manually (*high automation*). With *full automation*, the system will be capable of carrying out all driving tasks regardless of any driving conditions (SAE International, 2019).

Vehicles with increased automation levels have been shown to bring significant changes in various aspects, including energy usage, carbon emissions, and travel efficiency (Wadud et al., 2016), as well as in reducing traffic accidents, improving mobility, and reducing inequalities for disadvantaged groups (Alessandrini et al., 2015; Chan, 2017; Dicianno et al., 2021; Faber & van Lierop, 2020; Othman, 2021). As vehicles with differing levels of vehicle automation (SAE International, 2019) have become publicly available and integrated into the traffic system, users' perceptions and attitudes towards vehicles with new technologies have gained significant attention. Earlier research (e.g. Körber & Bengler, 2014; Liu et al., 2019; Nordhoff et al., 2019; Othman, 2021) has shown that

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various a range of human factors relate to drivers' attitudes and trust toward automated vehicles. In the following sections, the relations of technology adoption, knowledge of automated vehicles and personality were elaborated based on the literature.

1.1. Technology adoption

When studying the appeal that users have for new technologies, it is vital to account for the general inclination towards new technologies, also known as technology adoption or affinity. The innovation adoption curve model (Rogers, 2003) partitions users into innovators and laggards, which correspond to users who are enthusiastic about utilizing new technologies as soon as possible and those who are the last to embrace them.

Individuals with a propensity for early technology adoption displayed a greater likelihood of demonstrating favorable attitudes toward automated vehicles (Liljamo et al., 2018) and higher intentions to purchase and use automated vehicles (Berliner et al., 2019; Hardman et al., 2019; Lee et al., 2019; Sener et al., 2019; Thurner et al., 2022). Kraus et al. (2021) reported that individuals with a stronger proclivity toward technological advancement exhibited higher levels of trust and acceptance toward automation. Cunningham et al. (2019) found that early adopters perceived more advantages, exhibited fewer apprehensions, and demonstrated a greater willingness to purchase and invest in AV-related equipment. This strong correlation between early technology adoption and positive attitudes towards automated vehicles underscores the importance of understanding users' technology adoption tendencies in shaping the future of automated transport.

1.2. Knowledge of vehicle automation

Furthermore, road users' perception of automated vehicles may be influenced by their knowledge of vehicle automation, technological advancements, and interactions with vehicles. Multiple studies, including Anania et al. (2018), Berliner et al. (2019), Charness et al. (2018), Nordhoff et al. (2019), Othman (2023a, 2023b), and Sanbonmatsu et al. (2018), have indicated that familiarity with these systems could play an essential role in shaping how pedestrians, drivers, and other road users perceive automated vehicles in a positive manner.

According to Nordhoff et al.'s (2019) literature review, only a small fraction (6% of 124 studies) of research explored the correlation between knowledge/experience of AV and acceptance. For instance, in one study, prior knowledge was related to willingness to cede control and reduced concerns about automated vehicles. Knowledgeable drivers were more ready and less concerned when it came to relinquishing control of their vehicles (Charness et al., 2018). Likewise, other studies have found comparable links between knowledge and willingness to buy (Berliner et al., 2019) and familiarity and acceptance of automated vehicles (Othman, 2023a; Wang et al., 2022). Furthermore, König and Neumayr (2017) determined users who were well-informed about self-driving vehicles held more favorable attitudes than those who were unacquainted with the subject.

1.3. Personality

Personality is considered an important element within the realm of human factors in traffic and transport psychology studies. Personality, also known as personality traits, is defined as the thoughts, behaviors, and feelings of individuals that are relatively consistent over time (Costa & McCrea, 1992; McCrae & Costa, 1995). The Five-Factor Model, which has become one of the most widely accepted personality models, identifies five dominant traits: extraversion, conscientiousness, agreeableness, neuroticism, and openness (Costa & McCrae, 1992 Costa & McCrae, 2008). It has been found that personality factors can have direct or indirect links to various driving outcomes, including behaviors and accidents (Dahlen et al., 2012; Özkan & Lajunen, 2015).

Despite the potential importance of personality in user interactions with automated vehicles (Körber & Bengler, 2014), only a small number of studies – 14% of the 124 empirical studies – have explored the link between personality factors and acceptance of automated vehicles (Nordhoff et al., 2019). In these studies, the associations of personality traits (or facets of the traits [e.g. Bellem et al., 2018]) with various aspects of automated vehicles have been evaluated (Charness et al., 2018; Kyriakidis et al., 2015; Payre et al., 2014; Sener et al., 2019; Qu et al., 2021a, 2021b), such as automated vehicle driving style preference (e.g. Bellem et al., 2018), concerns, eagerness, and willingness (e.g. Charness et al., 2018), comfort (e.g. Dettmann et al., 2021) and trust (Kraus et al., 2020a; 2020b) by focusing on varying levels of vehicle automation (SAE International, 2019).

Nevertheless, the studies produced inconclusive findings regarding the five personality traits. For example, Charness et al. (2018) conducted a survey to explore the correlation between the five personality factors and three components of automated vehicles, namely concerns, eagerness to adopt, and willingness to relinquish control. The study revealed that extraversion was negatively associated with a willingness to relinquish control of the vehicle. Similarly, Li et al. (2020) found a negative relationship between extraversion and trust in automated driving. However, other studies have reported positive relations of extraversion with the willingness to drive and own automated vehicles (Qu et al., 2021b) and perceived benefits (Qu et al., 2021a).

Agreeableness was positively associated with the adoption of adaptive cruise control (Spurlock et al., 2019), trust (Kraus et al., 2021), as well as the willingness to drive and own automated vehicles (Qu et al., 2021b), and perceived benefits (Qu et al., 2021a). In contrast, a negative correlation was observed between agreeableness and the statement that automation is silly (Kyriakidis et al., 2015). However, in another study, Qu et al. (2021a) found that agreeableness was also negatively related to the perceived reliability and ease of use of automated vehicles.

Considering conscientiousness, while Charness et al. (2018) found that drivers with greater conscientiousness were more concerned and less willing to adopt automated vehicles, other studies by Qu et al. (2021a, 2021b) reported a positive association between conscientiousness and perceived benefits (2021a) and willingness to drive and own automated vehicles (2021b).

Neuroticism was reported to be negatively related to willingness to drive and own automated vehicles (Qu et al., 2021b), trust in automation (Kraus et al., 2021; Zhang et al., 2020) as well as adoption of AVs (Charness et al., 2018; Zhang et al., 2020) and perceived reliability and ease of use (Qu et al., 2021a).

