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A structural equation modeling approach for the acceptance of driverless automated shuttles based on constructs from the Unified Theory of Acceptance and Use of Technology and the Diffusion of Innovation Theory

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ABSTRACT

The present study investigated the attitudes and acceptance of automated shuttles in public transport among 340 individuals physically experiencing the automated shuttle 'Emily' from Easymile in a mixed traffic environment on the semi-public EUREF (Europäisches Energieforum) campus in Berlin. Automated vehicle acceptance was modelled as a function of the Unified Theory of Acceptance and Use of Technology (UTAUT) constructs performance expectancy, effort expectancy, social influence, and facilitating conditions, the Diffusion of Innovation Theory (DIT) constructs compatibility and trialability, as well as trust and automated shuttle sharing. The results show that after adding the DIT constructs, automated shuttle sharing, and trust to the model, the effect of performance expectancy on behavioural intention was no longer significant. Instead, compatibility with current travel was the strongest predictor of behavioural intention to use automated shuttles. It was further found that individuals who are willing to share rides in an automated shuttle with fellow travelers (i.e., automated shuttle sharing) and who trust automated shuttles (i.e., trust) are more likely to intend to use automated shuttles (i.e., behavioural intention). The highest mean rating was obtained for believing that automated shuttles are easy to use, while the lowest mean rating was obtained for feeling safe inside the automated shuttle without any type of supervision. The analysis revealed a preference for the supervision of the automated shuttle via an external control room to the supervision by a human steward onboard. We recommend future research to investigate the hypothesis that compatibility could serve as an even stronger predictor of the behavioural intention to use automated shuttles in public transport than performance expectancy.

1. Introduction

Automated shuttles can substantially contribute to the attractiveness of public transport. As these vehicles feed public transport on the first and last end of a public transport trip and can be ordered on-demand, they can provide flexible

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door-to-door transport around the clock, while being affordable due to decreased labor costs (Shen, Zhang, & Zhao, 2018). As a hybrid form of individual-public transport, automated shuttles can enhance the inter-modality and individualization of public transport due to smaller-sized vehicles (Shen et al., 2018). Given the large investments in the development of automated vehicles, forecasting the acceptance of automated vehicles in public transport and collecting feedback on prototypes from potential users as early as possible is desirable to increase the chance of acceptance and reduce the likelihood of rejection (Davis, 1993; Gould, Boies, & Lewis, 1991; Rosson, Maass, & Kellogg, 1987).

Venkatesh, Morris, Davis, and Davis (2003) Unified Theory of Acceptance and Use of Technology (UTAUT) posits that the intention to use technology is influenced by performance expectancy (i.e., perceived usefulness), effort expectancy (i.e., perceived ease of use), social influence (i.e., influence of the individual's social network on the acceptance of the individual), and facilitating conditions (i.e., objective factors in the individual's environment supporting usage). Roger's (2003) Diffusion of Innovation Theory (DIT) posits that an individual's adoption decision is influenced by compatibility (i.e., consistency of technology with individual's existing values, needs and experiences of potential adopters), trialability (i.e., trialling and experiencing technology before adoption), observability (i.e., observing someone using the technology), relative advantage, image, and complexity. Relative advantage, image, and complexity correspond with the UTAUT constructs performance expectancy, social influence, and effort expectancy, respectively (Venkatesh et al., 2003). As automated shuttles can currently only be experienced in the context of trials, there are no respondents who could be observed using automated shuttles. Therefore, the present study did not examine the effect of observability on behavioural intention.

Automated vehicle acceptance has received ample attention in the past few years. Previous studies have modelled the behavioural intention to use automated vehicles as a function of the UTAUT constructs and trust (Choi & Ji, 2015; Garidis, Ulbricht, Rossmann, & Schmäh, 2020; Hewitt, Politis, Amanatidis, & Sarkar, 2019; Kaur & Rampersad, 2018; Kettles & Van Belle, 2019; Madigan et al., 2016; Madigan, Louw, Wilbrink, Schieben, & Merat, 2017; Nordhoff et al., 2018; Xu et al., 2018; Zhang et al., 2019). The multi-level model on automated vehicle acceptance (MAVA) (Nordhoff, De Winter, Payre, Van Arem, & Happee, 2019; Nordhoff, Kyriakidis, Van Arem, & Happee, 2019), summarizing automated vehicle acceptance research on the basis of 124 studies, revealed that compatibility and automated shuttle sharing were examined in only 10 out of 124 studies, respectively. Trialability has not been investigated in any of these studies. Thus, little is known about the predictive effect of the DIT constructs compatibility and trialability and automated shuttle sharing on behavioural intention. Identifying and testing additional predictors can enhance the prediction of behavioural intention and provide a richer understanding of automated vehicle acceptance (see Venkatesh et al., 2003). Furthermore, there is limited knowledge on how the effect of the UTAUT constructs and trust on behavioural intention changes with the addition of the DIT constructs compatibility and trialability as well as automated shuttle sharing in one model. It is important to determine the ability of variables to predict the outcome variable in a multivariable context. While a variable can have a strong bivariate correlation with the outcome variable, its effect on the outcome variable can disappear when it is considered together with additional variables in a model. This would then imply that this particular variable is not needed to produce the optimal prediction of the outcome variable (Hair, Black, Babin, & Anderson, 2014). This knowledge can contribute to the development of more economic measures to investigate attitudes towards and acceptance of automated vehicles.

The examination of the relative importance of the UTAUT and the DIT constructs trialability and compatibility, trust in automation and automated shuttle sharing on behavioural intention provides unique contributions to the body of work on automated vehicle acceptance.

2. Research objectives

The main objectives of the present study therefore are:

i. To examine the direct effects of the UTAUT constructs performance expectancy, effort expectancy, social influence, and facilitating conditions, on the behavioural intention to use automated shuttles in public transport
ii. To examine the direct effects of the DIT constructs trialability, compatibility, as well as trust and automated shuttle sharing on the behavioural intention to use automated shuttles in public transport

2.1. Hypothesis development

In previous studies on automated vehicle acceptance, positive effects of performance expectancy, facilitating conditions, and social influence on individual's behavioural intention to use automated vehicles were found (Bernhard, Oberfeld, Hoffmann, Weismüller, & Hecht, 2020; Garidis et al., 2020; Kaur & Rampersad, 2018; Kettles & Van Belle, 2019; Madigan et al., 2016, 2017; Motamedi, Wang, Zhang, & Chan, 2020; Xu et al., 2018; Zhang et al., 2020). Note that the literature on automated vehicle acceptance has reported an ambiguous relationship between effort expectancy and behavioural intention (see Nordhoff, De Winter, et al., 2019; Nordhoff, Kyriakidis, et al., 2019). Several studies revealed positive effects of effort expectancy on behavioural intention (Bernhard et al., 2020; Garidis et al., 2020; Xu et al., 2018; Zhang et al., 2020), while others did not find significant effects (Madigan et al., 2017; Motamedi et al., 2020). The present study expects that individuals who consider automated shuttles useful (i.e., performance expectancy), easy to use (i.e., effort expectancy), and who believe that important others in their social networks support the use of automated shuttles (i.e., social influence) are more likely to intend to use automated shuttles (i.e., behavioural intention). We posit the following hypotheses:

H1–H4: *Performance expectancy (**H1**), effort expectancy (**H2**), social influence (**H3**), and facilitating conditions (**H4**) will have a positive effect on the behavioural intention to use automated shuttles.*

