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Understanding users' willingness to travel on autonomous buses: The moderating effect of experience

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ABSTRACT

The aim of this research is to analyse the factors that influence users' willingness to travel on an autonomous bus (AB). This analysis adopted a mixed-methods approach. The findings indicated that the main antecedents of willingness to travel on an AB are perceived behavioural control, attitude and subjective norms, while the effect of personal innovativeness was seen to be lower. Trust in the AB, and perceived safety, impacted on perceived benefits, and perceived benefits impacted on satisfaction. Seven of the eight relationships proposed in the model were moderated by participants' experience in the AB pilot test.

1. Introduction

Some researchers have argued that advanced technologies and digitalisation will soon become key elements of the vehicle driving systems used in urban transport (e.g., Litman, 2023). However, previous studies have identified drawbacks that hinder their adoption (e.g., perceived risk, reliability problems, the lack of control resulting from their inability to adequately perform all required tasks). In addition, not all users have the same predisposition to accept these technologies; their willingness so to do depends on characteristics such as their personal innovativeness, tech savviness and knowledge of autonomous vehicles (Jaiswal et al., 2022; Park and Han, 2023).

Previous studies that sought to understand the factors that influence intention to use autonomous vehicles focused mainly on private vehicles, and less on autonomous buses (ABs) (Pigeon et al., 2021; Park et al., 2021). In fact, Kassens-Noor et al. (2020) argued that there is very little knowledge of how users will perceive the application of artificial intelligence to public transport. The AB is a self-driving vehicle that does not require a driver (Hanif et al., 2021), it can communicate with proximate infrastructure and perceive its surrounding environment (Krawiec and Kłos, 2021). Earlier research has shown that users' acceptance of ABs depends on specific factors of the new systems, that is, service characteristics, for example, fares, safety, comfort and access, and users' personal characteristics (e.g., socio-demographics and personal innovativeness) (Pigeon et al., 2021). These studies mostly adopted data collection methodologies that did not require the respondents to have had direct experience of ABs, or were based on riding ABs of reduced capacity, or on riding reduced capacity ABs on ad hoc circuits not shared with other road traffic (e.g., Herrenkind et al., 2019; Mouratidis and Cobeña, 2021; Salonen, 2018). However, the unified theory of acceptance and use of technology (Venkatesh et al., 2003) proposes that the user's experience can moderate the influence of determinants of intention to use. This moderation has been shown to be significant in several prior studies examining intention to use small autonomous shuttles operating in closed circuits; the results of the studies showed that relationships between model factors varied based on whether or not participants had previously tried the service (e.g., Motak et al., 2017). However, to the best of the authors' knowledge, as yet no study has explored users' predispositions to use ABs of characteristics, for example, capacity, length and aesthetics, similar to those of normal

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urban passenger transport buses, after a trial on a route normally open to all vehicle traffic. Studying the impact of an AB on passengers, in a real urban traffic scenario (hereafter, "open urban route"), in a vehicle with characteristics similar to those of traditional buses can lead to a better understanding of the reaction of users to the introduction of ABs into urban mass transport systems.

The objectives of this study are to improve the understanding of the antecedents of users' willingness to use ABs and to evaluate the moderating impact on users of riding an AB on open urban routes. To this end, this research theoretically formulates, and empirically evaluates, a conceptual model based on the theory of planned behaviour (TPB) (Ajzen, 1987), extended and adapted using constructs identified in the previous literature as determinants in the decision-making processes of passengers of means of transport (i.e., satisfaction and perceived benefits), and other attitudinal factors important in individuals' perceptions of means of transport (i.e., safety and trust), and by personal innovativeness, a trait that is generally regarded as very influential in consumers' adoption of new technologies. The model was evaluated with data collected in the city of Malaga (Spain) in face-to-face surveys carried out with two groups of bus users, one which had previously ridden ABs on an open urban route, and one which had not; this approach allows the moderating effect of previous AB experience to be assessed. Subsequently, to try to better understand the results, a focus group-based qualitative study was carried out with the two groups. This research contributes to the literature and practice of the adoption of technologies in means of transport by providing a model that allows managers to evaluate, prior to their introduction, the predisposition of potential passengers to use ABs, and can help them understand the aspects on which they should focus to proactively promote ABs to the target population.

2. Theoretical framework

2.1. AB adoption studies

Autonomous buses/shuttles are a result of combining technological advances with the principles of mass public transport (Tsigdinos et al., 2021). The level of automation of these vehicles is such that they can perform all the functions of driver-operated vehicles, but without human supervision, as it is the vehicles themselves that analyse the environmental conditions, define the route and make the decisions needed to address any situation. To carry out these functions ABs are equipped with sensors and navigation controls that are managed through artificial intelligence systems. However, while autonomous driving is technically possible, it faces regulatory limitations. Thus, of the six levels of automation defined by the Society of Automotive Engineers (SAE, 2014) (0, no driving automation, 5, full driving automation), European legislation only allows buses with automation up to level 4 to operate in open urban routes; that is, level 4 must have an operator in the driving position.

In recent years, an increasing number of field studies have examined shared autonomous vehicles in Europe, Asia and North America, particularly looking at cars (up to 6 passengers) and, to a lesser extent, small buses/shuttles (7–20 passengers) (Greifenstein, 2024), in experiments involving Navya, Transdev and EZ10 (e.g., Anund et al., 2022; Yan et al., 2022). However, only a few studies have examined the acceptance of autonomous vehicles which look like the normal, commonly used, large urban transport bus. Of these, most presented visual stimuli (i.e., photographs, videos) to represent the AB and how it would provide its service (e.g., Cai et al., 2023; Goldbach et al., 2022), while only a few assessed passengers' perceptions after they underwent a real experience of using a large bus.

The literature on intention to use ABs predominantly examines small buses/shuttles. To an extent, this is understandable, because the smaller vehicles were developed earlier; but, as new vehicle types emerge (e.g., larger), the literature should analyse the behaviour of users towards other specific vehicle types to identify whether differentiating factors exist (Greifenstein, 2024), because, for example, vehicle size can influence users' perceptions (Salonen, 2018). In most studies participants' responses were made after they had been exposed to the AB service through watching a video, viewing a photograph or reading explanatory written text; only a few studies investigated actual use experiences, which may introduce biases. In addition, in many cases the vehicles were operating on closed circuits; only a few cases examined the vehicles on roads open to other vehicles. Doubtless these conditions will have shaped the users' perceptions, which will be more reliable the closer the conditions are to subsequent real-life implementation. The predominant methodology used in the literature is quantitative, especially cross-sectional studies with survey data. Very few qualitative and mixed-methods approaches, that would allow a better understanding of the phenomenon, and that might identify inconsistencies, have been undertaken. Moreover, the majority of research originates from Europe, the USA, and China. Appendix A shows some of the studies into the adoption of small ABs/shuttles based on pilot tests of self-driving vehicles.

To bridge some of these gaps, in this study an investigation is made into passengers' willingness to travel on a large conventional bus (60 passengers capacity) after they experienced a ride on open public roads in Spain, a country hitherto little studied. A mixed-methods approach is used, combining quantitative (survey) and qualitative (focus group) techniques. To explore users' willingness to travel on an autonomous bus on open urban routes, this study proposes a model that extends the TPB. To this end, to the three determinants of intention proposed in the TPB, that is, attitude towards the behaviour, subjective norms and perceived behavioural control, other factors, considered important in the literature, in transport passengers' decision-making processes, are added. These factors relate to service evaluation (satisfaction with, and the perceived benefits of, ABs) (Park et al., 2004), the adoption of autonomous vehicles (perceived safety of, and trust in, ABs) (Paddeu et al., 2020) and users' predisposition to accept innovations (personal innovativeness) (Chen and Yan, 2019; Herrenkind et al., 2019). In addition, an evaluation is made of the moderating effect of participants' experience of ABs (that is, if they had ridden them [AB-experienced], or not [AB-inexperienced]) on intention to use (Launonen et al., 2021).