Openness to experience was found to have a positive correlation with comfort regarding full automation and the willingness to relinquish control of the vehicle (Charness et al., 2018), perceived benefits (Qu et al., 2021a), intention to buy (Qu et al., 2021a; Zhang et al., 2020), trust (Zhang et al., 2020) and willingness to drive and own automated vehicles (Qu et al., 2021b). Contrary to the positive associations of being open to new experiences (Charness et al., 2018; Qu et al., 2021a, 2021b), Li et al. (2020) found a negative correlation between openness to experience and trust, indicating that road users who are more open to new experiences tend to have lower levels of trust.

In a recent study, Kraus et al. (2021) discussed a multi-level model that leads to trust in vehicle automation. The model suggests that personality factors, specifically big-five factors, drive technology adoption and dispositional trust. These factors are then linked to trust and acceptance of automated driving. In this study, extraversion and agreeableness were positively associated with dispositional trust, and neuroticism was negatively related to technology adoption, which was positively related to trust and acceptance of vehicle automation.

1.4. Aim of the present study

Previous studies have shown that different individual factors influence public acceptance of automated vehicles (Othman, 2021) and that these factors form a hierarchy in terms of their relationship with the acceptance of automated vehicles (Nordhoff et al., 2019). In accordance with the hierarchical model suggested by Kraus et al. (2021), this present study focused on the relationships of personality and technology adoption and knowledge of vehicle automation with the preferred level of vehicle automation, using double mediation analysis (Figure 1). For the first time in the literature, the present study investigates the proposed relations of technology adoption (corresponding to situational traits in Kraus et al., 2021), knowledge (corresponding to surface traits in Kraus et al., 2021), and personality (corresponding elemental traits in Kraus et al., 2021). Serial double mediation was chosen to test the hierarchical model considered by Kraus et al. (2021) in the proposed linear relationship. The model and analysis place the personality factors first in the relationship and test their relationship with technology adoption, knowledge, and preferred level of vehicle automation.

Previous studies (e.g. Nordhoff et al., 2022; Othman, 2023a) have also shown the value of cross-country research in understanding factors related to public acceptance of automated vehicles. This investigation is carried out in samples from Türkiye and Sweden in relation to users' preference of vehicle automation. Incorporating data from both Türkiye and Sweden augments the study's strength. This research was conducted in two dissimilar countries in terms of road user behaviors (e.g. Wallén Warner et al., 2011) and overall road safety statistics (World Health Organization, 2018). Therefore, testing the relationships outlined in Figure 1 magnifies the breadth and depth of our analysis, offering a more comprehensive perspective on the subject. With respect to that, the present study aimed to examine:

1. The differences in the preferred level of vehicle automation based on their technology adoption in Türkiye and Sweden

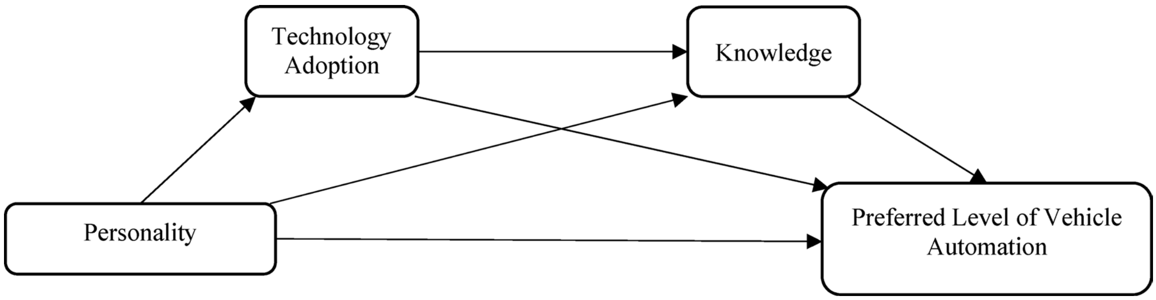

Figure 1. Personality to automation preference through technology adoption and knowledge: A double mediation model. The figure consists of 4 boxes labeled Personality, Technology Adoption, Knowledge, and Preferred Level of Vehicle Automation (from left to right of the page). The order of the boxes represents the serial mediation model tested. Direct arrows go from Personality to the other three factors, from Technology Adoption to Knowledge and Preferred Level of Vehicle Automation, and from Knowledge to Preferred Level of Vehicle Automation.

2. The differences in the preferred level of vehicle automation based on their knowledge of different levels of automation in Türkiye and Sweden
3. The role of personality on the preferred level of vehicle automation through technology adoption and knowledge in Türkiye and Sweden

2. Methods

2.1. Participants

University students with valid full vehicle (Type B) driving licenses from Türkiye and Sweden were invited to partake in the study. Upon completion of the data cleaning procedure detailed in Section 2.4, a total of 297 drivers from Türkiye (between the ages of 19 and 38, $M=22.47$, $SD=2.83$) and 332 drivers from Sweden (between the ages of 20 and 67, $M=30.06$, $SD=10.48$) used for the analysis in the study. In Türkiye, the gender distribution of the participants was 200 (67.3%) female and 97 (32.7%) male drivers. In Sweden, there were 332 individuals distributed as follows: 60.2% were female ($n=200$), 39.2% were male ($n=130$), and two fell into other gender identity categories.

2.2. Design

After translating the materials (see Section 2.4), we conducted a cross-sectional self-reported online questionnaire study (see the following sections for measurements used, procedures followed, and data cleaning and analyses).

2.3. Measurements

The present study included the following variables: preferred level of vehicle automation questions, demographic information (including age, gender, and years with driving license), technology adoption, knowledge of vehicle automation, and Basic Personality Traits Inventory.

2.3.1. Preferred level of vehicle automation

A single item question, 'Below the description of different levels of automation are given. As a driver, which of these levels do you prefer?', was constructed to measure the preferred level of vehicle automation. Respondents were presented with six levels of vehicle automation (from level 0: no automation to level 5: full automation), each level defined with concise explanations of the roles played by automated systems and drivers.

2.3.2. Technology adoption

The technology affinity of respondents was assessed through a single question that they rated on a 5-point Likert scale ranging from 1 (Strongly disagree) to 5 (Strongly agree). The question was presented as follows: 'From the following descriptions, please select one category which best describes you. I am the type of person who likes to use new technological solutions as soon as they are available on the market'.

2.3.3. Knowledge of vehicle automation

After indicating their preferred level of vehicle automation, participants were asked to indicate whether they have knowledge of each level (*Before today, which of the levels described have you heard of?*).