Compatibility is defined as the degree to which an innovation is perceived to be consistent with existing values, needs and experiences of potential adopters (Rogers, 2003). Deb et al. (2017) found that individuals who indicated that fully automated vehicles are compatible with the transportation system were more likely to accept fully automated vehicles in their area. Yuen, Cai, Qi, and Wang (2020) and Yuen, Wong, Ma, and Wang (2020) confirmed a positive, indirect relationship between compatibility and public acceptance of automated vehicles. Several studies in other domains evidenced positive direct effects of compatibility on behavioural intention (Aldás-Monzano, Ruiz-Mafé, & Sanz-Blas, 2008; Chang & Tung, 2008; Ozaki & Sevastyanova, 2011; Rezvani, Jansson, & Bodin, 2015; Sharif Sharifzadeh, Damalas, Abdollahzadeh, & Ahmadi-Gorgi, 2017). Based on these findings, we expect a positive relationship between compatibility and the behavioural intention to use automated shuttles. The assumption is that individuals who consider automated shuttles compatible with their existing mobility routines and needs are more likely to intend to use automated shuttles. We therefore hypothesize:

H5: *Compatibility will have a positive effect on the behavioural intention to use automated shuttles.*

Trialability is the extent to which an innovation can be trialled and experienced before the adoption (Rogers, 2003). Kaye, Buckley, Rakotonirainy, and Delhomme (2019) posit that the successful implementation of automated vehicles depends upon the outcomes of trials, and that it is important to evaluate automated vehicle acceptance by public trials. Liu, Xu, and Zhao (2019) posit that the investigation of the acceptance of road tests is a pressing research need that has to be addressed, especially after the occurrence of the first pedestrian fatality caused by an automated vehicle. The authors revealed a positive relationship between the perceived benefits (equivalent to performance expectancy) and road test acceptance, implying that individuals who value the perceived benefits of automated vehicles are more likely to accept road tests with automated vehicles (Liu et al., 2019). Yuen et al. (2020) and Yuen et al. (2020) found a positive, indirect effect of trialability on the public acceptance of automated vehicles. We expect a positive relationship between trialability and the behavioural intention to use automated shuttles. The assumption is that individuals who value experiencing automated shuttles in trials prior to adoption (i.e., trialability) are more inclined to use automated shuttles (i.e., behavioural intention). We hypothesize:

H6: *Trialability will have a positive effect on the behavioural intention to use automated shuttles.*

Trust is a key driver of automated vehicle acceptance (Choi & Ji, 2015; Du, Robert, Pradhan, Tilbury, & Yang, 2018; Herrenkind, Nastjuk, Brendel, Trang, & Kolbe, 2019; Kaur & Rampersad, 2018; Roche-Cerasi, 2019; Xu et al., 2018; Yuen et al., 2020; Zhang et al., 2019, 2020). Lee and Mirman (2018) revealed that the perceived concern 'I would not know how the autonomous vehicle will protect my child if there are aggressive or dangerous vehicles nearby' received the highest agreement among parents. On the basis of these results, we expect that individuals with higher levels of trust in automated shuttles are more likely to intend to use automated shuttles. We hypothesize:

H7: *Trust will have a positive effect on the behavioural intention to use automated shuttles.*

Synchronously sharing automated vehicles with strangers is one of the big central questions and top conditions for the widespread success and adoption of automated vehicles (Clayton, Paddeu, Parkhurst, & Parkin, 2020; Paddeu, Parkhurst, & Shergold, 2020). Nevertheless, it has received surprisingly little attention from scientific scholars so far (Axsen & Sovacool, 2019; Sanguinetti, Kurani, & Ferguson, 2019). Cunningham, Ledger, and Regan (2018) found that "travelling in public transport in which the vehicle is driverless" and "sharing a driverless vehicle" received the lowest agreement among respondents. This corresponds with the study of Clayton et al. (2020) in which the shared automated vehicle was the least popular option, with 38.90% of respondents willing to use it. Likewise, in the study of Bansal and Kockelman (2018), 50% of respondents reported to be comfortable with sharing a ride with a stranger for short durations during the day or with a friend of one of their Facebook friends. Gurumurthy and Kockelman (2020) found that the proportion of respondents willing to share an automated vehicle with strangers dropped with increases in travel time. Clayton et al. (2020) found that people who indicated to feel comfortable interacting with strangers are more likely to use shared automated vehicles. Faber and Van Lierop (2020) revealed that being able to travel and socialize with others is an important motive for using automated vehicles. We hypothesize:

H8*: Automated shuttle sharing will have a positive effect on the behavioural intention to use automated shuttles.*

The proposed relationships are shown in Fig. 1.

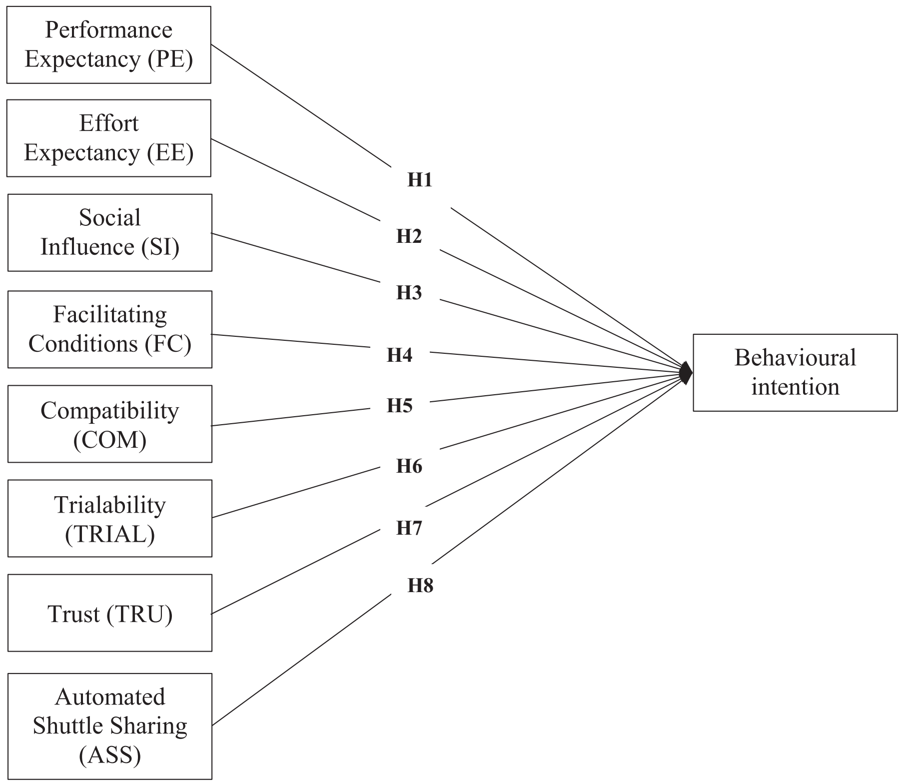

Fig. 1. Research model.

3. Method

3.1. Automated shuttle, respondent recruitment and procedure

The results reported here were part of a 45-item questionnaire, which was administered to users of the automated shuttle 'Emily' on the EUREF office campus in Berlin-Schöneberg (Germany) via tablet computers between March and December 2018. The automated shuttle that was involved in the trial is shown in Fig. 2.

The shuttle carried up to 12 passengers per trip (6 sitting, 6 standing) and ran at a maximum speed of 13 km/h. A steward was inside the shuttle to intervene in the vehicle operations when requested by the system. For example, obstacles that were on the trajectory of the shuttle had to be overtaken manually. Our previous trial at the EUREF campus involved an automated shuttle running on the basis of fixed stops, where stewards braked and accelerated manually (Nordhoff et al., 2018). In the current study, 'Emily' operated on the basis of virtual stops to simulate that the future hop-on and hop-off situation can be dynamic and without the constraints of fixed stops. 'Emily' now braked and continued to drive at stops in automated mode.

At the end of the ride, the stewards handed out the tablet computers with a questionnaire to individuals. Only individuals who took a ride with the automated shuttle were asked to complete the questionnaire. The questionnaire was offered in German and English, depending on the preference of the respondent. The information was recorded anonymously and no financial compensation was offered to respondents.