2.2. Hypotheses development

The individual's attitude towards ABs is formed by his/her beliefs about their advantages and disadvantages; it is his/her favourable or unfavourable predisposition towards that behaviour. Attitude, according to Fishbein and Ajzen (1975), is one of the main determinants of intention to perform a behaviour; in the present study, attitude relates to one's willingness to travel on an AB. Specifically, willingness to travel is increased if the individual has a positive attitude towards ABs. Previous studies have demonstrated this relationship in travellers' decisions to use a fully automated shuttle (Kaye et al., 2020; Launonen et al., 2021). Thus, the following hypothesis is proposed:

H1. The user's attitude towards ABs positively influences his/her willingness to travel on an AB.

Subjective norms are another key antecedent of consumers' behavioural intentions (Fishbein and Ajzen, 1975). Subjective norms capture social influence through the importance that individuals attach to what they believe that people or groups, socially important to them, think about a given behaviour. In the present study, subjective norms are taken to reflect the individual's perception of the approval or disapproval of others of him/her travelling on an AB. If the user perceives that other people, important to him/her, are in favour of using ABs, his/her willingness to travel on them will be greater than if (s)he perceives they are not in favour of travelling on them. This relationship has been demonstrated in previous studies into autonomous shuttles (Kaye et al., 2020; Nordhoff et al., 2017). Accordingly, the following hypothesis is proposed:

H2. Subjective norms positively influence willingness to travel on an AB.

Perceived behavioural control refers to the ease or difficulty that individuals believe will be associated with carrying out a behaviour. This reflects the individual's beliefs about the facilitating factors and barriers associated with conducting particular behaviours (Ajzen, 1987). It is reasonable to conclude that if potential passengers consider ABs easy to use, their predisposition so to do will be enhanced. Merat et al. (2017) showed that users considered ABs as easy to use as other, conventional means of transport, such as trains and trams. The positive influence of perceived behavioural control on intention to use autonomous shuttles has been demonstrated in the relevant literature (Launonen et al., 2021). Therefore, the following hypothesis is proposed:

H3. Perceived behavioural control positively influences willingness to travel on an AB.

In addition to individuals' attitudes and beliefs, their personal characteristics can also help predict their behaviours in terms of the adoption and use of transport technologies (Cheng and Huang, 2013). Several studies have highlighted the importance of personal innovativeness in the adoption of products based on new technologies, such as artificial intelligence-powered service delivery devices (Park and Woo, 2022), and new means of transport (Tunçel, 2022). Personal innovativeness has been defined as a personality trait that represents the individual's positive willingness to try new technologies (Agarwal and Prasad, 1998). Previous works have shown that personal innovativeness positively influences the acceptance of autonomous vehicles (Chen and Yan, 2019). People with more personal innovativeness are likely to perceive that new technologies are useful and easy to use, which positively influences their intention to use them (Agarwal and Prasad, 1998). Recently, Herrenkind et al. (2019) showed that personal innovativeness influences intention to use ABs through greater perceived ease of use. Thus, the following hypothesis is proposed:

H4. Personal innovativeness positively influences willingness to travel on an AB.

Traffic circulation carries the risk of accidents. In fully autonomous vehicles on-board systems perform all the safety-critical driving functions. Therefore, it seems logical to conclude that trust in these systems may be one of the most important factors to take into account when predicting passengers' intentions to use autonomous vehicles (Zhang et al., 2019). Trust in these vehicle types is based on the individual's belief that the system is predictable, understandable and will efficiently and accurately perform the required tasks (Choi and Ji, 2015). Thus, trust is the user's perception of the probability that (s)he will receive the expected performance and benefits from the vehicle. Previous studies have shown that users' acceptance of ABs is highly dependent on their trust in the systems (Nordhoff et al., 2018), and that increased trust enhances intention to use (Herrenkind et al., 2019). In the present study, it is proposed that trust increases the perceived benefits of the AB based on the user's belief that it will provide an efficient and reliable service. Recently, Liu et al. (2019) showed that trust increases the perceived benefits of fully automated vehicles. Therefore, the following hypothesis is proposed:

H5. Trust in ABs positively influences the perceived benefits of ABs.

Alongside trust, perceived safety also contributes to increased perceived benefits. Users' perceptions of safety inside and outside vehicles have a significant influence on their acceptance of public transport (Salonen, 2018). Perceived safety relates to the user's perceptions of the risk of traffic accidents. Perceived safety has been shown to positively influence intention to use autonomous vehicles (Montoro et al., 2019) including, specifically, ABs (Yan et al., 2022). The perceived safety of autonomous vehicles can increase users' perceptions of their benefits, because they believe they carry a lower risk of collisions, they provide greater on-board security and they offer a better travel experience (Ahmed et al., 2020). Therefore, the following hypothesis is proposed:

H6. Perceived safety positively influences the perceived benefits of ABs.

Perceived benefits relate to users' beliefs of the general benefits/value they perceive they receive from using ABs. Some studies into autonomous buses and taxis have shown that automation offers various benefits, including, reduced costs, environmental impact and traffic accidents (Li et al., 2022). Liu et al. (2019) showed that perceived benefits positively influence passengers' acceptance and intention to use autonomous vehicles. In the present work it is suggested that this influence is mediated by user satisfaction, understood as their evaluation of the service outcome against their expectations; this satisfaction evokes positive feelings towards ABs (Rosell and Allen, 2020). Satisfaction with ABs has been shown to be based on service characteristics such as punctuality, reliability, comfort, departure frequency, cost, safety and speed (Mouratidis and Serrano, 2021; Yan et al., 2022). This relationship can be explained from the perspective of customer satisfaction theory (Oliver, 1980). This perspective postulates that consumer satisfaction is an overall affective response to his/her perceptions of the discrepancies between his/her expectations and perceived outcomes. Li et al. (2021) demonstrated that perceived benefits positively influence satisfaction with autonomous vehicles. Therefore, the following hypothesis is proposed:

H7. Perceived benefits positively influence users' satisfaction with AB services.

One of the most important consequences of user satisfaction is its positive impact on intention to use (Oliver, 1980), that is, the greater the user's satisfaction with a service, the greater will be his/her intention to reuse the service. As noted above, meeting consumers' expectations of service delivery generates in them a positive perception of these services that encourages reuse. Studies into various public transport modes have shown that, when users derive greater satisfaction from services, they are more likely to develop greater intention to use them in the future (Chen, 2019; Fu and Juan, 2017). This positive relationship between satisfaction and intention to use has been found also in the context of autonomous vehicles (Dai et al., 2021a,b) including, specifically, ABs (Mouratidis and Cobeña, 2021; Yan et al., 2022). Therefore, the following hypothesis is proposed:

H8. Satisfaction positively influences willingness to travel on an AB.

Venkatesh et al. (2003) argued that the effect of the antecedent factors of intention to use a technology is moderated by the user's experience. For example, the effect of the perceived effort required to operate a technology and the effect of social influence will be greater among less, than among more, experienced users. Liu and Xu (2020) showed that direct experience of autonomous vehicles positively influenced the attitude of users towards permitting them to operate on public roads. Motak et al. (2017) demonstrated that prior experience of ABs reduced users' safety-related concerns and provided the information they needed to avoid difficulties when using them (i.e., perceived behavioural control). Liu et al. (2019) showed that the influence of constructs such as trust, perceived benefits and perceived risk on intention to use changed in a sample of users after they had ridden an autonomous vehicle in a demonstration test. More recently, Dai et al. (2021a,b) showed that attitudes towards autonomous taxis/robotaxis is more positive among experienced users, who value, above all, the simplicity and usefulness of the service. Later, Dai et al. (2023) argued, in a survey-based study that collected data from autonomous taxi users, that these individuals will be more likely to enjoy trips in these vehicles than will passengers with no experience of autonomous taxis, and will have a lower perception of risk than the latter group. Therefore, it seems reasonable to conclude that user experience with autonomous public transport vehicles will moderate the relationships of the proposed model; thus, the following hypothesis is proposed:

H9. Previous experience of ABs will moderate the effects of the antecedents of willingness to travel on ABs.

Fig. 1 shows the relations of the proposed conceptual model.

3. Methodology

3.1. Research scope

The data collection for the empirical evaluation of the proposed model was performed in the context of the pilot test of an AB. From February to March 2021, the first pilot test was carried out of an autonomous, high-capacity bus on European open urban routes. The bus was a 100% electric model, 12 m in length, with capacity for 60 passengers (Fig. 2). Based on international classifications, the bus has level 4 autonomy, that is, its autonomous driving system executes the acceleration and deceleration orders, monitors its surrounding environment and performs the dynamic driving task, with an operator in the driving position. The bus operated in mixed traffic on open urban public roads on a circuit of more than 8 km. There were 5 stops on the designated route, and both scheduled, and on-demand services, were offered. This is currently the highest level of autonomy developed and authorised for vehicle traffic in Europe.