2.3.4. Basic personality traits inventory

The BPTI was created by Gençöz and Öcül (2012) to assess six fundamental characteristics of personality:

extraversion (e.g. timid and withdrawn), conscientiousness (e.g. self-disciplined and tidy), agreeableness (e.g. sincere and compassionate), neuroticism (e.g. nervous and aggressive), openness to experience (e.g. self-confident and self-assured) and negative valence (e.g. ill-mannered and pretentious). Respondents were required to rate 45 adjectives in a 5-point Likert form from 1 (Does not represents me at all) to 5 (Represents me very well). The Cronbach's alpha reliabilities were found as 0.88 for Türkiye and 0.75 for Sweden of extraversion with eight items, 0.83 for Türkiye and 0.61 for Sweden of conscientiousness with eight items, 0.86 for Türkiye and 0.72 for Sweden agreeableness with eight items, 0.83 for Türkiye and 0.71 for Sweden of neuroticism with nine items, 0.75 for Türkiye and 0.70 for Sweden of openness to experience with six items, 0.70 for Türkiye and 0.61 for Sweden of negative valence with six items.

2.4. Procedure

The questionnaire was initially drafted in English. The items and scales that were not previously available in Turkish or Swedish were translated as a part of the study. Following the translation, measures were back-translated to English, and their meaning was cross-checked. After finalizing the survey, ethical approval for data collection was obtained from the Human Research Ethics Committee of Middle East Technical University (Protocol Number: 511 ODTU 2019). Data was collected through an online survey platform, Qualtrics.

The study was part of a big project funded by the Swedish Institute. Details for the project and the rest of the measures applied can be found in the following publications: Öztürk, 2021; Öztürk et al., 2022, 2023. The online survey included several sections presented on different pages. The first part of the survey was the demographic information form, including the technology adoption question. After the demographic information form, the preference and knowledge of vehicle automation questions were presented. The BFI was introduced as the final measure, following other self-report measures.

Convenience and snowball sampling methods were used to approach participants in this study. In addition to using social media platforms to recruit participants, the survey link was distributed through lecturers from universities and the Department of Psychology METU Research Sign-Up System in Türkiye. Besides, in Sweden, participants were invited to the study through e-mail invitation. The e-mail addresses were acquired from LADOK (the student registration and grading document system). Data were collected between March 2020 and July 2020. The anonymity and confidentiality of the participants were ensured. Unique participant IDs were created by the system only for the participants receiving course credits, which are automatically processed.

2.5. Analyses

Analyses were conducted with SPSS v26. In the first step, data with unrealistically short response times were excluded, and data cleaning was applied by analyzing the outlier values (those with a *z*-value above 3.0) in terms of age and kilometers driven in the last year separately for each country to ensure some level of control in the sample in terms of driving experience. Studies show that the z-value performs better in comparison to other methods of detecting outliers (e.g. Chikodili et al., 2020). Van Selst and Jolicoeur (1994) stated that outlier detection is sensitive to the nature of the data, such as skewness, sample size, and criterion cut-offs (such as *z* scores of 2.5, 3.0, or 3.5). Given this and the purpose of the outlier detection process (to eliminate the most extreme values in terms of demographics that could lead to significant differences in experience), a *z*-score of 3.0 was chosen (Bakker & Wicherts, 2014; Chikodili et al., 2020; Tabachnick et al. 2013 for further discussion). However, to minimize the potential impact of this decision and sampling procedure, the variables were entered as control variables. The final sample consisted of 297 drivers from Türkiye and 332 drivers from Sweden. In the first step, two separate hierarchical regression analyses were conducted to investigate the direct relations of technology adoption across the two countries (Table 1). Age, gender, and license year were entered into the model in the first step as statistical control variables, followed by technology adoption in the subsequent step.

In the second stage, a series of ANOVA tests were carried out to examine whether knowledge of each level has an impact on the preferred level of vehicle automation across two counties (Table 2). After investigating individual scores, the overall knowledge score was calculated by considering the weight of higher levels of automation to include further analysis. Drivers indicated their knowledge of each level (from level 1 to level 5) separately. The final score

Table 1. Technology adoption on the preferred level of vehicle automation after controlling for age, gender, and license year.

	Türkiye						Sweden					
	R^2	$R^2\Delta$	*df*	$F\Delta$	β	*p*	R^2	$R^2\Delta$	*df*	$F\Delta$	β	*p*
1st Step	0.03	0.03	3,293	2.69		.047	0.05	0.05	3,327	5.12		.002
Age					0.18	.072					−0.11	.571
Gender (0: male, 1: female)					−0.12	.038					−0.19	<.001
License year					−0.20	.047					0.20	.314
2nd Step	0.04	0.01	1,292	4.48		.035	0.18	0.14	1,326	54.21		<.001
Technology adoption					0.12	.035					0.39	<.001

Table 2. Differences in automation preference across Türkiye and Sweden between drivers with and without knowledge of each level.

		Have knowledge			Not have knowledge			Country		Knowledge		Country by knowledge	
		N	*M*	*SD*	*N*	*M*	*SD*	*F*	*p*	*F*	*p*	*F*	*p*
L1: Driver assistance	Türkiye	235	3.08	1.63	62	3.55	1.45	11.69	<.001	2.56	.110	2.13	.145
	Sweden	251	2.78	1.63	81	2.80	1.51						
L2: Partial automation	Türkiye	174	3.03	1.57	123	3.39	1.62	11.78	<.001	.42	.518	4.13	.043
	Sweden	237	2.84	1.58	95	2.65	1.65						
L3: Conditional automation	Türkiye	118	3.24	1.57	179	3.14	1.62	9.72	.002	.45	.501	.01	.935
	Sweden	170	2.82	1.53	162	2.75	1.67						
L4: High automation	Türkiye	84	3.39	1.72	213	3.09	1.54	8.93	.003	5.59	.018	.03	.854
	Sweden	121	3.01	1.73	211	2.66	1.50						
L5: Full automation	Türkiye	126	3.40	1.76	171	3.02	1.46	8.48	.004	9.80	.002	.04	.848
	Sweden	131	3.05	1.82	201	2.62	1.41						

Note: Dfs = 1, 625.

was calculated by dividing the sum of levels drivers know by the number of levels they know. For instance, if a driver knew level 2 and level 3, their score is calculated by dividing 5 (2 [level] + 3 [level]) by 2 (number of levels they knew), equaling 2.5 to quantify levels they possess knowledge of.