3.2. Questionnaire content

With the first six questions (Q1–Q6), the respondents were asked to assess their level of agreement with items pertaining to the perceived usefulness and ease of use (i.e., performance and effort expectancy) of automated shuttles in public transport. The next question (Q7) asked respondents to rate the user-friendliness, adequateness for daily use, reliability, environmental friendliness, affordability and innovativeness of the automated shuttle. Next, respondents were asked to rate their level of satisfaction with automated shuttles (Q8). Question Q9 asked respondents to indicate how their personal view on automated shuttles has changed since their personal test ride.

Next, three questions (Q10–Q12) were presented to assess the agreement of respondents with items capturing the availability of conditions supporting the use of automated shuttles (i.e., facilitating conditions). Questions Q13–Q18 asked

Fig. 2. Automated shuttle ‘Emily’, EZ10, by Easymile on the EUREF campus in Berlin, Germany.

respondents to indicate their agreement with items pertaining to their desired level of privacy in automated shuttles (i.e., automated shuttle sharing) and their reliance on the opinions of others (i.e., social influence).

Respondents were asked to rate the level of comfort for the driving maneuvers of the automated shuttle (Q19). Questions Q20 and Q21 asked respondents to rate the amount of effort required to maintain a posture/balance during the ride and to carry out a task (if respondents were carrying out a task), respectively. Question Q22 asked respondents to rate the level of comfort felt for specific vehicle characteristics.

Next, questions Q23–Q30 asked respondents to rate their level of trust in (i.e., trust) and acceptance of automated shuttles (i.e., behavioural intention). Questions Q31 and Q32 asked respondents to rate the importance of having a steward inside the shuttle (Q31), and supervising the automated shuttle from an external control room to provide manual control (Q32). Question Q33 asked respondents whether they would feel safe without any type of supervision. Questions Q34–Q37 asked respondents to indicate their level of agreement with items capturing the importance of experiencing automated shuttles in the context of trials (i.e., trialability). Questions Q38–Q41 asked respondents to rate questions pertaining to the compatibility of automated shuttles with their existing mobility needs and behavior (i.e., compatibility).

With the final questions Q42–Q45, respondents were asked to provide information on their gender (Q42), age (Q43), access to a valid driver license (Q44), and transport pass (Q45).

The operationalization of the questions pertaining to the UTAUT and DIT constructs Q1–Q6, Q10–Q12, Q15–Q18, Q28–Q30, and Q34–Q41 were used from Venkatesh et al. (2003) and Rogers (2003) and adjusted to the context of this study. Q7–Q9, Q13–Q14, and Q26 were adapted from the WOB (2016) Emobility cube questionnaire that was conducted by the InnoZ to assess the acceptance of electric vehicles. Q23–Q25 were adapted from Choi and Ji (2015). Q27, and Q31–Q33 were self-constructed.

3.3. Analysis of responses

A two-step approach was adopted (Anderson & Gerbing, 1988). First, a confirmatory factor analysis was performed to assess the measurement relationships between the latent and observed variables. Latent variables are hypothetical or theoretical constructs that are indirectly measured by the observed variables (i.e., questionnaire items). The psychometric properties of the measurement model were assessed by its indicator reliability, internal consistency reliability, convergent validity and discriminant validity. Convergent validity was assessed by four criteria: 1) All scale items should be significant and have loadings exceeding 0.60 on their respective scales, 2) the average variance extracted (AVE) should exceed 0.50, 3) construct reliability (CR) and 4) Cronbach’s alpha values should exceed 0.70 (Anderson & Gerbing, 1988; Fornell & Larcker, 1981). Discriminant validity of our data was examined with the test of squared correlations by Anderson and Gerbing (1988), which implies that the correlation coefficient between two latent variables should be smaller than the square root of the average variance extracted (AVE) of each latent variable to demonstrate sufficient discriminant validity.

The second step of the analysis involved testing the structural model, which relates the UTAUT and DIT constructs with trust in automation and automated shuttle sharing. Maximum-likelihood (ML) estimation was used to estimate the measurement and structural model, which has proven robust to violations of the normality assumption (Hair et al., 2014). Full Information Maximum Likelihood (FIML) was used to deal with missing data. Note that we did not perform a Multiple Cause Multiple Indicator (MIMIC) model that captures a latent construct with both several formative indicators (“cause” in the name of MIMIC) and reflective indicators (“effect” in the name of MIMIC) (Jöreskog & Goldberger, 1975; Peng & Lai, 2012) as no latent construct in our study has both formative and reflective indicators.

The confirmatory factor analysis and structural equation modeling were performed with R software lavaan package (Rosseel, 2012).

4. Results

4.1. Respondents

Responses from 340 individuals were gathered between April and December 2018. Respondents completed the questionnaire after their ride with the automated shuttle in a building of the InnoZ. When the respondents did not have time to fill out the questionnaire at the InnoZ, they were provided with an online link to access the questionnaire at a convenient place and time. Missing values (i.e., *'I prefer not to respond'* – responses to the questions Q1–Q6, Q9–Q18, and Q23–Q41) were deleted. The mean age of respondents was 31.34 years (SD = 11.27). 162 respondents were female, 148 respondents were male, and seven respondents picked the gender option "Other". 268 respondents indicated to be in possession of a public transport ticket, while 40 specified they were not. 248 respondents reported to have access to a valid driver license, while 63 respondents specified they did not.

4.2. Ratings of attitudinal questions

As shown in Table 1, on a scale from very negative (1) to very positive (6), respondents rated the automated shuttle as innovative (Q7.6, *M* = 5.11, SD = 1.27), environmentally-friendly (Q7.4, *M* = 4.66, SD = 1.36), user-friendly (Q7.1, *M* = 4.34, SD = 1.25), adequate for daily use (Q7.2, *M* = 4.05, SD = 1.15), reliable (Q7.3, *M* = 4.02, SD = 1.10), and affordable (Q7.5, *M* = 3.87, SD = 1.21) (Q7).

The respondents indicated to be slightly satisfied with the automated shuttle (Q8), with a mean of 3.76 (SD = 1.19) on a scale from very unsatisfied (1) to very satisfied (6) (Q8). As shown by Fig 3, 41.96% of respondents indicated that taking a ride with the automated shuttle has produced no change of their view on automated vehicles in public transport, while 37.20% reported a rather positive and 16.37% a positive change of their view on automated shuttles (Q9, *M* = 3.65, SD = 0.81, on a scale from very negative (1) to very positive (5)).

On a Likert scale from strongly disagree (1) to strongly agree (6), the highest mean rating was obtained for the item pertaining to the belief that learning to use automated shuttles would be easy (Q3, *M* = 5.44, SD = 0.91). The lowest mean rating was obtained for feeling safe without any type of supervision (Q33, *M* = 2.92, SD = 1.56) (see Fig. 4). A moderate rating was obtained for abolishing the own car in favor of public transport and automated shuttles as feeder systems to public transport (Q27, *M* = 3.35, SD = 1.56).

As shown by Figs. 5 and 6, respectively, on a scale from not at all important (1) to very important (6), respondents considered a steward inside the automated shuttle moderately important (Q31, *M* = 3.85, SD = 1.67), and favor the supervision of the automated shuttle from an external control room (Q32, *M* = 4.81, SD = 1.30).