The test was carried out in the city of Malaga, Spain, within the framework of the AutoMOST (Automated driving for dual-Mode System Transport) project funded by the Spanish Government. Malaga, with more than 570,000 inhabitants, is the sixth most populous city in Spain. The pilot test was carried out in three phases. In the first, the route was mapped out and the communications between the bus and its driving environment (e.g., traffic lights) were tested. In the second, the system was tested/operated without passengers. In the third, two-week phase, a total of 1281 passengers rode the AB at no cost. The vehicle drove from the Maritime Station Malaga Port to Paseo del Parque (Fig. 3). As a pioneering experiment in Europe, the project has received two awards: the Award for the Best Industrial Application of the Spanish Chapter of the Intelligent Transportation Systems Society (IEEE-ITSS) and the ITS Award for Autonomous and Connected Vehicles, granted by Intelligent Transport System (ITS) Spain.

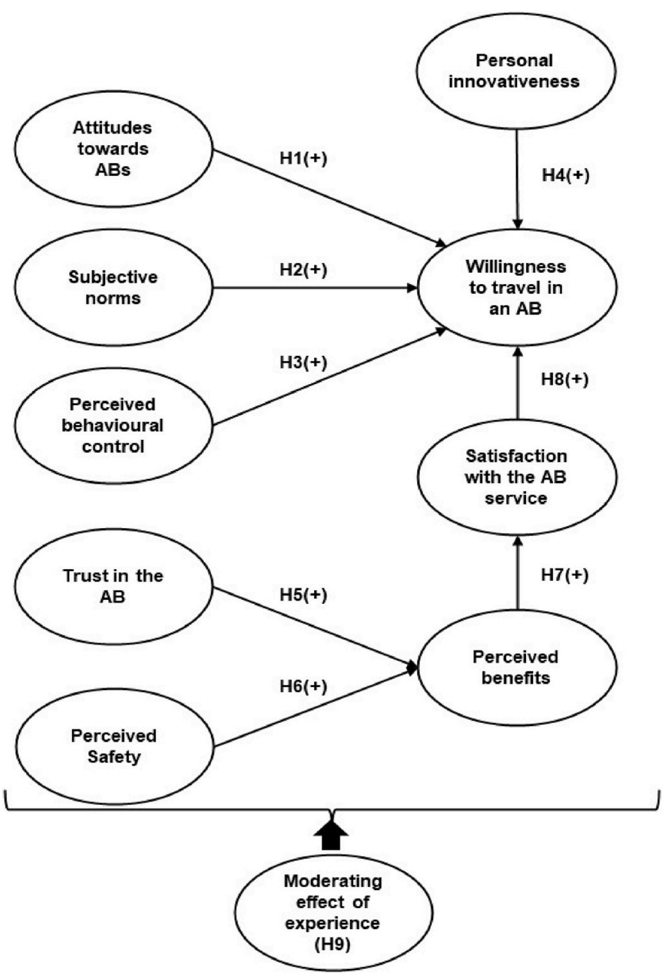

Fig. 1. Research model.

3.2. Research overview

To evaluate the conceptual model, this research adopted a mixed-methods approach (see Fig. 4), taking advantage of the strengths of quantitative and qualitative methods (Creswell and Clark, 2017). Specifically, an explanatory sequential design was used, the collection and analysis of quantitative data obtained through a face-to-face survey followed by, to improve the explanation and interpretation of this data, the collection and analysis of qualitative data obtained in focus groups (Bell et al., 2019). These designs are very useful for bridging possible gaps in survey research in terms of the interpretation of results, particularly when differences are observed between groups of participants (Harrison, 2013). Focus group facilitated the understanding of quantitative responses by delving deeper into the participants' perceptions, motivations, and experiences. Mixed-methods research is a growing methodological approach in the business and management disciplines due to its capacity to explain the complex nature of human behaviours (Harrison et al., 2020).

4. Quantitative study: survey data

4.1. Procedure and sample

The quantitative data for the evaluation of the proposed conceptual model were collected through face-to-face surveys conducted by professional interviewers. In the study's target population, two groups of urban public transport users were differentiated: 1. Users who had tried the AB during its trial period; 2. Users who had not tried it. The interviewers approached users at bus stops during the months of March and April 2021. Once they had agreed to participate in the survey, the users who had not tried an AB were shown a 1-min video that explained how the system works, and how the bus circulates around the city of Malaga. This provided them with a better understanding of this new transport system so that they could answer the survey questions with more information. Participation in the survey was voluntary.

The model's constructs were measured using scales validated in previous studies: subjective norms (Chen and Yan, 2019; Kaye et al., 2020), perceived behavioural control (Ajzen, 2002), attitude, trust and satisfaction (Chen, 2019), perceived safety (Salonen, 2018), perceived benefits (Liu et al., 2019), personal innovativeness (Agarwal and Prasad, 1998) and willingness to travel on an AB (Bennett et al., 2019). The items were originally developed in English, so a professional translation service was used to provide an accurate Spanish language version. A 7-point Likert scale was used to measure the constructs (Appendix B).

The potential participants received a brief explanation of the study's objectives and, thereafter, some 301 completed the questionnaire. Of these, 101 had ridden an AB, while 200 had not. Some 57.81% of the participants were female, 18.94% were between 25 and 34 years old and 37.21% had a university degree. Regarding family income levels, 39.53% had income between 20,001 and 40,000 euros per year (Appendix C).

4.2. Data analysis

The model was evaluated using partial least squares-structural equation modelling (PLS-SEM). PLS-SEM is useful if the goal is to predict a key construct for exploratory research or to extend an existing

Fig. 2. The autonomous bus.

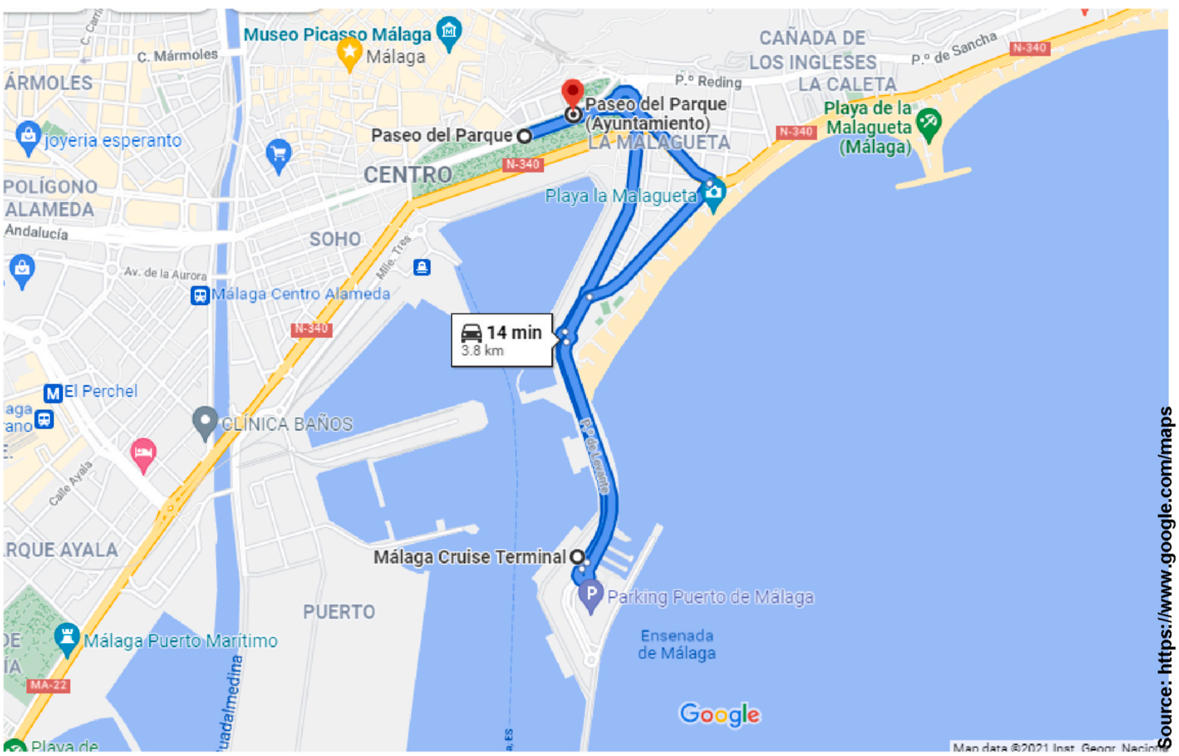

Fig. 3. Autonomous bus route (in blue).