Bivariate correlation coefficients were assessed in the third step, accounting for demographic variables, technology adoption, knowledge of vehicle automation, the BFPI dimensions, and the preferred level of vehicle automation (Table 3) for Türkiye and Sweden separately. In the final step, the final double mediation model was tested using model 6 from the PROCESS custom dialogue for IBM SPSS (Hayes, 2018) through a series of mediation analyses. The estimates of 95% confidence intervals were estimated by using 5000 resamples (Hayes, 2018). Mediation analyses were conducted separately for Türkiye and Sweden, with each dimension of personality entered as the independent variable separately. Previous studies (Othman, 2023b; Weigl et al., 2021, 2022) have shown that demographic variables play a significant role in explaining drivers' attitudes toward automated vehicles. Considering the diversity between the two countries and the uneven distribution of the samples on certain demographic variables, age, gender, and license year were also entered into the analyses as control variables.

3. Results

3.1. Preferred level of vehicle automation and technology adoption

The regression models were significant both in Türkiye ($F(4, 292)=3.16$, $p=.014$) and Sweden ($F(4, 326)=18.02$, $p<.001$). After controlling for the statistical effects of age, gender and license year, high technology adoption was positively related to the preferred level of vehicle automation in Türkiye (95% CI [0.95, 1.05]) and Sweden (95% CI [0.88, 1.13]).

3.2. Preferred level of vehicle automation and knowledge

Country differences indicated that drivers from Türkiye favored vehicles with higher levels of automation. The main effect of knowledge was significant only for high automation and full automation, indicating that drivers who possessed knowledge of these systems preferred vehicles with higher levels of automation than those who did not in the two countries. The country-by-knowledge interaction was only significant for partial automation. Drivers from Türkiye who were familiar with partial automation preferred vehicles with higher levels of automation than drivers from Türkiye without the knowledge of partial automation ($t(625) = 3.11$, $p_{bonf} = 0.012$) and drivers

Table 3. Correlation Coefficients in Türkiye and Sweden.

	Age	Lyear	Gender	LYKm	TA	Kn	Ex	Con	Ag	Ne	Op	Nv	AP	*M*	*SD*
Age	1	.96**	−0.01	0.17**	0.04	−0.06	0.17**	0.03	−0.06	−0.18***	.02	−0.16**	0.08	30.06	10.48
Lyear	0.82***	1	−0.00	0.15*	0.09	−0.05	0.19***	0.06	−0.03	−0.22***	.02	−0.19***	0.09	10.39	10.32
Gender	−0.14*	−0.16**	1	−0.24***	−0.27***	−0.18**	0.17**	0.19**	0.20***	0.05	−.04	−0.09	−0.18***		
LYKm	0.10	0.17**	−0.12*	1	0.12	0.11	0.06	0.04	−0.07	−0.02	.01	0.07	−0.00	7514.44	10805.42
TA	−0.07	−0.05	−0.19**	0.00	1	0.13*	0.13*	0.08	−0.01	−0.12*	.17**	−0.04	0.42***	3.09	1.12
Kn	−0.07	−0.04	−0.21**	0.09	0.14**	1	−0.05	−0.01	0.02	−0.11*	.04	−0.04	0.10	2.46	1.00
Ex	0.02	0.04	−0.03	0.17**	0.13*	−0.01	1	0.32***	0.20***	−0.19***	.47***	−0.28***	−0.14**	3.55	.63
Co	−0.03	−0.06	0.09	−0.12*	−0.00	−0.08	0.19***	1	0.26***	−0.20***	.23***	−0.25***	−0.09	3.52	.49
Ag	−0.06	−0.06	0.09	0.03	−0.02	−0.07	0.20***	0.26***	1	−0.12*	.20***	−0.36***	−0.09	3.97	.47
Ne	−0.07	−0.03	0.22***	0.02	−0.01	−0.07	−0.22**	−0.23***	−0.24***	1	−.13*	0.52***	−0.12*	2.46	.56
Op	−0.02	0.01	−0.14*	0.12*	0.16**	0.03	0.58***	0.24***	0.30***	−0.10	1	−0.16**	−0.04	3.56	.60
Nv	−0.07	−0.13*	−0.12*	−0.07	0.06	0.10	−0.24***	−0.29***	−0.49***	0.36***	−.14*	1	−0.02	2.00	.57
AP	0.03	−0.03	−0.12*	−0.13*	0.14*	0.16**	−0.11*	0.08	−0.06	−0.03	−.11	0.13*	1	2.79	1.60
M	22.47	3.07		5058.06	3.12	2.24	3.47	3.60	4.19	2.82	3.65	1.73	3.18		
SD	2.83	2.52		11856.82	1.14	1.10	0.80	0.68	0.52	0.70	0.62	0.53	1.60		

Note. Correlation coefficients in Türkiye were given in bold. *p<.05; **p<.01; ***p<.001. Lyear: year of driving licensing; Gender: 0: male, 1: female; LYKm: kilometers driven in the previous year; TA: technology adoption; Kn: knowledge; Ex: extraversion; Co: conscientiousness; Ag: agreeableness; Ne: neuroticism; Op: openness to change; Nv: negative valence; AP: automation preference.

from Sweden without the knowledge of the same level (t(625)=3.38, p_{bonf}=0.005).

3.3. Preferred level of vehicle automation and technology adoption, knowledge and personality

The correlation coefficients in Türkiye indicated positive correlations of technology adoption, knowledge, and negative valence with the preference for higher levels of automation; conversely, extraversion was negatively associated with the automated vehicle preference. In Sweden, technology adoption was positively and extraversion and neuroticism were negatively correlated with the preferred level of vehicle automation (Table 3).

3.4. Relations of technology adoption, knowledge, and personality with automation preference

In the final step, the mediating roles of technology adoption and knowledge were tested in the relation between personality and the preferred level of vehicle automation in a double mediation model. The explained variances (R^2) were presented in Table 4.

As shown in Figure 2, extraversion was positively related to technology adoption in Türkiye (t(292) = 2.26, p=025) and in Sweden (t(326) = 3.16, p=002), which in return positively related to the preferred level of vehicle automation in Türkiye (t(290) = 2.21, p = .028) and in Sweden (t(324) = 7.99, p < .001). Besides, in Türkiye, knowledge (t(290) = 2.20, p = .029) was positively related to the preferred level of vehicle automation. The direct association was negative for extraversion in Türkiye (t(290) = −2.28, p = .023) and in Sweden (t(324) = −3.89, p < .001). The total indirect effect (B=0.18, LLCI = 0.06; ULCI = 0.31) and the indirect effect of extraversion on the preferred level of vehicle automation through technology adoption were significant in Sweden (B=0.18, LLCI = 0.07; ULCI = 0.31).