4.3. Results of confirmatory factor analysis

The results of the confirmatory factor analysis are shown in Table 2. The items measuring effort expectancy (EE1), trust (TRU4), trialability (TRIAL1), automated shuttle sharing (ASS1), and behavioural intention (BI1–BI2) were omitted from the analysis as their loading was below the recommended threshold of 0.60. The fit parameters of the measurement model were acceptable for all latent variables. The **C**onfirmatory **F**it **I**ndex (CFI) (0.94 0.95), **R**oot **M**ean **S**quare **E**rror **A**pproximation (RMSEA) (0.05), **S**tandardized **R**oot **M**ean **S**quare **R**esidual (SRMR) (0.05), and chi-square statistic (χ^2/df) (1.14) were acceptable. Composite reliability and Cronbach's alpha both exceeded the recommended threshold of 0.70, confirming internal consistency reliability. The average variance extracted (AVE) values exceeded the recommended minimum threshold of 0.50 for all latent variables except for effort expectancy and automated shuttle sharing. As shown by Table 3, which reports the inter-construct correlations, discriminant validity was acceptable for all latent variables.

4.4. Results of structural equation modeling

We ran two structural models for this study. First, the effects of the UTAUT constructs performance expectancy, effort expectancy, facilitating conditions, and social influence on the behavioural intention to use automated shuttles were investigated. Second, the effects of the DIT constructs compatibility, trialability, as well as trust and automated shuttle sharing on the behavioural intention were investigated. The results of the structural equation modeling are shown in Table 4, and interpreted in the discussion.

5. Discussion and conclusion

New data was collected with a dedicated set of questions among 340 individuals physically experiencing the automated shuttle 'Emily' from Easymile in a mixed traffic environment on the semi-public EUREF campus in Berlin. The main objective was to examine the direct effects of the UTAUT and DIT constructs, trust and automated shuttle sharing on behavioural intention. Prior research separately applied the UTAUT and DIT constructs to predict automated vehicle acceptance. Our current study uniquely integrates the UTAUT and DIT constructs into one model to predict the acceptance of automated shuttles

Table 1
Means (M), standard deviations (SD), rating scale, number of respondents (n), absolute frequencies.

Questionnaire item	*M*	SD	1	2	3	4	5	6	*n*
Q1. My interaction with the automated shuttle would be clear and understandable.	4.74	1.19	8	16	16	59	141	87	327
Q2. I think that automated shuttles would be useful for my daily travel.	4.33	1.52	16	43	31	67	84	96	337
Q3. Learning to use automated shuttles would be easy for me.	5.44	0.91	3	5	5	23	91	209	336
Q4. I think that an automated shuttle would be more useful than my existing form of travel.	3.58	1.46	32	53	69	87	59	36	336
Q5. I think that automated shuttles would be a useful extension of our current transport systems.	5.09	1.08	5	10	8	50	118	148	339
Q6. I would find automated shuttles easy to use.	5.12	0.94	2	3	11	59	121	139	335
Q7.1. – Q7.6. According to your experiences: How would you rate automated shuttles?									
Q7.1. User-friendly	4.34	1.25	2	7	96	93	43	93	334
Q7.2. Adequate for daily use	4.05	1.15	2	21	88	113	59	47	330
Q7.3. Reliable	4.02	1.10	3	21	76	128	61	37	326
Q7.4. Environmentally-friendly	4.66	1.36	4	8	75	68	30	146	331
Q7.5. Affordable	3.87	1.21	5	36	79	116	43	40	319
Q7.6. Innovative	5.11	1.27	1	4	64	25	33	205	332
Q8. Please let us know to what extent you are unsatisfied or satisfied with automated shuttles.	3.76	1.19	3	24	147	85	26	49	334
Q9. To what extent has your personal view on automated shuttles changed since your personal test ride?	3.65	0.81	1	14	141	125	55	0	336
Q10. I have the knowledge necessary to use automated shuttles.	4.51	1.41	16	17	42	64	95	99	333
Q11. Given the resources, opportunities and knowledge it takes to use automated shuttles, it would be easy for me to use automated shuttles.	4.91	1.13	4	10	22	63	112	124	335
Q12. I have the resources necessary to use automated shuttles.	4.35	1.45	12	34	41	71	77	92	327
Q13. Even when I am in public space, privacy is important for me.	4.42	1.31	10	19	49	83	97	81	337
Q14. I feel comfortable sharing the space of the automated shuttle with fellow travellers at the same time.	4.84	1.10	3	9	25	74	114	112	335
Q15. People whose opinion I value would like me to use automated shuttles.	3.87	1.46	34	20	50	104	65	43	316
Q16. I intend to share an automated shuttle with around 6–8 fellow travelers who have the same route like me.	4.63	1.23	11	10	31	83	98	98	331
Q17. People who influence my behavior would think that I should use automated shuttles.	3.66	1.46	38	25	62	94	61	30	310
Q18. People who are important to me think that I should use automated shuttles.	3.63	1.48	40	28	63	93	56	34	314
Q19.1. – Q19.3. Please rate the discomfort felt for the following maneuvers from a scale of 1 to 5, 5 being uncomfortable and 1 being comfortable.									
Q19.1. Braking	1.84	1.04	143	98	34	16	10	–	301
Q19.2. Accelerating	1.73	0.96	156	98	28	11	8	–	301
Q19.3. Turning	1.74	0.86	144	102	40	10	2	–	298
Q20. Please rate from a scale of 1 to 5, the amount of effort required to maintain posture/ balance during the ride, 5 being high amount of effort and 1 is no effort at all.	2.64	1.50	94	75	38	39	58	–	304
Q21. If you were carrying out a task during the ride, please rate from a scale of 1 (no effort at all) to 5 (high amount of effort) the amount of effort required to carry out the task. The task can be something like reading/writing an email or playing a game.	2.10	1.09	106	94	56	28	8	–	292
Q22.1. – Q22.6. Please rate the discomfort felt for the following features on a scale from 1 being comfortable to 5 being uncomfortable.									
Q22.1. Inside temperature	2.02	1.24	140	77	35	27	19	–	298
Q22.2. Available leg space	1.48	0.77	198	72	25	3	3	–	301
Q22.3. Available arm space	1.99	1.04	122	86	63	18	7	–	296
Q22.4. Seating	2.10	1.09	113	82	70	25	8	–	298
Q22.5. Vehicle noises	1.70	0.97	176	53	54	10	4	–	297
Q22.6. Air quality/ventilation	1.94	1.08	129	98	40	19	11	–	297
Q23. I think that automated shuttles would be reliable.	4.45	1.15	2	19	39	90	102	60	312
Q24. I think that my interactions with this type of vehicle would be predictable.	4.54	1.03	1	9	37	88	114	54	303
Q25. I would trust this type of vehicle for my everyday travel.	4.41	1.17	4	15	46	87	100	57	309
Q26. For automated shuttles I would expect a large user acceptance.	4.63	1.16	2	19	52	92	96	48	331
Q27. I plan to abolish my own car in favor of public transport and automated shuttles as feeder systems as soon as automated shuttles are available.	3.35	1.64	53	43	56	57	41	37	287
Q28. Assuming that I had access to automated shuttles, I predict that I would use them when they are available.	4.68	1.15	3	14	30	66	115	82	310
Q29. I plan to use automated shuttles in public transport systems when they are available.	4.86	1.08	1	11	22	65	110	102	311
Q30. I intend to use automated shuttles from the train station or some other public transport stop to my final destination or vice versa when they are available.	4.93	1.04	1	10	13	68	109	106	307
Q31. Please rate the importance of having a steward inside the vehicle that would provide manual control if necessary.	3.85	1.67	37	49	31	63	72	60	312
Q32. Please rate the importance of the supervision of a driverless shuttle by an external control room to provide manual control if necessary.	4.81	1.30	9	15	19	60	90	119	312
Q33. I would feel safe without any type of supervision.	2.92	1.56	76	61	64	55	32	23	311
Q34. Being able to try out automated shuttles was important for me in deciding whether I should use them in the future or not.	4.31	1.47	16	31	31	72	80	78	308
Q35. I want to be able to use automated shuttles on a trial basis.	4.69	128	9	11	32	63	94	100	309

Table 1 (*continued*)