Fig. 4. Mixed-methods design strategy: explanatory sequential schema.

theory (Hair et al., 2011), as is the case with the present study. The technique is considered less restrictive when it is not possible to assume the normality of data and the sample size is not very large (Hair et al., 2019a). The sample satisfies the "10-times rule" recommended for the minimum sample size at which PLS-SEM achieves an acceptable level of power (Hair et al., 2011). It has also, recently, been suggested that PLS-SEM effectively evaluates moderation effects (Hair et al., 2019b). The data analysis was performed with SmartPLS 3.0 software.

Prior to the evaluation of the model, a check was made to ensure that the data were not affected by biases caused by the measurement instrument used in the study. To do so, a Harman's single factor test of common method bias (CMB) was conducted. If a single factor explains more than 50% of total variance, CMB is likely to influence the data and, consequently, the empirical results (Podsakoff et al., 2003). In the present study the highest total variance explained by a single factor was 39.72%, while the full set of model factors explained 74.55% of the variance. This suggests that CMB is very unlikely to exist.

Similarly, the normality of the data was evaluated through the asymmetry and kurtosis values of each item (Table 1). The results returned small and moderate values for both kurtosis (±1.96) and skewness (±1.82) (Curran et al., 1996). Then, multicollinearity was measured through variance inflation factors (VIF) (Table 3). The mean VIF value was 2.956, and all values were below the maximum recommended threshold of 5 (Hair et al., 2011), except three with values very close to 5 (TR3, WT3, and WT4), so we conclude that the data have no multicollinearity problems.

4.3. Results

First, the reliability and convergent and discriminant validity of the measurement model were evaluated. Four criteria were used to evaluate the reliability of the model: factor loadings, Cronbach's alpha (CA), the Rho coefficient and composite reliability (CR) (Table 1). The item loadings for each factor were above 0.70, and significant (Barclay et al., 1995). The values of the Cronbach's alpha coefficient (CA), the Rho coefficient and composite reliability (CR) were above the minimum recommended 0.7 (Nunnally and Bernstein, 1994). Convergent validity was measured through average variance extracted (AVE). The AVE values were higher than the recommended minimum of 0.5 (Fornell and Larcker, 1981). Two criteria were used to assess discriminant validity: the inter-construct correlations were below the square root of the AVEs (Fornell and Larcker, 1981) and the heterotrait-monotrait (HTMT) ratios between any two constructs were below 0.9 (Henseler et al., 2015) (Table 2). These results show that the measurement model fulfils the relevant reliability and validity criteria.

To assess the significance of the path coefficients of the structural model, a bootstrapping procedure of 5000 subsamples was used (Hair et al., 2011). Table 3 shows the results of the tests of the hypotheses. All the hypotheses were supported, except H8. The effect sizes of the model's relationships were measured through their f^2 values. The results showed that the effects of trust on perceived benefits, and of perceived benefits on satisfaction, were large (>0.35), while the effect sizes in the remaining relationships were small (<0.15) (Henseler et al., 2016). The predictive relevance of the model was measured through its Stone--Geisser's Q^2 values. The results showed that the predictive relevance of the endogenous constructs was moderate for perceived benefits (0.289) and willingness to travel (0.442), and low for satisfaction (0.215) (Hair et al., 2019a). The explanatory capacity of the model was measured through the R^2 parameter (Hair et al., 2011). The model's R^2 values suggest it has moderate explanatory capacity for the endogenous constructs' variance: 40.7% of perceived benefits, 31.4% of satisfaction and 52.5% of willingness to travel. The model's standardised root mean squared residual (SRMR) value of 0.074 was within the recommended levels (≤0.080), so it can be concluded that it has adequate goodness of fit (Henseler et al., 2016).

Finally, the moderating effect of experience (H9) was tested. To do so, the sample was divided into two subgroups, people who had ridden an AB, and people who had not ridden an AB. First, the invariance of the measurement instrument was assessed to determine whether the measurement model provided measurements of the same attribute even in the circumstance that the conditions of the observation and study of the phenomenon changed (Henseler et al., 2015); that is, to determine whether the measurement model might cause differences in the results obtained from the subgroups. A scale has measurement invariance when the construct evaluated is measured in the same way in all groups. In the present study, the configural invariance, compositional invariance and composite equality values allow us to confirm the measurement invariance of the model. Thereafter, to analyse the possible moderating

Table 1
Descriptive statistics, reliability and convergent validity.

Item	M	SD	Kurtosis	Skewness	VIF	Loading	CA	Rho_A	CR	AVE
ATT1	5.638	1.809	0.435	−1.218	3.640	0.906	0.926	0.929	0.947	0.819
ATT2	5.934	1.573	1.743	−1.583	3.805	0.923				
ATT3	5.834	1.597	1.242	−1.399	4.648	0.936				
ATT4	5.897	1.492	1.671	−1.356	2.405	0.852				
PB1	5.930	1.498	1.564	1.822	2.748	0.880	0.873	0.876	0.914	0.726
PB2	6.060	2.600	1.480	1.136	2.833	0.890				
PB3	5.891	1.478	1.539	1.293	2.200	0.857				
PB4	5.452	1.876	1.962	−0.523	1.631	0.778				
TR1	5.522	1.728	−0.138	−0.855	3.372	0.875	0.889	0.903	0.931	0.818
TR2	5.834	1.616	1.301	−1.434	2.339	0.884				
TR3	5.512	1.672	−0.008	−0.953	5.061	0.952				
PBC1	5.213	2.071	−0.630	−0.849	1.827	0.829	0.817	0.827	0.891	0.732
PBC2	5.485	1.836	−0.053	−1.079	1.683	0.832				
PBC3	5.561	1.816	0.368	−1.196	2.239	0.904				
SN1	4.399	2.314	−1.509	−0.250	2.258	0.860	0.880	0.906	0.917	0.735
SN2	4.937	1.941	−0.778	−0.631	2.481	0.878				
SN3	4.508	2.073	−1.164	−0.368	1.827	0.777				
SN4	4.910	1.716	−0.545	−0.522	2.776	0.908				
WT1	5.734	1.877	0.807	−1.412	3.741	0.922	0.947	0.952	0.962	0.864
WT2	5.143	2.156	−0.789	−0.822	3.673	0.911				
WT3	5.249	1.994	−0.428	−0.914	5.490	0.946				
WT4	5.282	2.002	−0.246	−0.994	5.105	0.939				
PI1	4.439	2.078	−1.228	−0.277	1.543	0.811	0.774	0.782	0.869	0.689
PI2	3.326	2.043	−1.076	0.451	1.546	0.806				
PI3	4.419	2.037	−1.249	−0.171	1.770	0.871				
PS1	5.681	1.748	0.903	−1.376	3.425	0.928	0.911	0.935	0.944	0.849
PS2	5.465	1.772	0.117	−1.089	4.419	0.955				
PS3	5.216	1.876	−0.434	−0.844	2.616	0.879				
SAT1	5.482	1.652	−0.242	−0.850	2.435	0.827	0.913	0.921	0.933	0.700
SAT2	5.611	1.815	0.215	−1.139	2.904	0.807				
SAT3	5.532	1.569	−0.660	−0.689	2.433	0.832				
SAT4	5.462	1.825	−0.205	−0.970	4.438	0.897				
SAT5	5.083	1.863	−0.664	−0.667	1.996	0.758				
SAT6	5.525	1.464	−0.169	−0.774	3.219	0.889				

Note. M = mean; SD = standard deviation; VIF = variance inflation factor; CA = Cronbach's alpha; CR = composite reliability; AVE = average variance extracted.

Table 2
Discriminant validity.