Table 4. Explained variances across Türkiye and Sweden.

	Türkiye		Sweden	
	Total effect R^2	Final model R^2	Total effect R^2	Final model R^2
Extraversion	0.04	0.07	0.06	0.22
Conscientiousness	0.03	0.07	0.05	0.20
Agreeableness	0.03	0.06	0.05	0.19
Neuroticism	0.03	0.06	0.05	0.19
Openness to experience	0.04	0.08	0.05	0.20
Negative valence	0.04	0.07	0.05	0.18

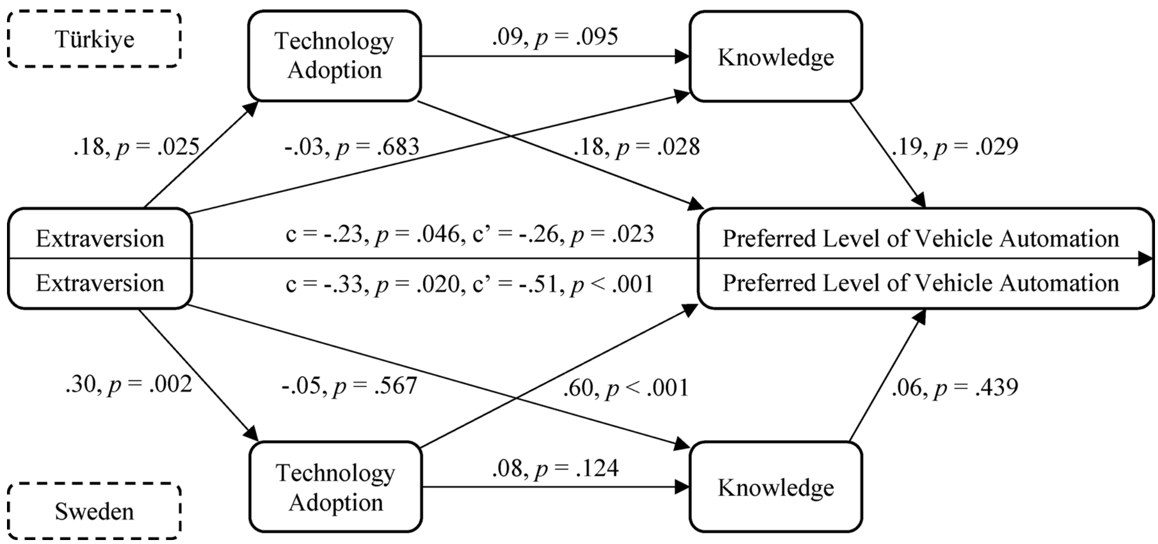

Figure 2. Extraversion to automation preference through technology adoption and knowledge in Türkiye (top half) and Sweden (bottom half).

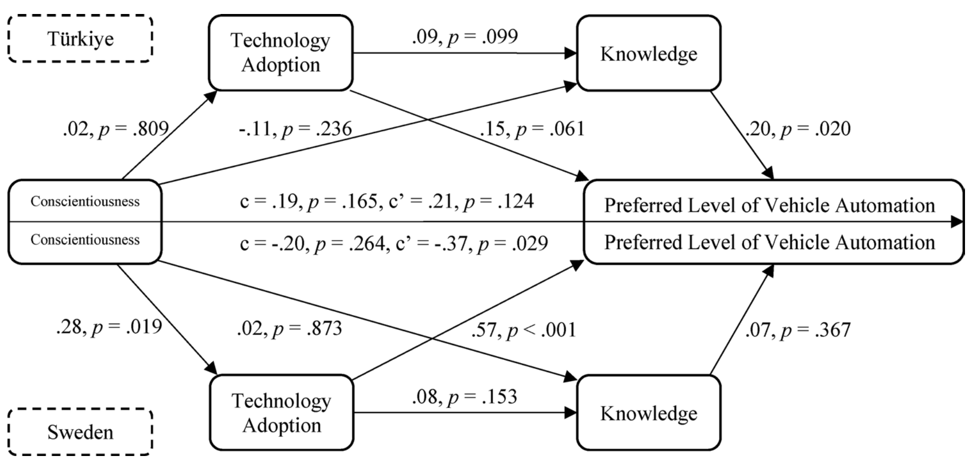

Figure 3. Conscientiousness to automation preference through technology adoption and knowledge in Türkiye (top half) and Sweden (bottom half).

As shown in Figure 3, in Türkiye, knowledge was positively associated with the preferred level of vehicle automation ($t(290) = 2.35$, $p = .020$). In Sweden, while conscientiousness ($t(324) = -2.20$, $p = .029$) was negatively related to the preferred level of vehicle automation, the dimension was positively associated with technology adoption ($t(326) = 2.35$, $p = .019$) in return positively related to automation preference ($t(324) = 7.53$, $p < .001$). The total indirect effect (B=0.17, LLCI = 0.03; ULCI = 0.31) and the indirect effect of conscientiousness on the preferred level of vehicle automation was significant through technology adoption (B=0.16, LLCI = 0.03; ULCI = 0.30) in Sweden.

For the model with agreeableness (Figure 4), knowledge in Türkiye ($t(290) = 2.19$, $p = .029$) and technology adoption in Sweden ($t(324) = 7.31$, $p < .001$) were positively associated with the preferred level of vehicle automation.

For the model with neuroticism (Figure 5), knowledge in Türkiye ($t(290) = 2.24$, $p = .026$) and technology adoption in Sweden ($t(324) = 7.17$, $p < .001$) were positively associated with the preferred level of vehicle automation.

As shown in Figure 6, openness to experience was positively related to technology adoption in Türkiye ($t(292) = 2.30$, $p = .022$) and in Sweden ($t(326) = 3.09$, $p = .002$) and in return, technology adoption was positively predicted the preferred level of vehicle automation in Türkiye ($t(290) = 2.23$, $p = .026$) and in Sweden ($t(324) = 7.57$, $p < .001$). Knowledge in Türkiye was also positively related to the preferred level of vehicle automation ($t(290) = 2.23$, $p = .027$).