Questionnaire item	*M*	SD	1	2	3	4	5	6	*n*
Q36. I am more likely to want to use automated shuttles because of being part this pilot test.	4.09	1.46	20	31	42	78	77	58	306
Q37. I want to be permitted to use automated shuttles on a trial basis long enough to see what they can do.	4.55	1.37	11	18	37	62	86	94	308
Q38. Using automated shuttles would be compatible with all aspects of my mobility behavior.	4.22	1.31	12	24	40	97	81	56	310
Q39. I think that using automated shuttles fits well with the way I like to travel.	4.17	1.30	9	28	48	90	83	51	309
Q40. I expect to be able to handle all my mobility trips well with automated shuttles.	3.69	1.50	36	29	67	76	64	37	309
Q41. Using automated shuttles is completely compatible with my current situation.	3.65	1.44	26	49	59	78	68	29	309

Note: Q1–Q6, Q10–Q18, and Q23–Q41 were measured on a six-point Likert scale from 1 (strongly disagree) to 6 (strongly agree).
Q7 was measured on a six-point scale from 1 (very negative) to 6 (very positive).
Q8 was measured on a six-point scale from 1 (very unsatisfied) to 6 (very satisfied).
Q9 was measured on a five-point scale from 1 (very negative) to 5 (very positive).
Q19 and Q22 were measured on a five-point scale from 1 (comfortable) to 5 (uncomfortable).
Q20–Q21 were measured on a five-point scale from 1 (no effort at all) to 5 (high amount of effort).
Q30–Q31 were measured on a six-point scale from 1 (not at all important) to 6 (very important).

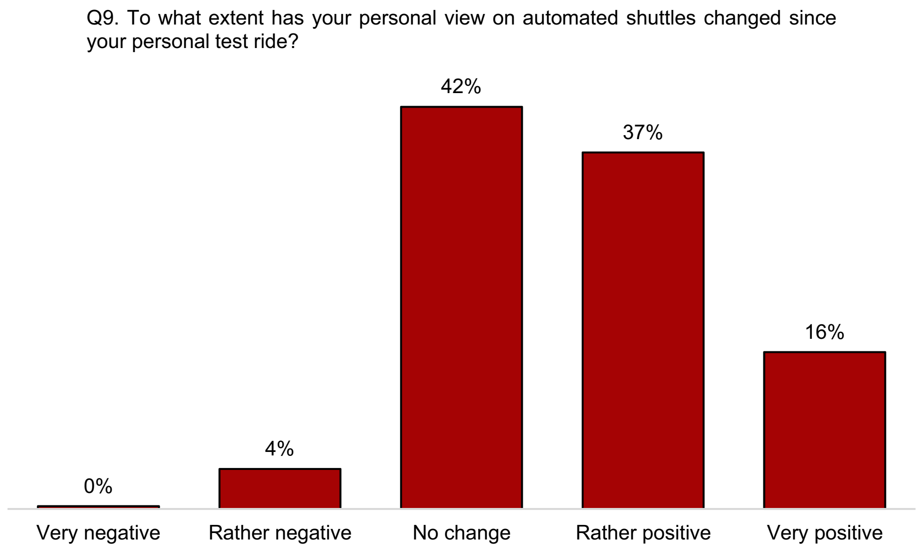

Fig. 3. Frequency distribution of the responses for the questionnaire item Q9 "*To what extent has your personal view on automated shuttles changed since your personal test ride?*" on the scale from very negative (1) to very positive (5), n = 336.

in public transport. Trust was further added to the model to tailor it to the context of automated driving technology and respond to research studies that corroborated the role of trust in determining automated vehicle acceptance. Automated shuttle sharing was integrated into our model to account for the fact that sharing space with fellow travellers in automated shuttles will become a relevant part of the user experience of public automated vehicles. The knowledge obtained in this study can inform and guide the decision-making of practitioners regarding the identification of the determinants and the development of the corresponding strategies to enhance automated vehicle acceptance.

5.1. Theoretical implications

5.1.1. Ratings of attitudinal questions

Our results have shown that the highest mean rating was obtained for believing that automated shuttles are easy to use. This finding is not surprising as the role of the respondents who experienced the automated shuttle in the trial was simply to enter the vehicle and enjoy the ride while being driven. When automated shuttles are part of functional public transport, using automated shuttles will involve identifying, booking, ticketing, entering, getting seated, and leaving the shuttle. This implies that the ratings of the perceived ease of use of automated shuttles in trials might differ from the ratings of the per-

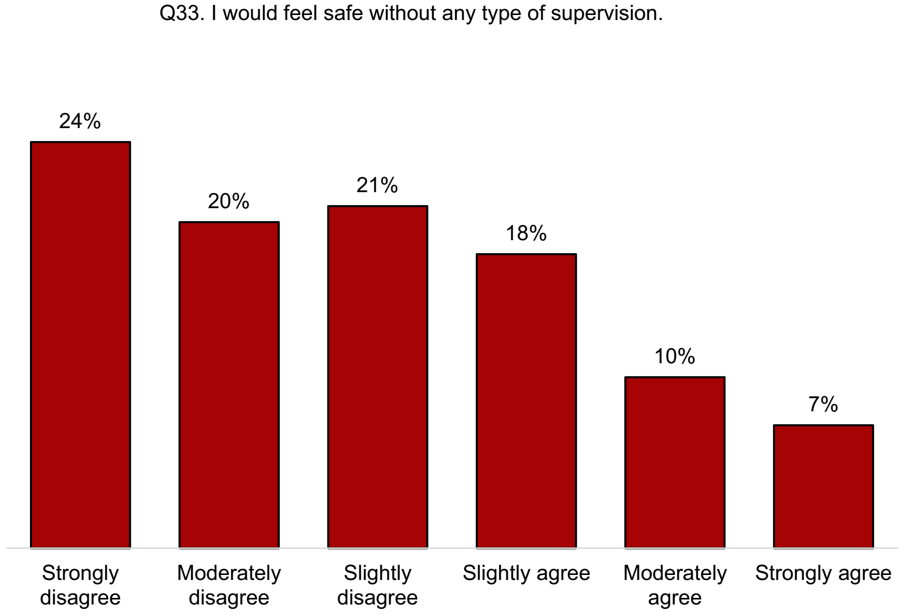

Fig. 4. Frequency distribution of the responses for the questionnaire item Q33 *"I would feel safe without any type of supervision"* on the scale from strongly disagree (1) to strongly agree (6), $n = 311$

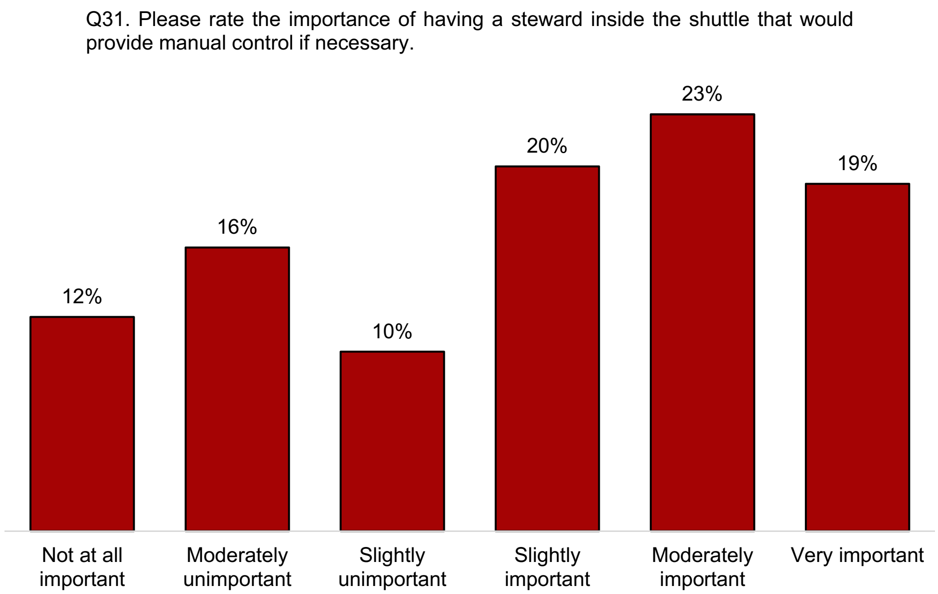

Fig. 5. Frequency distribution of the responses for the questionnaire item Q31 "*Please rate the importance of having a steward inside the shuttle that would provide manual control if necessary*" on the scale from not at all important (1) to very important (6), n = 312.

ceived ease of use in future operational systems. We recommend future research to revisit the operationalization of the UTAUT construct 'effort expectancy', which is equivalent to the perceived ease of use, as effort expectancy tends to be operationalized in very generic terms. It could be assessed which associations respondents have with the perceived ease of use of automated shuttles; whether it relates to the actual use of the automated shuttle, and/or the processes that precede or succeed the actual use (e.g., booking, ticketing, getting seated, entering & leaving the shuttle).