Construct	ATT	PB	TR	PBC	PI	SN	WT	SAT	PS
Attitude (ATT)	***0.905***	0.660	0.846	0.738	0.192	0.496	0.647	0.845	0.113
Perceived Benefits (PB)	0.594	***0.852***	0.679	0.535	0.196	0.250	0.324	0.625	0.290
Trust (TR)	0.859	0.606	***0.904***	0.770	0.165	0.460	0.569	0.824	0.116
Perceived Behavioural Control (PBC)	0.647	0.449	0.663	***0.856***	0.135	0.591	0.717	0.749	0.180
Personal Innovativeness (PI)	0.167	0.127	0.136	0.092	***0.830***	0.210	0.243	0.110	0.094
Subjective Norms (SN)	0.465	0.228	0.416	0.516	0.166	***0.857***	0.582	0.415	0.071
Willingness to Travel (WT)	0.611	0.297	0.528	0.637	0.208	0.545	***0.929***	0.574	0.063
Satisfaction (SAT)	0.784	0.560	0.838	0.658	0.059	0.392	0.545	***0.836***	0.112
Perceived Safety (PS)	0.107	0.260	0.101	0.160	−0.056	0.024	0.038	0.088	***0.921***

Note. The square roots of the AVEs are in bold on the main diagonal. The Fornell-Larcker criterion is depicted below the main diagonal. The heterotrait-monotrait (HTMT) ratio values are above the main diagonal.

Table 3
Results of the hypotheses testing.

Hypothesis	Path coefficient	t-value	p-value*	f2	Supported
H1. Attitude → WT	0.243	2.778	0.006	0.042	Yes
H2. Subjective Norms → WT	0.233	4.847	0.000	0.079	Yes
H3. Perceived Behavioural Control → WT	0.320	5.579	0.000	0.101	Yes
H4. Personal Innovativeness → WT	0.097	2.262	0.024	0.019	Yes
H5. Trust → Perceived Benefits	0.585	13.780	0.000	0.572	Yes
H6. Perceived Safety → Perceived Benefits	0.201	4.439	0.000	0.068	Yes
H7. Perceived Benefits → Satisfaction	0.560	12.678	0.000	0.458	Yes
H8. Satisfaction → WT	0.047	0.748	0.455	0.002	No

Note. WT = Willingness to Travel on an AB. n = 5000 subsamples. * 95% confidence level – two tailed.

effect of AB experience, the structural model was estimated through a multigroup analysis (MGA) (Hair et al., 2016). Table 4 shows the results of the path coefficients' difference test between the two groups. The results show that there are significant differences in all of the structural model's relationships, except for the impact of perceived safety on perceived benefits. Specifically, five of the model's relationships are stronger for the AB-experienced group than for the AB-inexperienced group: the effect of subjective norms on willingness to travel ($\beta_{Difference} = 0.170$, p = 0.0 78), the influence of personal innovativeness on willingness to travel ($\beta_{Difference} = 0.338$, p = 0.000), the impact of trust on perceived benefits ($\beta_{Difference} = 0.298$, p = 0.005), the effect of perceived benefits on satisfaction ($\beta_{Difference} = 0.544$, p = 0.000) and of satisfaction on willingness to travel ($\beta_{Difference} = 0.265$, p = 0.0 97). Conversely, two of the model's relationships were stronger in the inexperienced group than in the experienced group: the impact of attitude ($\beta_{Difference}$ = - 0.535, p = 0.000) and perceived behavioural control ($\beta_{Difference}$ = - 0.311, p = 0.009) on willingness to travel. Consequently, the results largely support Hypothesis 9, as experience moderates all but one (H6) of the model's relationships.

5. Qualitative study: FOCUS groups

5.1. Procedure, sample and data analysis

To complement and better interpret the results of the quantitative study, two focus groups were conducted. One group had ridden an AB, and one had not. The recommended number of participants for this study technique is usually small, ranging from 6 to 12 (Aurini et al., 2021; Bell et al., 2019). Based on the criterion of theoretical saturation, it was not considered necessary to expand the number of groups. Given the complexity of the research topic, small groups of six people were employed (Morgan et al., 1998), randomly selected from the user database of the municipal transport company. Participation was voluntary. Two researchers participated in the sessions, one as moderator, and one took notes. The moderator followed a semi-structured guide with open-ended questions (e.g., what benefits do ABs have? Do you think it is safe to travel on an AB?). The two sessions were held at the facilities of the authors' parent university in June 2021. They lasted approximately 2 h, were audio recorded and later transcribed for analysis. The twelve people who participated were equally divided between both genders, 41.7% were over 45 years old, 66.7% were employed and 50% had a household income of between 10,000 and 20,000 euros per year.

To identify, analyse and report patterns (themes) in the data collected in the interviews, a thematic analysis, following Liu et al. (2020) was undertaken. Two researchers reviewed the transcripts in parallel, identified and coded the concepts in the themes, and then validated the codes, agreeing on a common interpretation. NVivo 12 software was used in the encoding process. Kassarjian's (1977) recommendations were followed to ensure category reliability and agreement between the researchers.

Table 4
Results of the multigroup analysis (MGA).

Hypothesis	With AB Experience			Without AB Experience			Result		
	Path Coef.	t	p	Path Coef.	t	p	Path-difference	t	p
H1. Attitude → WT	−0.136	0.928	0.354	0.400	5399	0.000	−0.535	3653	0.000
H2. Subjective Norms → WT	0.209	2508	0.012	0.039	0.714	0.476	0.170	1767	0.078
H3. Perceived Behavioural Control → WT	0.048	0.401	0.689	0.359	6099	0.000	−0.311	2631	0.009
H4. Personal Innovativeness → WT	0.261	3611	0.000	−0.076	1684	0.093	0.338	4135	0.000
H5. Trust → Perceived Benefits	0.745	7877	0.000	0.447	7622	0.000	0.298	2813	0.005
H6. Perceived Safety → Perceived Benefits	0.161	2595	0.010	0.214	3291	0.001	−0.053	0.524	0.601
H7. Perceived Benefits → Satisfaction	0.846	10199	0.000	0.302	3741	0.000	0.544	4262	0.000
H8. Satisfaction → WT	0.496	2649	0.008	0.231	3625	0.000	0.265	1662	0.097

Note. Path Coef: Path coefficient. WT = Willingness to Travel on an AB

5.2. Results

The analysis of the transcribed material identified fourteen topics that corresponded to the ten model variables, prior knowledge and other topics emerging from the interviews: emotional state, job losses and price of the AB service. The topics most discussed were subjective norms, safety and price. The topics least discussed were user satisfaction and perceived behavioural control. As one of the study objectives was to compare the dynamics of the model's relationships between the two user groups, differentiated by experience of ABs (AB experienced vs. AB inexperienced), special attention was paid to the (dis)similarities between the data obtained from the groups.

The first topic addressed in the focus groups was the participants' level of understanding of what ABs are. Participants with no experience of ABs found it difficult to define what they were; three asked if an autonomous bus was the same as an electric bus. On the other hand, participants who had ridden the AB defined it as a vehicle that operates without the need for human intervention. Their experiences have given them extensive knowledge of ABs' operations, as they used terms such as sensors, GPS, artificial intelligence and satellites. Overall, both groups expressed positive attitudes towards the vehicles and recognised that trying out the AB by riding on it is a good idea.

The influence of the social context (i.e., subjective norms) did not clearly emerge in the first discussion stage. The participants all stated that their personal opinions shaped their behaviours, and downplayed the role of the opinions of their family and friends. This topic generated a broad debate in both focus groups, the participants commenting on the unconscious influence of one's environment, particularly social networks and forums, among other online spaces. Their decisions reflect the opinions of, and suggestions made by, others, particularly when they, themselves, harbour doubts.

People are closely linked to each other […]. People can talk a lot but, in the end, the decision is about oneself, although, certainly, in interactions others influence you (Man2, employee, 37 years old, no AB experience).

The participants believed they would have no difficulties using ABs (i.e., perceived behavioural control). However, some of the AB-inexperienced participants suggested that autonomous vehicles could pose difficulties for certain groups, particularly the elderly, whose relationship with technology is more limited. The AB-experienced group made no mention of this potential problem; thus, it is reasonable to conclude that AB experience increases perceived control.