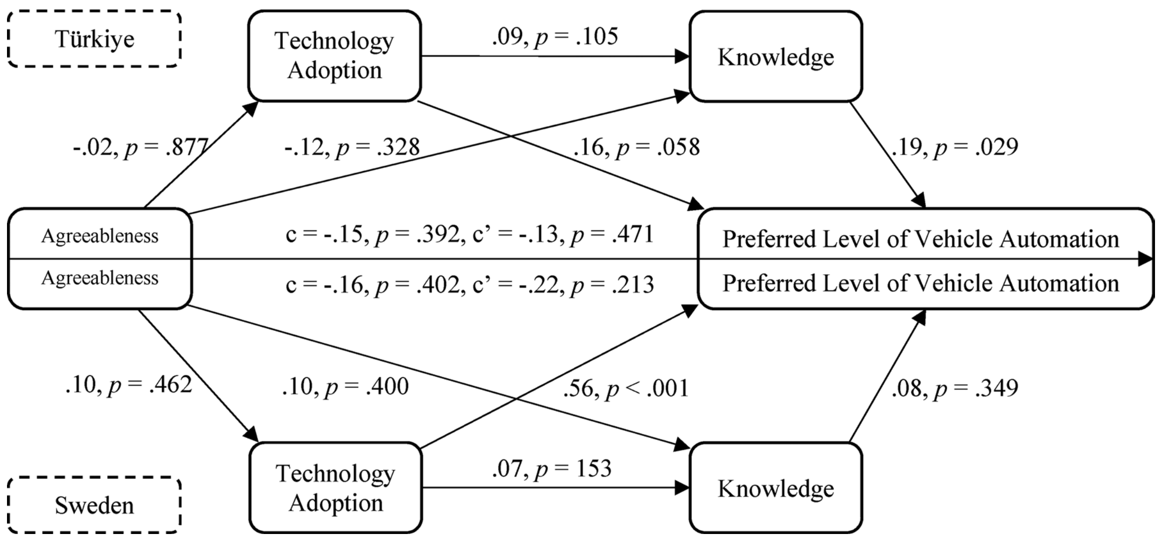

Figure 4. Agreeableness to automation preference through technology adoption and knowledge in Türkiye (top half) and Sweden (bottom half).

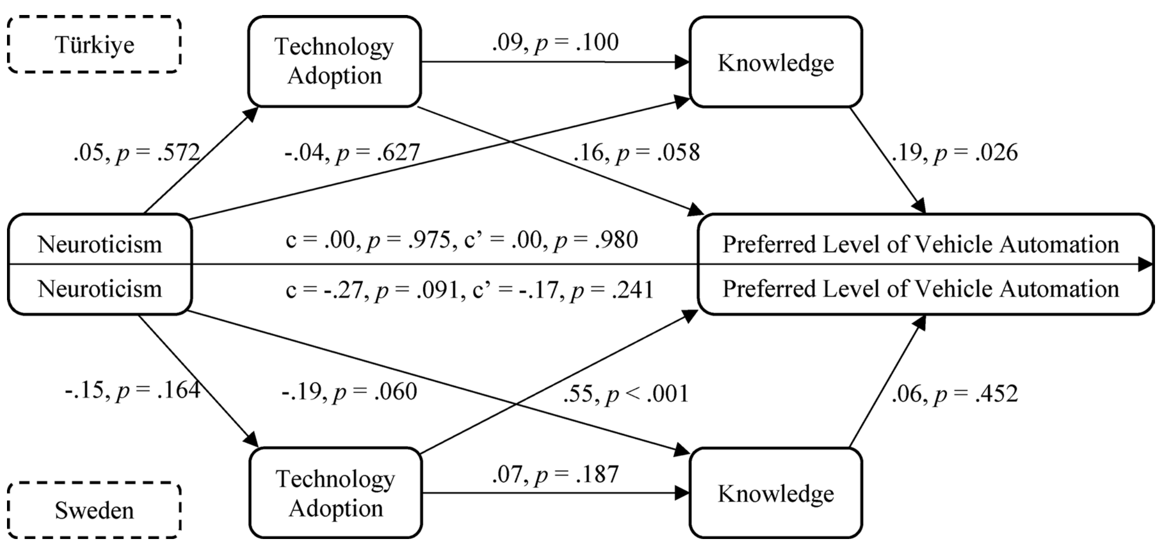

Figure 5. Neuroticism to automation preference through technology adoption and knowledge in Türkiye (top half) and Sweden (bottom half).

The direct effect of openness to change was negative on the preferred level of vehicle automation in Türkiye ($t(290) = -2.41$, $p = .016$) and Sweden ($t(324) = -2.20$, $p = .029$). The indirect effect of openness to change through technology adoption ($B=0.02$, LLCI = 0.00; ULCI = 0.04) was significant in Türkiye. The total indirect effect of openness to change ($B=0.17$, LLCI = 0.05; ULCI = 0.31) and the indirect effect through technology adoption ($B=0.17$, LLCI = 0.05; ULCI = 0.30) were significant in Sweden.

For the model with negative valence (Figure 7), knowledge in Türkiye ($t(290) = 2.14$, $p = .034$) and technology adoption in Sweden ($t(324) = 7.24$, $p <$ .001) were positively associated with the preferred level of vehicle automation.

4. Discussion

In the current study, the preferred level of vehicle automation of drivers from Türkiye and Sweden was examined in relation to technology adoption, previous knowledge of vehicle automation, and personality.

Regarding the first aim of examining the differences in the preferred level of vehicle automation based on their technology adoption in Türkiye and