The lowest mean rating was obtained for feeling safe without any type of supervision of the automated shuttle, suggesting that respondents do not entirely trust the automated shuttle to execute the entire driving task on its own. This finding corresponds with latest research on trust in automated vehicles (Lee & Kolodge, 2020), which has shown that respondents generally do not trust automated vehicles. Respondents in our study questioned the presence of a steward in the shuttle,

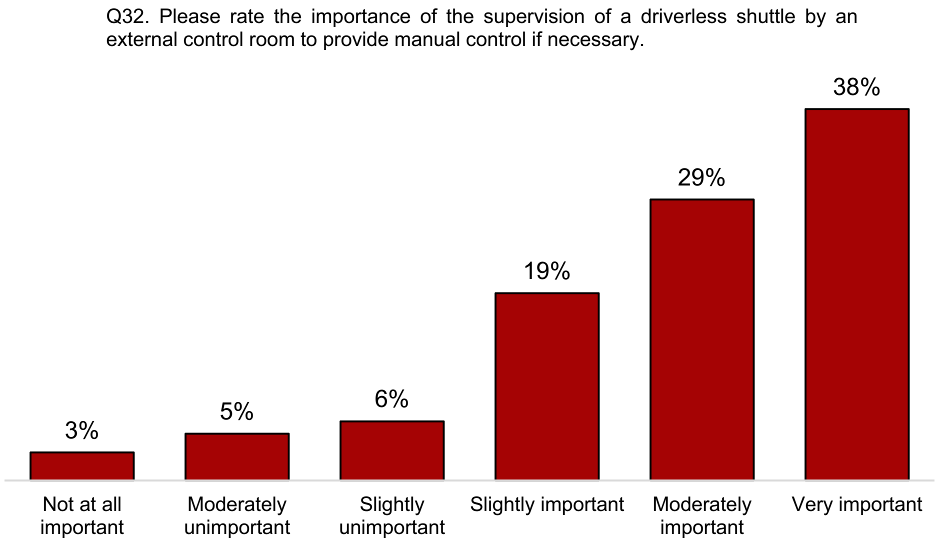

Fig. 6. Frequency distribution of the responses for the questionnaire item Q32 "*Please rate the importance of the supervision of a driverless shuttle by an external control room to provide manual control if necessary*" on the scale from not at all important (1) to very important (6), n = 312.

probably because they did not expect physical supervision in an automated vehicle that is supposed to be driverless. They preferred the supervision of the automated shuttle from an external control room, which corresponds with our study (Nordhoff et al., 2018), which has identified the supervision from an external control room as the favorite supervision type, followed by supervision by a human steward and no human supervision. In contrast, Roche-Cerasi (2019) found that 54.9% of respondents indicated that automated buses should still have drivers, while only 8.5% preferred that buses are monitored and remotely controlled by a control room operator. Lee et al. (2019) revealed that 71.3% of the respondents reported to be comfortable with automation levels in which the human driver remains in control, while 27.7% of respondents indicated to be comfortable with automated driving features that placed the vehicle in control. As the automated shuttle in the present study was supervised by the steward, future research should be conducted in automated shuttles that are supervised from an external control room or not at all rather than relying on physical human supervision onboard.

A moderate rating was obtained for abolishing the private car in favour of public transport and automated shuttles feeding public transport. This suggests that while respondents are positive towards the idea of using automated shuttles in public transport, it is questionable whether automated shuttles in public transport will lead to substantial reductions of the use of private cars. It is likely that a substantial reduction of private car use can only be realised when automated shuttles provide all or most of the benefits of the private car (Nordhoff, De Winter, et al., 2019; Nordhoff, Kyriakidis, et al., 2019).

5.1.2. Predictors to behavioural intention

The first structural model examined the main effects of the UTAUT constructs performance expectancy, effort expectancy, social influence, and facilitating conditions on the behavioural intention to use automated shuttles.

In line with several studies on automated vehicle acceptance (Kaur & Rampersad, 2018; Madigan et al., 2016, 2017), performance expectancy was the strongest predictor of the behavioural intention to use automated shuttles in the first structural model. The effect of effort expectancy and facilitating conditions on behavioural intention was not significant, which corresponds with Madigan et al. (2017) and Zhang et al. (2019), but is contradictory to the studies of Buckley, Kaye, and Pradhan (2018), Xu et al. (2018), and Wu, Liao, Wang, and Chen (2019). Social influence was not predictive of the behavioural intention to use automated shuttles, which does not correspond with Madigan et al. (2016, 2017). Social influence failed to predict behavioural intention in voluntary usage contexts (Venkatesh et al., 2003), such as the intention to use demand-responsive transport and carsharing systems as well as e-scooter virtual reality services (Fleury, Tom, Jamet, & Colas-Maheux, 2017; Huang, 2020; König & Grippenkoven, 2020).

When the DIT constructs compatibility and trialability, trust and automated shuttle sharing were added in the second structural model, compatibility was the strongest predictor of behavioural intention. This implies that individuals who consider automated shuttles compatible with their existing mobility needs and routines are more likely to intend to use automated shuttles. In contrast, Rahman, Deb, Strawderman, Burch, and Smith (2019) did not find significant effects of compatibility on automated vehicle acceptance. The effect of performance expectancy was insignificant. This is not in line with several studies on automated vehicle acceptance (Kaur & Rampersad, 2018; Madigan et al., 2016, 2017), in which performance expectancy was the strongest predictor of the behavioural intention to use automated vehicles. Scientific research in other domains has shown positive effects of compatibility on behavioural intention, while the effect of performance expectancy was both significant and non-significant when modelled together with compatibility (Han, Mustonen,

Table 2
Results of confirmatory factor analysis.