The predisposition of the participants towards the use of new technologies was, in general, positive, although with nuances. In the AB-experienced group some diversity was noted. On the one hand, one participant said he likes to be up to date and constantly updates his mobile phone to incorporate the latest innovations. Another had a more utilitarian relationship with new technologies, and adopted them based solely on need, and did not buy state-of-the-art devices if previous purchases satisfied his needs. A third conditioned her use of new technologies to her purchasing power. On the other hand, in the AB-inexperienced group, there was greater consensus that new technologies should be adopted if they satisfied a need. Indeed, they affirmed that, in principle, one's predisposition to use a new technology may be influenced by its novelty but, once this has worn off, the use of the technology will depend on its capacity to satisfy needs. Therefore, adoption is related to need.

The comments made about trust in the two groups differed. The AB-experienced group expressed total trust in the technology, based on their own experiences, while the inexperienced group referred to their trust in the municipal transport company and in public institutions. The second group suggested that new technologies, such as ABs, that had been trialled with end users, must have been evaluated positively by the relevant authorities, in accordance with current regulations.

For something to be introduced in Europe it must have been appropriately tested, because it is difficult to implement new things. Quality controls are very important, that is, I trust the regulations and standards of the European Union. (Male 4, employee, 52 years, no AB experience).

What gives me confidence is that it is endorsed by the Malaga Transport Company. Regardless of whether it has been trialled before, or not (Woman4, housewife, 41 years old, no AB experience).

Both groups expressed safety concerns. In particular, about ABs operating on open public roads. The AB-experienced participants claimed that to respond to possible dangers the ABs had to slow down, which meant they took longer to get to their destinations than did conventional buses. They hoped that, when introduced, ABs will maintain higher average speeds and will operate mainly on roads with several lanes in each direction so they can better coexist with other vehicles. Although participants showed concerns about how passengers would be treated in an accident or emergency if there was no driver, neither of them expressed issues about operations, such as device failures or cyberattacks. In fact, they agreed that the vehicles are very safe.

In the same vein, the AB-inexperienced participants were concerned about traffic safety when the AB is sharing the road with other vehicles. They considered that, in particular, bicycles and electric scooters pose a risk to autonomous vehicles and noted that bicycles are poorly governed by traffic regulations. In addition, they believed that ABs required more response time to address collision hazards than did humans (but were less concerned with computer errors and hacks). These risks make some participants believe that ABs may be unattractive to more vulnerable groups, such as pregnant women, people travelling with young children and older people. As to the implementation of ABs, this group expressed the preference that not all buses would be autonomous, and that ABs might be used mainly on long-distance routes, where driver fatigue/the monotony of the road might cause accidents.

The main safety problem is traffic, that is, other vehicles. Especially electric scooters. A lot of rules will have to be introduced and traffic effectively regulated to make it safe (Man3, employee, 45 years old, AB experienced).

If, for example, an accident occurs, the ABs' systems will have to react automatically. In addition, how will the bus respond to an internal emergency (e.g., a violent robbery, or a passenger suffering a heart attack)? Who will see the *images on the interior screen if the driver is not there? (Woman3, administrative technician, 47 years old, AB experienced).*

As to perceived benefits, both groups agreed that ABs offered advantages for the city and the environment, by (probably) reducing accidents and pollution, but do not offer them direct benefits as users. If ABs offer the same service as conventional buses, there is no additional direct benefit for users. They did acknowledge, however, that ABs would have a positive effect on the reputation and image of Malaga as a technological city, which would have a positive impact on inward investment and tourism.

With regard to satisfaction, both groups positively assessed the ABs. Those who had ridden the AB stated that, as it had the same interior space, seats, etc., as a conventional bus, it was just as comfortable. No differences were reported between the bus types in terms of reliability, frequency and speed. Both groups expressed high satisfaction with the service provided by the urban transport company's conventional vehicles, which can positively influence evaluations of ABs, even among those who have not tried them.

In addition to these aforementioned aspects, three additional topics were highlighted: emotional state, job losses and the price of the service. As for emotional state, AB-experienced participants said they had been curious and excited about riding the AB, and that their expectations of the experience had been high. However, their expectations were not met in the trial. Their experiences, although satisfactory in terms of a transport service, were exactly the same as when they rode conventional buses. They said they were somewhat excited and expected to enjoy a different experience due to the images evoked by the messages conveyed by the media and by science fiction (e.g., first autonomous bus, driverless bus, smart bus).

> *At first, I was very curious, but after the first test run I was disappointed and frustrated, and I wanted to try it again to see if my emotions were different. I thought that an AB was going to offer me more, but I felt the same again, no different to the experience of being on a conventional bus (Female5, retired, 62 years old, AB experienced).*

As to the emotional state of the AB-inexperienced participants, they suggested that before riding the AB they thought they would feel uncertainty, uneasiness and a sense of joy about trying something that could be considered almost an attraction, given that the system is still only in the testing phase. However, they believed that these emotions would evolve into tranquillity and trust once the experience had been concluded positively.

Regarding job losses arose spontaneously in both groups and was seen as a negative aspect of ABs. However, both groups agreed this was a lesser evil as, in addition to the other benefits derived from the system, labour costs would be reduced. They agreed that the displaced bus drivers could be redeployed within the company, and even that this development could be seen as an opportunity for the drivers to land better jobs. However, the youngest AB-inexperienced participant argued that the loss of the driver cannot be reduced simply to a loss of employment, lost also would be user-driver social interaction; he created a discourse about the specific benefits of keeping the driver.

Finally, all were interested in the price of the AB service. They would not be willing to pay more to use an AB than they would to use a conventional bus, given that the service provided is similar. This would reconsider this position if the AB offered additional advantages, such as fewer stops, more frequency and/or was quicker.

The positive perceptions developed by all participants about these aspects led them to be more predisposed both to repeat the AB experience or to start using them regularly. In fact, most participants agreed that when the city deploys resources to innovate to improve services, they must, in parallel, ensure the citizenry are favourable towards the developments.

6. Discussion and conclusions

6.1. Theoretical implications

This study makes several contributions to the literature on users' predispositions to travel on ABs in urban areas. First, hitherto studies on intention to use ABs have focused mainly on Asia; in Europe no experiments have examined passengers travelling in large vehicles on open public roads. The quantitative data supported eight of the nine model hypotheses, with good predictive and explanatory capacity.

Second, it was confirmed that willingness to travel on an AB is fundamentally determined by attitude towards the AB, by subjective norms and by perceived behavioural control; this supports the applicability of the TPB (Ajzen, 1987) for assessing intention to use ABs. These results are in line with the recent studies of Kaye et al. (2020) and Launonen et al. (2021). In addition, the results showed that the impact of the moderating effect of experience is key. The influence of attitude towards ABs on willingness to travel was statistically significant among AB-inexperienced users, but not significant among AB-experienced users (even if their attitude is positive). The qualitative study suggested that this could be because, once the novelty of the AB has worn off, and the curiosity of the users has been satisfied, the AB is perceived to be similar to a conventional bus, and even has some additional drawbacks (i.e., possible job losses, concerns about collision risk). The participants in both groups of the qualitative study reported they initially were curious, held idealised expectations about the abilities of ABs and felt uncertainty about how the experience would turn out. The AB-experienced group reported that, after they had ridden the AB, they felt disappointment because their idealised expectations were not met. The idealisation was based on the belief that the experience of travelling on an AB must be highly technological and substantially different from travelling on a conventional bus.

Similarly, prior experience moderates the relationship between subjective norms and willingness to use ABs, so the relationship is meaningful for AB-experienced users, and not meaningful for the inexperienced. In the qualitative study, both groups recognised the effect of their social environment on their behaviours. This maybe because the AB-experienced users had had the chance to discuss the experience with their family and friends, thus they were aware of the opinions of their close, social environment. Conversely, the AB-inexperienced users may not have been able to judge how their use of ABs would be perceived by their social group/family. This moderating effect of experience is also important in terms of the influence of perceived behavioural control on willingness to use an AB; this relationship is significant for the AB-inexperienced group, but not for the AB experienced. This maybe because once users have ridden the AB, they find that using it requires no more capacities than are necessary to ride conventional buses, which diminishes the effect of perceived behavioural control as a determinant of intention of use. This result is in line with Yan et al. (2022), analysing AB-experienced users in China, who showed that perceived ease of use does not significantly affect continuance intention to use ABs.