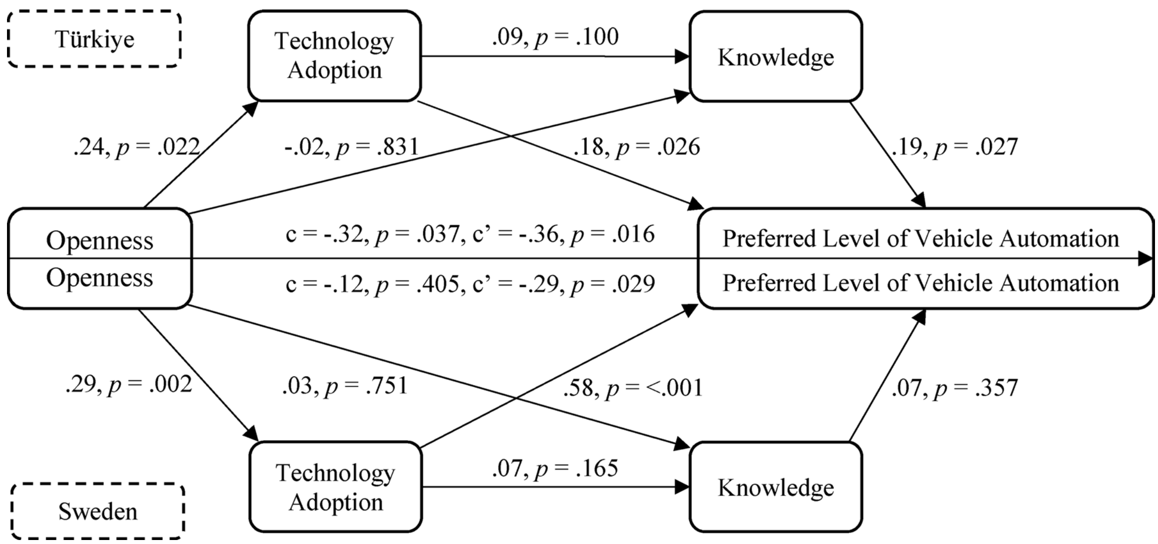

Figure 6. Openness to automation preference through technology adoption and knowledge in Türkiye (top half) and Sweden (bottom half).

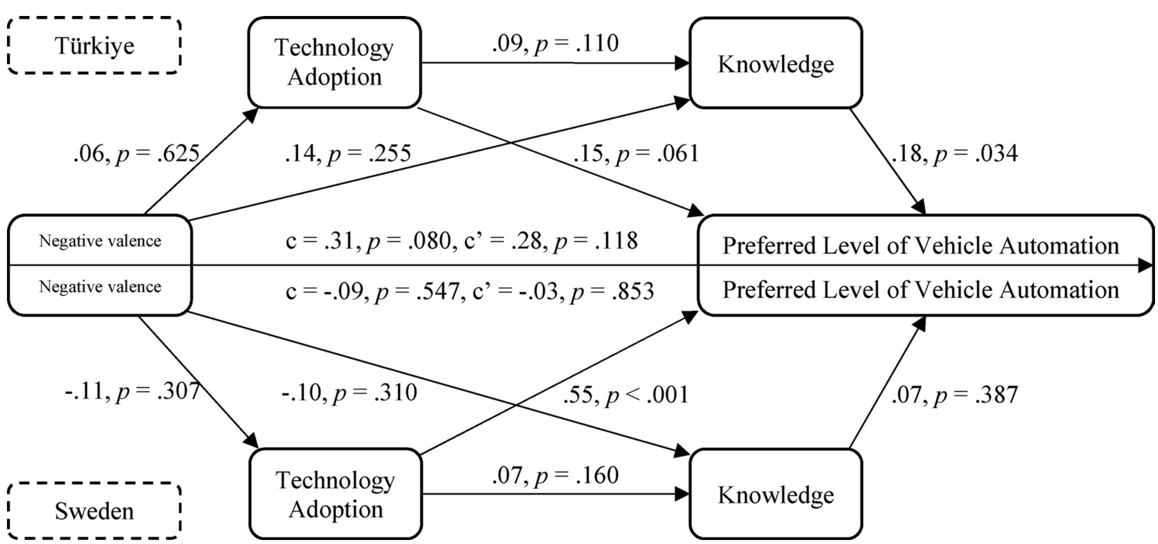

Figure 7. Negative valence to automation preference through technology adoption and knowledge in Türkiye (top half) and Sweden (bottom half).

Sweden, the results supported the previous findings on technology adoption (Hardman et al., 2019; Lee et al., 2019; Sener et al., 2019; Thurner et al., 2022). As discussed by Vishwanath (2005), being an innovator involves being in situations with high novelty and complexity. At these stages, higher levels of automation would be evaluated as something novel and complex for traditional driving. Furthermore, the findings demonstrated that drivers with higher technology adoption preferred vehicles with higher levels of automation across Türkiye and Sweden.

For the second objective of investigating the differences in the preferred level of vehicle automation as a result of familiarity with different levels of automation in Türkiye and Sweden, akin to the finding of König and Neumayr (2017) and Othman (2023a), drivers who had knowledge of high or full automation preferred vehicles with higher levels of automation compared to drivers who did not hear of these levels. Similarly, drivers from Türkiye with knowledge of partial automation preferred higher levels of automation than those who had not heard of partial automation across the two countries. Even though the average preference was below high automation, a relatively higher preference for vehicle automation could be a positive indicator of previous knowledge.

However, it is noteworthy that, similar to the study by Sanbonmatsu et al. (2018), a significant proportion of participants lacked awareness of diverse vehicle technologies prior to the investigation. Sanbonmatsu et al. (2018) highlighted that individuals possessing the least acquaintance formed the most pessimistic opinions. The non-significant difference between users who heard or did not hear of these levels could be because of the strong negative view of users without knowledge of higher levels of automation and negative knowledge of those who have heard previously. Anania et al. (2018) also suggested that the content of the information provided, whether positive or negative, was also crucial in shaping users' willingness to ride automated vehicles. Building on prior research regarding knowledge and experience (Charness et al., 2018), revealing that previous knowledge was associated with decreased concerns, it could be posited that information dissemination initiatives geared towards highlighting the potential of such vehicles might be a crucial factor in fostering greater acceptance and uptake of higher levels of automation in the future.

According to the final aim, to examine the role of personality on the preferred level of vehicle automation through technology adoption and knowledge in Türkiye and Sweden, both extraversion and openness to change in the two countries and conscientiousness in Sweden were positively related to the technology adoption leading to a preference for higher levels of automation. Moreover, both extraversion and openness to change showed inconsistent mediation (MacKinnon et al., 2007) by showing positive indirect effects through technology adoption and knowledge, even though the direct effect was negative. The associations between personality, by focusing on extraversion and openness to change, and technology adoption and the preferred level of vehicle automation showed that curiosity and being something new could be the more salient components of the higher levels of automation at these early stages. Both extraversion and openness to change were positively associated with technology adoption. The positive relations were not surprising as both dimensions of personality are related to being enterprising, active, talkative, and creative (Gençöz & Öcül, 2012). In general, high levels of extraversion and openness to change could be critical personality traits that enable drivers to manage uncertainty and embrace new technologies.

Furthermore, the relationship between conscientiousness and automation preference was also mediated by technology adoption in Sweden. Conscientiousness was positively related to technology adoption, which in turn increases higher automation preference. Within Sweden, technology adoption could be responsible for adapting to novel advancements, thus linking conscientiousness with vehicle preferences due to technology adoption. Taking into account the examined factors and the explained variances, the outcomes have displayed that technology adoption has a more significant impact in Sweden. Conversely, familiarity with vehicle automation is more potent in predicting drivers' inclination towards higher levels of automation in Türkiye.