Latent variable	Observed variable	*M*	SD	λ	α	CR	AVE
Performance expectancy (PE)		3.47	0.92		0.77	0.79	0.57
	PE1: I think that automated shuttles would be useful for my daily travel.			0.80			
	PE2: I think that an automated shuttle would be more useful than my existing form of travel.			0.77			
	PE3: I think that automated shuttles would be a useful extension of our current transport systems.			0.63			
Effort expectancy (EE)		4.42	0.81		0.71	0.75	0.47
	EE1: My interaction with the automated shuttle would be clear and understandable.			Omitted from the analysis due to factor loading < 0.6			
	EE2: Learning to use automated shuttles would be easy for me.			0.75			
	EE3: I would find automated shuttles easy to use.			0.83			
Social influence (SI)		3.35	1.19		0.91	0.91	0.77
	SI1: People whose opinion I value would like me to use automated shuttles.			0.84			
	SI2: People who influence my behavior would think that I should use automated shuttles.			0.89			
	SI3: People who are important to me think that I should use automated shuttles.			0.91			
Facilitating conditions (FC)		3.87	0.95		0.80	0.80	0.59
	FC1: I have the knowledge necessary to use automated shuttles.			0.81			
	FC2: Given the resources, opportunities and knowledge it takes to use automated shuttles, it would be easy for me to use automated shuttles.			0.75			
	FC3: I have the resources necessary to use automated shuttles.			0.74			
Trialability (TRIAL)		3.68	0.89		0.76	0.77	0.45
	TRIAL1: Being able to try out automated shuttles was important for me in deciding whether I should use them in the future or not.			Omitted from the analysis due to factor loading < 0.6			
	TRIAL2: I want to be able to use automated shuttles on a trial basis.			0.70			
	TRIAL3: I am more likely to want to use automated shuttles because of being part this pilot test.			0.66			
	TRIAL4: I want to be permitted to use automated shuttles on a trial basis long enough to see what they can do.			0.80			
Compatibility with existing mobility needs (COM)		3.50	0.95		0.84	0.85	0.59
	COM1: Using automated shuttles would be compatible with all aspects of my mobility behavior.			0.77			
	COM2: I think that using automated shuttles fit well with the way I like to travel.			0.83			
	COM3: I expect to be able to handle all my mobility trips well with automated shuttle.			0.72			
	COM4: Using automated shuttles is completely compatible with my current situation.			0.75			
Trust (TRU)		4.03	0.75		0.80	0.79	0.59
	TRU1: I think that automated shuttles would be reliable.			0.73			
	TRU2: I think that my interactions with this type of vehicle would be predictable.			0.88			
	TRU3: I would trust this type of vehicle for my everyday travel.			0.67			
	TRU4: I would feel safe without any type of supervision.			Omitted from the analysis due to factor loading < 0.6			
Automated shuttle sharing (ASS)		4.11	0.83		0.65	0.72	0.39
	ASS1: Even when I am in public space, privacy is important for me.			Omitted from the analysis due to factor loading < 0.6			
	ASS2: I feel comfortable sharing the space of the automated shuttle with fellow travelers at the same time.			0.59			
	ASS3: I intend to share an automated shuttle with around 6–8 fellow travelers who have the same route like me.			0.92			
Behavioural intention (BI)		4.24	0.83		0.88	0.90	0.73
	BI1: For automated shuttles, I would expect a large user acceptance.			Omitted from the analysis due to factor loading < 0.6			
	BI2: I plan to abolish my own car in favor of public transport and automated shuttles as feeder systems as soon as automated vehicles are available.			Omitted from the analysis due to factor loading < 0.6			
	BI3: Assuming that I had access to automated shuttles, I predict that I would use them when they are available.			0.84			
	BI4: I plan to use automated shuttles in public transport systems when they are available.			0.92			

Table 2 (*continued*)

Latent variable	Observed variable	*M*	SD	λ	α	CR	AVE
	BI5: I intend to use automated shuttles from the train station or some other public transport stop to my final destination or vice versa when they are available.			0.80			

Notes: λ (i.e., lambda) = Loading of the observed variable on the latent variable.
α (Cronbach alpha) and CR (construct reliability) = Internal consistency measure defined as the extent to which the observed variables measure the same construct on the basis of their interrelationships.
AVE = The average variance extracted in the observed variable accounted for by the latent variables.

Table 3
Inter-construct correlation matrix.

Construct	PE	EE	SI	FC	TRU	COM	TRIAL	ASS	BI
PE	**0.75**								
EE	0.39	**0.69**							
SI	0.44	0.22	**0.88**						
FC	0.24	0.46	0.14	**0.76**					
TRU	0.41	0.32	0.35	0.30	**0.77**				
COM	0.59	0.18	0.31	0.02	0.40	**0.77**			
TRIAL	0.26	0.08	0.24	−0.06	0.12	0.40	**0.67**		
ASS	0.21	0.27	0.41	0.17	0.29	0.24	0.19	**0.62**	
BI	0.55	0.35	0.32	0.25	0.46	0.50	0.22	0.34	**0.85**

Note: The diagonal values represent the square root of the average variance extracted (AVE).
PE = Performance expectancy, EE = Effort expectancy, SI = Social influence, FC = Facilitating conditions, TRU = Trust, COM = Compatibility, TRIAL = Trialability, ASS = Automated shuttle sharing, BI = Behavioural intention.

Table 4
Results of structural equation modeling, hypotheses, standardized path coefficients (β), standard errors, p-values (p), model fit parameters, and variance explained (R^2).

Hypotheses	Standardized path coefficients	Standard errors	*p*-values	CFI	RMSEA	SRMR	χ^2/df	R^2	Supported?
First structural model									
H1: PE → BI	0.489	0.070	0.000	0.967	0.060	0.051	1.96	0.397	Yes
H2: EE → BI	0.154	0.136	0.088						No
H3: SI → BI	0.079	0.054	0.233						No
H4: FC → BI	0.031	0.066	0.687						No
Second structural model									
H1: PE → BI	0.186	0.136	0.115	0.942	0.053	0.052	1.73	0.485	No
H2: EE → BI	0.081	0.252	0.358						No
H3: SI → BI	−0.052	0.066	0.460						No
H4: FC → BI	0.082	0.083	0.313						No
H5: COM → BI	0.280	0.117	0.017						Yes
H6: TRIAL → BI	0.043	0.091	0.566						No
H7: TRU → BI	0.180	0.102	0.026						Yes
H8: ASS → BI	0.177	0.118	0.011						Yes

Seppänen, & Kallio, 2006; Ifinedo, 2012; Schaper & Pervan, 2007). A data-driven explanation for the non-significant effect of performance expectancy in our study lies in the existence of some degree of redundancy between performance expectancy and compatibility as shown by the moderate relationship between performance expectancy and compatibility. A theory-driven explanation is that performance expectancy involves a more general appraisal of the usefulness of technology without necessarily linking usefulness to the mobility lives of individuals. Compatibility, on the other hand, has a direct linkage with individuals' mobility routines: In order to make the use of automated shuttles compatible with individual's mobility routines and practices, individuals may need to make significant changes in their mobility behavior. Agarwal and Prasad (1998) argue that of the constructs perceived usefulness and ease of use, compatibility is the only construct that requires individuals to change their behavior, which renders the examination of this construct highly important. Note that compatibility is rooted in the construct facilitating conditions (Venkatesh et al., 2003). We propose to treat compatibility with existing mobility needs and practices to be conceptually distinct from facilitating conditions. Facilitating conditions is defined as the degree to which infrastructure exists to support the use of the system (Venkatesh et al., 2003), in our case automated shuttles. This conceptualization, in our view, does not address the compatibility of automated shuttles with the mobility patterns of individuals. We encourage future research to investigate more closely the similarity between compatibility and performance expectancy, and examine whether these constructs can be merged. A hypothesis *tentatively* derived from this finding is that compatibility may even substitute performance expectancy as the strongest predictor of the behavioural intention to use automated shuttles. We invite scientific scholars to examine this further.

Trust was the second-strongest positive predictor of the behavioural intention to use automated shuttles in public transport. This implies that individuals who trust automated shuttles are more likely to intend to use them. Our finding corresponds with research on the role of trust for automated vehicle acceptance (Choi & Ji, 2015; Xu et al., 2018; Zhang et al., 2019). Note that trust bears a close conceptual resemblance to the construct perceived safety, which was identified as key driver of attitudes towards automated vehicles and automated vehicle acceptance (Garidis et al., 2020; Motamedi et al., 2020; Xu et al., 2018; Zhang et al., 2019; Zoellick, Kuhlmey, Schenk, Schindel, & Blüher, 2019). Studies examining opinions towards trust and perceived safety without physically exposing respondents to automated vehicles in quasi-naturalistic settings may produce biased estimates. In these studies, respondents' opinions may be based on information obtained by mass media, specialized literature, and entertainment sources. We recommend future research to unravel the nature of the relationship between perceived safety and trust, and investigate differences in the ratings measuring perceived safety and trust across research settings that vary the exposure rate to automated vehicles.