Third, personal innovativeness was shown to positively influence willingness to use an AB among both the AB experienced and inexperienced. The results of the qualitative study suggested that, while the participants might be predisposed towards accepting innovations, their effect on intention to use will be conditioned by need. In this sense, the participants did not, on a personal level, believe that ABs satisfy any additional needs, given that they consider that they provide the same service as conventional buses. This perhaps explains why the effect of personal innovativeness on willingness to travel on an AB is low. This finding contributes to the literature by confirming a direct relationship hitherto little examined, and that, until now, had been identified only with the mediation effect of perceived ease of use (Herrenkind et al., 2019).

Fourth, the results support the hypothesis that trust in ABs positively affects perceived benefits. The literature has shown the direct and indirect influence of trust on intentions to use autonomous taxis (Liu et al., 2022) and shuttles (e.g., Chen, 2019; Goldbach et al., 2022). The present study contributes to the literature by showing that trust in ABs is higher among AB-experienced users than among inexperienced individuals. Therefore, the present study has expanded the understanding of the effect of trust in ABs. In this sense, the qualitative study showed that AB-experienced users' trust in the vehicles was based on their technologies and their proper functioning, and that AB-inexperienced users' trust was based on their confidence in the service-operating transport company and in the institutions and regulations of the European Union.

Fifth, the present study confirmed the positive impact of perceived safety on the perceived benefits of ABs. For participants, feeling safe brought benefits that translated into greater satisfaction. However, as noted above, it should be remembered that in this study the AB circulated with an operator in the driving position, in accordance with European regulations. This could have had a positive influence on perceived safety and the user experience. In fact, in the qualitative study both user groups expressed concerns about the coexistence of ABs and other vehicles on the same roads (e.g., cars, electric scooters). In addition, the AB-inexperienced expressed concerns about possible cyber-attacks on the vehicles' driving systems.

Sixth, perceived benefits were shown to positively influence satisfaction with the AB service. This is an original contribution to the literature as this relationship has not been evaluated in previous works. Nesheli et al. (2021) suggested that several studies conducted into driverless shuttles have reported conflicting results about user satisfaction; some have highlighted negative aspects, such as the slowness of the service, abruptness of braking, the very few routes available and the perception of insecurity evoked by the risk of collision. Therefore, this study contributes to the literature by statistically demonstrating the effect of perceived benefits on user satisfaction with an AB in a specific context and specific conditions, although it is true that in the qualitative study sessions the participants made some negative comments. For example, the AB-inexperienced expressed concerns about its possible limitations in providing public transport for some segments of the population (e.g., older people), in line with Kassens-Noor et al. (2020). Nonetheless, it should be noted that the AB-experienced did not believe that ABs were any more difficult to access than were conventional buses, which demonstrates again the importance of trialling ABs to reduce users' objections and enhance intention to use.

Seventh, contrary to expectations, the results did not support the proposed relationship between satisfaction and willingness to travel on an AB. Some studies, for example, Mouratidis and Cobeña (2021) and Yan et al. (2022), have suggested that users who are most satisfied with AB services will have the highest intention of reusing them. In the present study the impact of satisfaction was statistically significant in the two user groups, but not in the evaluation of the model using the total sample. In fact, the effect of satisfaction on willingness to travel was significantly greater in the AB-experienced group than in the inexperienced. We believe that these results are an empirical manifestation of the Yule-Simpson paradox, also known as aggregation bias. These researchers analysed a statistical anomaly in which aggregated data revealed a trend or outcome that reverses or disappears when subgroup data is analysed (Goltz and Smith, 2010), as in the present study. The appearance of different results when two heterogeneous populations are aggregated into one can be seen as a form of spurious correlation (Di Matteo and Petrunia, 2022).

Eighth, this research shows the importance of previous experience in users' decisions to travel on ABs. Specifically, the participation of users in the AB pilot test moderated seven of the eight relationships of the proposed model. The effects of perceived benefits, trust, satisfaction, subjective norms and personal innovativeness were greater among the AB-experienced. In contrast, the effects of attitude and perceived behavioural control were greater among the AB-inexperienced. The effect of user experience on intention to use a new technology was proposed by Venkatesh et al. (2003) and has since been identified in many different contexts. However, to date, few studies have included experience as a moderating factor in models of intention to use ABs.

6.2. Managerial implications

The results of the study highlight the importance of informing potential users about the characteristics of AB services and what their implementation implies in terms of safety, sustainability and employment. Transport company managers should pay attention to this aspect as enhancing users' knowledge will increase their feelings of trust and perceived security, which will raise intention to use, and reduce the hi-tech-based idealisation of the service that can cause disappointment among users after they ride the AB. They should also provide information about their plans to redeploy their drivers to address social concerns about job losses, which can adversely affect the image of the company and of ABs.

Generating a favourable opinion of ABs will have a positive impact on intention to use through attitude and subjective norms. In addition, explaining how ABs operate will increase intention to use as users will then understand that all groups, including the elderly and the disabled, can ride them with ease. That ABs appear very similar to conventional buses can reduce the user's concern in this regard. Similarly, to generate trust in ABs, the good reputation of the transport company itself is important, as is informing users that they comply with European Union regulations and have passed the relevant quality and safety tests.

In terms of benefits, the results suggest that transport companies should communicate the positive aspects that ABs can bring to cities, such as sustainability, safety, efficiency and improved image. In addition, given that users currently do not perceive that ABs will provide them personal benefits beyond those provided by conventional buses, transport companies should also work on increasing the benefits users derive from aspects such as frequency of service, access, interior comfort and on-board safety. These steps will improve users' perceptions of the benefits they will derive, increase their satisfaction and, consequently, their willingness to travel on ABs.

6.3. Limitations and future research

Despite its important contributions, this research has limitations that future studies might address to improve the knowledge of the perceptions', and intention to use, of bus passengers. First, the study was undertaken only in one city, so it would be advisable, to enhance the generalisation of the results, to carry out experiments in different cultural environments. Second, the study is cross-sectional as the pilot test was conducted for only two weeks. Future work could be based on longer periods of time, so that the evolution of users' perceptions and their continued use of the service could be observed longitudinally. Third, current regulations require that an operator occupies the driver's position, which may impact on the user's perception of issues such as safety and trust. Future work should evaluate the user's experience and intention to use ABs in the absence of a driver. Fourth, in this research an extension of the TPB model is proposed, featuring a set of variables and relationships included based on the literature review. However, future research might explore the effects of other variables (see Greifenstein, 2024) and relationships (e.g., perceived benefits and trust as antecedents of attitude) to expand knowledge about the processes of adoption and use of ABs. Fifth, the present study is based on two focus groups, one with experienced users, and the other with inexperienced. Although both groups had the minimum size required, and their composition was representative of the population under study, future research might increase the numbers used in these groups to try to capture perceptions that did not manifest themselves in the work. Finally, this study is based on qualitative and quantitative data expressed by users. Future works might use other, non-self-reported analysis techniques, to collect emotional data, for example, eye-tracking, galvanic skin response and facial expressions.

CRediT authorship contribution statement

Sebastian Molinillo: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Lidia Caballero-Galeote:** Writing – review & editing, Writing – original draft, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francisco Liébana-Cabanillas:** Writing – review & editing, Writing – original draft, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Miguel Ruiz-Montañez:** Writing – review & editing, Writing – original draft, Resources, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors did not receive support from any organization for the submitted work. The authors SM, LCG and FLC declare that they have NO affiliations with or involvement in any organization or entity with any financial interest or nonfinancial interest in the subject matter or materials discussed in this manuscript. Author MRM is on the board of directors of the Association of Urban and Metropolitan Public Transport of Spain and receives no compensation as a member of this board, and is the manager of the Malaga Transport Company.

Data availability

Data will be made available on request.