The significant impact of extraversion and openness to change might be reasonable for the public since we are at the stage of quite a limited level of experience and exposure to these systems. Nonetheless, it could be speculated that the associations for other dimensions of personality might get stronger as drivers become more familiar and knowledgeable with the systems. As discussed by Penmetsa et al. (2019), public opinion of automated vehicles might get more positive as the interactions with these systems increase. When users experience and observe vehicles with higher levels of automation, such as those owned by their friends and neighbors (Bansal et al., 2016), other factors, such as agreeableness or conscientiousness, may have a stronger impact on drivers' vehicle preferences, taking into account various aspects such as the environment, price, and comfort.

Last but not least, the findings also supported the hierarchical model of Kraus et al. (2021) by examining the technology adoption, knowledge, and personality relationships with the preferred level of automation. Additionally, it is worth noting that the cross-country differences in terms of explained variances and strength of relationships can also be considered as a multi-level factor to be considered in this hierarchical context. The aforementioned results also support the previous findings highlighting regional differences (Liljamo et al., 2018; Sener et al., 2019). According to statistics on road safety in the respective countries (European Transport Safety Council, 2020; World Health Organization, 2018), it is probable that these differences could account for some of the variations in findings. As previously discussed (Öztürk et al., 2022a; 2022b), the difference in preferred levels of automation between two countries may be attributed to road safety indicators in each country and how road users respond to good and bad practices. This can increase their own safety as well as promote a safer driving environment overall.

4.1. Limitations and future suggestions

There are some limitations to the current study that should be addressed, along with suggestions for future research. Different studies have shown that experience is a critical component in shaping users' perception of a system (e.g. Eden et al., 2017; Hartwich et al., 2019; Lehtonen, Malin, et al., 2022; Othman, 2023a). In the present study, knowledge is only measured as a measure of awareness of a system, but the degree of knowledge and experience was not detailed for practical reasons. The limited impact of knowledge of vehicle automation could result due to the limited level of information and chance of experience to the general public. Furthermore, in another study, Othman (2023a, 2023b) found a change in public attitudes after exposure to information and visuals of crash scenes involving automated vehicles. These should be considered while interpreting the results and planning future studies focusing on the knowledge/experience aspect of vehicle automation.

Another important limitation to consider when interpreting the results of the study and implementing the model for future studies is the potential impact of demographic variables and the representativeness of the samples across countries. As can be seen from the descriptive statistics, the samples are not evenly distributed in terms of demographic variables across the two counties. Previous studies have shown (Weigl et al., 2021, 2022) that these variables are important for acceptance of automated vehicles. In order to quantify the possible effects, these variables were used as control variables in the present study. However, future studies with sufficient sample sizes across different groups should consider testing the proposed conceptual model across groups. Nevertheless, the results show the relationships proposed in the conceptual model within the given samples. However, it is difficult to claim the generalizability of the findings given the sample size and sampling methodology used. For this reason, studies with larger samples are recommended.

The present study only focused on the preferred level of vehicle automation, allowing participants to choose by considering the capabilities of each level of automation. In addition, future studies could also investigate discrete factors such as willingness to pay (e.g. Liu et al., 2019; Othman, 2021; Skjeret et al., 2023; Weigl et al., 2022) to examine specific conceptual factors. Moreover, while addressing the preferred level of vehicle automation, the focus is on individuals' private vehicle preferences. While this provides some information about the users, future studies on the impact of these preferences on individual mobility behavior (e.g. Lehtonen et al., 2022), transport mode change (e.g. Wallén Warner et al., 2021) or the use of shared mobility (Schuß et al., 2021a, 2021b) will provide more detailed and comprehensive information on the attitudes of users.

Although we ensured anonymity and confidentiality of responses and also took some precautions, such as excluding respondents with extremely short response times and restricting access to the survey if an individual attempted to access it again after completion (to prevent multiple responses), the data and findings of the study may be subject to certain limitations due to its methodology (see Bethlehem, 2010; Curran, 2016; Van Selm & Jankowski, 2006 for further discussion). Therefore, caution should be exercised in interpreting and using the data.

One of the important aspects of the future of automated vehicles is the training part. According to Merriman et al. (2021), personality and attitudes present a crucial challenge that needs to be considered to enhance the effectiveness of training programs. The findings could be used to highlight the possible effectiveness of developing more technology-oriented training programs for users with higher extraversion and/or openness to change scores. Conversely, a technology-focused training program may underperform for drivers with lower technology adoption or lower levels of extraversion and openness to change. It is therefore recommended to take users' personality traits into account in the planning and implementation of training programs to enhance their effectiveness.

Finally, similar to the association between different personality aspects and preferences for automated driving styles (Bellem et al., 2018), some of the relations between personality factors and the preferred level of vehicle automation were not statistically significant. Additionally, the explained variances for the mediation analyses were around 4–6% in Türkiye and 18–21% in Sweden, where the majority of the variance was added when technology adoption was introduced to the model in Sweden. Similar to the discussion of Spurlock et al. (2019), a considerable amount of users' automation adoption still needs further studies to be explored.

5. Conclusion

In conclusion, the findings of the present study revealed that users' technology adoption, previous knowledge of automated vehicles, and personality had a crucial role in determining the preferred level of vehicle automation. Individuals with a higher rate of technology adoption and knowledge of higher levels of vehicle automation had a preference toward higher levels of vehicle automation. As extraversion and openness to change were positively related to technology adoption, higher technology adoption also led to preferring vehicles with higher levels of automation. The hierarchical structure introduced by Kraus et al. (2021) was supported by the present study's findings, and this study additionally highlighted a cross-country aspect to be considered in the model. The study concluded that future acceptance of vehicle automation is highly dependent on aspects such as technology adoption, previous knowledge, and personality, all of which display varying relationships across different countries.

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CRediT authorship statement

İbrahim Öztürk: Conceptualisation, Methodology, Formal analysis, Writing – Original Draft, Writing – Review & Editing. **Henriette Wallén Warner:** Conceptualisation, Methodology, Writing – Review & Editing, Supervision. **Türker Özkan:** Conceptualisation, Methodology, Writing – Review & Editing, Supervision.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Data availability statement

We make the associated syntax available on an open science platform, along with the preprint (https://osf.io/564d9/). For further information, please contact the corresponding author (I.O., i.ozturk@leeds.ac.uk).

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