Automated shuttle sharing was the third-strongest positive predictor of the behavioural intention to use automated shuttles. This suggests that individuals who are willing to share space with strangers are more likely to intend to use automated shuttles. This finding corresponds with Bhat (2018) who found that the success of shared automated vehicles hinges on the willingness of travellers to share rides with strangers, where privacy-sensitivity reduced the likelihood to share a ride in an automated vehicle, and with Morales Sarriera et al. (2017) who have shown that travellers are concerned about taking a ride with unfamiliar people due to a lack of trust, security and privacy concerns. In Nordhoff, De Winter, et al. (2019), Nordhoff, Kyriakidis, et al. (2019), Nordhoff, Madigan, Happee, Van Arem, and Merat (2020), Nordhoff, Stapel, Van Arem, and Happee (2020) and Motamedi et al. (2020), respondents considered sharing the automated vehicle with fellow travellers an uncomfortable aspect of automated vehicle use. In line with Bhat (2018), we encourage future research to identify the population segments that differ in their propensity to use shared automated shuttles.

5.2. Practical implications

The findings obtained in the present study yield important practical implications for policy makers, vehicle designers and operators. Respondents indicated to not feel entirely safe in a driverless shuttle, favoring the supervision of the shuttle from an external room to a lack of supervision. The study of Brell, Philipsen, and Ziefle (2019) revealed that respondents preferred the option of being able to control the actions of an autonomous vehicle at all times as it was difficult for them to envision a complete surrender of control to the technology. Woldeamanuel and Nguyen (2018), who studied the perceived benefits and concerns of millennials versus non-millennials towards autonomous vehicles, found that 95% of millennials were most concerned about riding in a vehicle without driver controls such as a steering wheel, brake and gas pedals. This finding implies that increasing the perceived level of control of passengers of automated shuttles will be a key factor in automated vehicle acceptance. This can be achieved by displays inside shuttles visualising the person/s in the external control room that remotely control/s the shuttle, and that can be called by passengers for all sorts of technical and non-technical questions during the ride using a button inside the shuttle or a smartphone app. As shown by our accompanied test ride study (Nordhoff, Madigan, et al., 2020; Nordhoff, Stapel, et al., 2020), a second strategy is to equip automated shuttles with displays showing the current and future actions of automated shuttles and the external environment (e.g., road users in close proximity) in order to increase the predictability of the shuttle behaviour for passengers. A third strategy is to implement emergency stop buttons inside shuttles (see Nordhoff, Madigan, et al., 2020; Nordhoff, Stapel, et al., 2020).

Compatibility exhibited the strongest effects on behavioural intention. This implies that policy makers and public transport companies should design strategies to make automated shuttles compatible with the existing mobility needs of individuals. This can be done in multiple ways. First, vehicle manufacturers and public transport companies can make the use of automated shuttles compatible with the use of public transport systems, implying that using automated shuttles is familiar for public transport users (see Chan et al., 2010). Second, policy makers and public transport companies could identify individuals who consider automated shuttles compatible with their existing mobility routines, and who have a higher level of technology openness and enthusiasm (see Chan et al., 2010). These people can then serve as starting point to introduce the technology into the market and "sell" automated shuttles among their peers.

Furthermore, as suggested by our model, the individual's level of trust in automated shuttles should be enhanced, and the benefits of automated shuttles (e.g., increases in efficiency, comfort and safety of public transport systems and livability of cities) more effectively advertised by the social (analog and digital) networks of individuals, and governmental education campaigns. Public trials with automated shuttles can be implemented in order to make the public familiar with automated shuttles, educate them about their expected benefits and risks (see Venkatesh, 2006), and how to interact with these vehicles as vulnerable road users and human drivers (Kaye et al., 2019; Pettigrew & Cronin, 2019). Brown, Massey, Montoya-Weiss, and Burkman (2002) have argued that increases in the knowledge of the public about the technology, the greater the potential impact of the importance of the opinions of others, which, in turn, may promote the use of the technology. These activities can be part of a sophisticated expectation management system to align the expectations of the public to the real technical capabilities of automated shuttles, and design interventions to make the use of automated shuttles safe, comfortable and acceptable.

Automated shuttle sharing was identified as a positive predictor of behavioural intention. Vehicle manufacturers and public transport companies should consider the deployment of smaller-sized vehicles to mitigate privacy concerns and simulate the "private cocoon" effect that has contributed to the attractiveness of the private car (Fraedrich & Lenz, 2016; Fraedrich, Beiker, & Lenz, 2015; Pudāne et al., 2019; Sovacool & Axsen, 2018). A second strategy is that public transport companies and vehicle manufacturers could alleviate potential safety, security and privacy concerns by the installation of cameras inside the shuttle and at the station. Gurumurthy and Kockelman (2020) found that only 8% and 4% of respondents indicated to be willing to share an automated vehicle with a stranger during the night if the stranger has no criminal record, and if information about the strangers is given ahead of time, respectively. Thus, sharing information about fellow travelers via a smartphone application ahead of the trip could be a practical option to mitigate concerns about sharing rides with strangers. A fourth strategy can encompass the promotion of social network-based services, which could alleviate privacy and security concerns in automated vehicles (Bhat, 2018).

5.3. Limitations

The results of the present study have to be interpreted with regards to its caveats. First, the automated shuttle operated at a limited speed in a controlled environment, which could bias the safety and trust perceptions of respondents. Second, the sample was not representative of the general population but represents a convenience sample that consists of more highly-educated and tech-savvy individuals. Their level of knowledge and excitement about automated vehicles may be higher than in the general population. We recommend future research to use more representative samples. Third, we can't also rule out social desirability effects as respondents may have provided their ratings of the questionnaire items in accordance with their general beliefs about automated shuttles despite having experienced automated shuttles, and to please the automated shuttle team. Fourth, method effects are also likely in the sense that items with a similar wording received a similar rating by respondents. Fifth, respondents took a ride in the automated shuttle alone, and were asked to reflect on the use of these vehicles as feeders in public transport without these vehicles operating as feeders. Thus, they were asked to rate a hypothetical scenario that has not formed an integral part of their lives yet. Sixth, respondents physically experienced the shuttle only once for a limited amount of time. This may be insufficient for establishing stable attitudes.

5.4. Final conclusions

In conclusion, our questionnaire study showed that respondents considered automated shuttles in public transport easy to use, but most did not feel safe without any type of human supervision. They favored the supervision of the shuttle from an external control room to a human steward onboard, and no supervision. A moderate mean rating for planning to abolish the private car in favor of public transport and automated shuttles feeding public transport suggests that respondents are undecided about whether automated public transport will lead to substantial reduction in their use of the private car. The effect of performance expectancy on the behavioural intention to use automated shuttles became insignificant with the addition of the DIT constructs compatibility and trialability, automated shuttle sharing and trust to the model. Instead, compatibility was the strongest predictor of the behavioural intention to use automated shuttles. We recommend future research to examine the importance of compatibility for automated vehicle acceptance, and assess whether compatibility can substitute performance expectancy as strong and robust predictor of automated vehicle acceptance.

CRediT authorship contribution statement

Sina Nordhoff: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Resources, Data curation, Writing - original draft, Writing - review & editing, Visualization, Supervision, Project administration, Funding acquisition. **Victor Malmsten:** Writing - review & editing. **Bart van Arem:** Writing - review & editing, Supervision. **Peng Liu:** Writing - review & editing. **Riender Happee:** Writing - review & editing, Supervision.

Appendix A. Supplementary material

When the study is accepted for publication, the dataset will be published on the following website: https://researchdata.4tu.nl/en/. The script to perform the statistical analyses can be found in the README file. Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2021.01.001.

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