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Appendix A. A non-exhaustive list of studies (in chronological order) examining users' intention to ride autonomous buses following a real transportation experience

Source	Place & Vehicle Type	Theory & Variables	Methodology	Findings
Madigan et al. (2016).	La Rochelle (France) and Lausanne (Switzerland). Shuttle (max. 12 passengers).	UTAUT. Performance Expectancy, Effort Expectancy, Social Influence and Behavioural intentions.	A survey with 349 respondents.	Performance expectancy is the most important factor.
Madigan et al. (2017).	Trikala (Greece). Shuttle (max. 12 passengers).	UTAUT. Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions and Hedonic Motivation.	A survey with 315 respondents.	Hedonic motivation (users' enjoyment of the AB system) has a strong impact on future behavioural intentions to use automated road transport systems.
Nordhoff et al. (2018).	Berlin-Schöneberg (Germany). Shuttle (max. 12 passengers).	Intention to use, shuttle and service characteristics, and shuttle effectiveness compared to existing transport.	A survey with 384 respondents.	Participants were positive about the AB although they were not satisfied with the speed and luggage space.
Salonen (2018).	Vantaa (Finland). Shuttle (max 10 passengers).	AB passengers' experiences of traffic safety, in-vehicle security and emergency management compared to conventional buses.	197 interviews.	Participants stated that the AB was safer in traffic; however, in relation to their personal safety, users felt slightly more insecure than on a conventional bus. The lack of perceptions of personal safety on board needs to be further explored.
Nordhoff et al. (2019)	Berlin-Schöneberg (Germany). Shuttle (max. 12 passengers).	Transport mode choice, perceptions and experiences during the ride, their associations with automated driving before the ride, factors that influence respondents' acceptance, family members' opinions, and how they envision the future of mobility.	30 interviews.	Participants have idealised expectations about the capabilities of ABs. They were positive about implementation based on speed and reliability.
Salonen and Haavisto (2019).	Espoo (Finland). Shuttle (max. 10 passengers).	Theory of Interpersonal Behaviour (TIB). Attitudes, social factors, feelings, habits, behaviour and intentions.	44 semi-structured interviews.	Participants felt safe although they are more intolerant of accidents caused by autonomous vehicles. Attitudes were positive. Routing and flexibility are the key factors for behavioural changes.
Herrenkind et al. (2019).	Germany. Shuttle (max. 10 passengers).	An extended model of the TAM with determinants obtained from a qualitative study and from the literature.	15 interviews and 268 survey respondents.	A mix of individual characteristics, social impacts and system characteristics determine intention to use an AB.
Papadima et al. (2020).	Trikala (Greece). Shuttle (max. 12 passengers).	Attitudes towards the operation of ABs, factors favouring or discouraging use, and the reasons for being hostile to the future implementation of AVs.	A survey with 158 respondents.	The participants showed a positive attitude towards the AB. Promotion was very important, although those who opposed implementation based their concerns on the loss of jobs and parking spaces. Price was the most important attribute.
Bernhard et al. (2020).	Mainz (Germany). Shuttle (max 7 passengers).	UTAUT. Performance and effort expectancy, and their moderators age, gender and experience. Willingness to use, perceived safety, valence, minibus characteristics and environmental friendliness.	A survey with 942 respondents.	While performance expectancy predicted AB acceptance, effort expectancy did not predict willingness to use an autonomous minibus. Valence and external factors predicted willingness to use. Experience and environmental friendliness are important and contribute to improved user opinion.
Mouratidis and Cobeña (2021).	Oslo (Norway). Shuttle (max 8 passengers).	Intention to use autonomous buses before and after use.	A survey with 117 respondents.	Participants showed high intention to use ABs. They were satisfied with the additional service offered by the buses, felt safe, but believed that there is a need to increase speed and reduce braking.
Launonen et al. (2021).	Finland. Shuttle (max 10 passengers).	TPB. Attitudes, subjective norms and perceived behavioural control.	A survey with 141 respondents and 70 interviews.	Attitudes, subjective norms and perceived behavioural control are predictors of intention to use an AB.
Wu et al. (2021).	China	TAM, with new factors, including perceived comfort (PC) and perceived risk (PR).	A survey with 401 respondents.	Attitude positively affects behavioural intention, and trust and perceived usefulness positively affect attitudes. In addition, perceived ease of use and perceived comfort have positive effects on perceived usefulness and trust. Perceived risk was negatively associated with trust.
Li et al. (2022).	Nanjing (China).	Acceptance and individual differences (gender, age, region, nationality, educational background,	A survey with 453 respondents.	Gender, age, educational background, income level, frequency of use and personality traits have a significant effect on levels of acceptance of ABs.

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Source	Place & Vehicle Type	Theory & Variables	Methodology	Findings
		marital status, income level, frequency of bus use and personality traits.)		
Yan et al. (2022).	Tianjin (China). Small Autonomous bus (max 19 passengers + 1 a wheelchair).	TAM with characteristics of both autonomous driving and conventional buses.	A survey with 576 respondents.	Perceived usefulness positively affects continuance intention to use, and perceived ease of use positively affects perceived usefulness. Past bus use habits and trust in the driver were found to be two significant, moderating variables.

Appendix B. Measurement scales

Variables	Items	Source
Attitude	– Using an AB is a good idea. – Using an AB is a pleasant idea. – Using an AB is a wise idea. – Using an AB is a positive idea.	Chen (2019).
Subjective Norms	– People who are important to me will encourage me to use ABs. – Most people who influence my behaviour would think that I should use an AB. – Most people whose opinions I value would approve of me using an AB. – My friends and family would like me to use an AB.	Kaye et al. (2020), Chen and Yan (2019).
Perceived Behavioural Control	– It would be very easy for me to use an AB. – There are no problems using an AB. – I have everything that is needed to use an AB.	Ajzen (2002).
Trust	– An autonomous shuttle provides a robust and safe environment in which I can use the service. – I trust that the autonomous shuttle provider has enough safeguards to protect me from liability for damage for which I am not responsible. – Overall, an autonomous bus is trustworthy	Chen (2019).
Perceived Safety	– Traffic safety in terms of the risk that the vehicle can be involved in an accident with a pedestrian. – Traffic safety in terms of the risk that the vehicle can be involved in an accident with another vehicle. – Traffic safety in terms of the risk of more traffic accidents.	Salonen (2018).
Perceived Benefits	– ABs can reduce vehicle collisions. – ABs can reduce vehicle emissions. – ABs can improve fuel economy. – ABs can reduce transport costs.	Liu et al. (2019).
Satisfaction	– Safety perceptions. – Clarity of information. – Stability and comfort. – Convenience. – Speed of shuttle service. – Overall satisfaction.	Chen (2019).
Willingness to Travel on an AB	– I would be willing to travel on an AB. – I would want to travel on an AB for everyday use. – I would be delighted to travel on an AB. – The prospect of travelling on an AB appeals to me.	Bennett et al. (2019).
Personal Innovativeness	– If I heard about a new information technology, I would look for ways to experiment with it. – Among my peers, I am usually the first to try out new information technologies. – I like to experiment with new information technologies.	Agarwal and Prasad (1998).

Appendix C. Sample characteristics (n = 301)

Characteristic	Frequency	Percentage
Gender		
Woman	174	57.81%
Male	127	42.19%
Age		
Under 18 years old	41	13.62%
18–24 years old	54	17.94%
25–34 years old	57	18.94%
35–44 years old	52	17.28%
45–54 years old	36	11.96%
55–64 years old	22	7.31%
65–74 years old	39	12.96%
More than 74 years	0	0.00%
Level of studies completed		
Primary education	19	6.31%
Secondary education, basic vocational training, or similar	32	10.63%
Baccalaureate, intermediate vocational training, or similar	33	10.96%
Higher vocational training, or similar	79	26.25%
University studies	112	37.21%

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Characteristic	Frequency	Percentage
Postgraduate university studies	26	8.64%
Main employment situation		
Student	86	28.57%
Employee	123	40.86%
Self-employed or entrepreneur	15	4.98%
Housework	27	8.97%
Retired, pensioner or similar	21	6.98%
Unemployed	21	6.98%
Other	8	2.66%
Household income		
Less than 10,000 euros per year	65	21.59%
Between 10,000 euros and 20,000 euros per year	62	20.60%
Between 20,001 euros and 40,000 euros per year	119	39.53%
Between 40,001 euros and 60,000 euros per year	49	16.28%
More than 60,000 euros per year	6	1.99%
Experience of autonomous buses		
Yes	101	33.55%
No	200	66.45%

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