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What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of Automated Road Transport Systems

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Abstract

The main aim of this study was to use an adapted version of the Unified Theory of Acceptance and Use of Technology (UTAUT) to investigate the factors that influence users' acceptance of automated road transport systems (ARTS). A questionnaire survey was administered to 315 users of a CityMobil2 ARTS demonstration in the city of Trikala, Greece. Results provide evidence of the usefulness of the UTAUT framework for increasing our understanding of how public acceptance of these automated vehicles might be maximised. Hedonic Motivation, or users' enjoyment of the system, had a strong impact on Behavioural Intentions to use ARTS in the future, with Performance Expectancy, Social Influence and Facilitating Conditions also having significant effects. The anticipated effect of Effort Expectancy did not emerge from this study, suggesting that the level of effort required is unlikely to be a critical factor in consumers' decisions about using ARTS. Based on these results, a number of modifications to UTAUT are suggested for future applications in the context of automated transport. It is recommended that designers and developers should consider the above issues when implementing more permanent versions of automated public transport.

Keywords: automated public transport, acceptance of automation, social-psychological model, user-acceptance

1. Introduction

There is currently an intense interest in the potential benefits to road transport of various types of automated vehicles, with both private vehicle manufacturers, and service providers such as Google (Urmson, 2015), considering the benefit of such technology. Examples include Tesla's Model S Autopilot (TESLA, 2016), and the Volvo IntelliSafe Autopilot (Volvo Cars, 2016), which provide automation at SAE Levels 2 and 3 (SAE, 2016). Another category of automated vehicles, functional at SAE Level 4, operate at low speeds in urban environments, and do not include a steering wheel or any other conventional driver controls. These vehicles operate without a driver, and use simultaneous localisation and mapping (SLAM) along with laser and LiDAR technology to navigate through designated areas (e.g. Roldão, Pérez, González, & Milanés, 2015). Examples of such vehicles include the Google "driverless" pods (Google, 2016), the LUTZ pathfinder vehicles (Transport Systems Catapult, 2016), and the CityMobil2 Automated Road Transport Systems (ARTS) – see Figure 1. Funded as part of the European Commission's Seventh Framework Programme, the main aim of the CityMobil2 project is to test the feasibility of such vehicles in providing an alternative public transport option to urban environments across Europe. It is anticipated that these vehicles can deliver a first mile/last mile option which will provide users with a way to get to and from their homes to public transport hubs.

The ARTS vehicles range in capacity between 2 and 10 passengers, and their aim is to provide public transport options when demand is low or pick-up points are far apart. Also known as ‘cyber-cars’, these vehicles operate within existing infrastructure, and can be deployed in a shared environment among pedestrians, cyclists, motorcyclists and cars (Alessandrini, Campagna, Delle Site, Filippi, & Persia, 2015). To date, CityMobil2 has implemented seven demonstrations of ARTS in various cities across Europe, including large scale demonstrations in La Rochelle in France, Lausanne in Switzerland, and Trikala in Greece. The purpose of these demonstrations was, firstly, to gain an understanding of the design and implementation issues related to ARTS (see Milanés, 2014); along with investigating the interaction between ARTS and other road users (see Merat, Louw, Madigan, Dziennus, & Schieben, submitted). In addition, they provided an opportunity to explore the legal framework for certifying automated vehicles (see Csepinszky, Giustiniani, Holguin, Parent, Flament & Alessandrini, 2015), and to establish the technical specifications for connected ARTS, including communication architecture (CityMobil2, 2016).

Figure 1: An example of one the CityMobil2 ARTS Vehicles (designed by Robosoft)

If ARTS are to provide a viable alternative to other modes of transport, and for their value to be recognised by public organisations investing in such systems, it is important to establish users’ acceptance and uptake of these systems. This point is highlighted by Najm, Stearns, Howarth, Koopman and Hitz (2006), who suggest that “driver acceptance is the precondition that will permit new automotive technologies to achieve their forecasted benefit levels” (p.5-1). For that reason, the main aim of this study was to identify the factors that affect the use of such automated systems, using a validated social-psychological model of user acceptance: the

Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh, Morris, Davis, & Davis, 2003).

1.1 User acceptance of technological systems

Across the domains of psychology, information systems, and sociology, numerous theoretical models have been developed to explain users' acceptance of technology. One of the most widely cited frameworks in the area of transport technology is the Technology Acceptance Model (TAM), which builds on Ajzen's (1985) Theory of Reasoned Action (TRA) in an effort to understand acceptance related specifically to the uptake of new technologies (Davis, 1989). Using TAM, Davis (1989) posits that Perceived Ease of Use and Perceived Usefulness are the two most important determinants of technology use. Adaptations of TAM have since been used to explain technology acceptance in a variety of transportation contexts, including switching intentions towards public transport (Chen & Chao, 2011), eco-driving interfaces (Meschtscheriakov, Wilfinger, Scherndl, & Tscheligi, 2009; Hötl & Trommer, 2012), navigational systems (Park & Kim, 2014), and distraction mitigation systems (Roberts, Ghazizadeh, & Lee, 2012); explaining up to 50% of the variance in Behavioural Intentions around these systems.

One of the most useful aspects of TAM is the capacity to successfully extend the core constructs of the model to include additional external variables which may become relevant in different contexts (Ghazizadeh, Lee, & Boyle, 2012). One such extension is the Unified Theory of Acceptance and Use of Technology (UTAUT, Venkatesh et al., 2003), which focuses on acceptance of technology in the workplace. The UTAUT framework brings together eight different models of acceptance, including the TRA and TAM, into a coherent model designed to capture all of the factors impacting on Behavioural Intentions to use a particular technology. UTAUT posits that Performance Expectancy, Effort Expectancy and Social Influence all influence Behavioural Intentions towards technology use, which in turn predicts actual system use (see Table 1 for definitions). This model has been found to predict 56% of the variance in Behavioural Intentions and 40% variance in actual use of a technology or system. UTAUT2, the most recent, consumer-oriented version of UTAUT, claims that there are seven main constructs that influence consumer Behavioural Intentions towards technology use, namely Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation, Price Value, and Habit (Venkatesh, Thong, & Xu, 2012, see Table 1). Based on the research conducted by Venkatesh et al. (2012), age and gender are proposed as moderators of the relationship between these variables and Behavioural Intentions. Previous research has not shown any impact of increased experience with a system on the relationship between Performance Expectancy and Behavioural Intentions, and thus experience is only expected to moderate the relationship between Effort Expectancy, Social Influence, Facilitating Conditions, and Hedonic Motivation with Behavioural Intentions (see Figure 2). Venkatesh et al. (2012) found that UTAUT2 predicted an additional 14% variance in Behavioural Intentions of consumers, above that of the original UTAUT, and predicted over 50% variance in actual use of a mobile internet system.

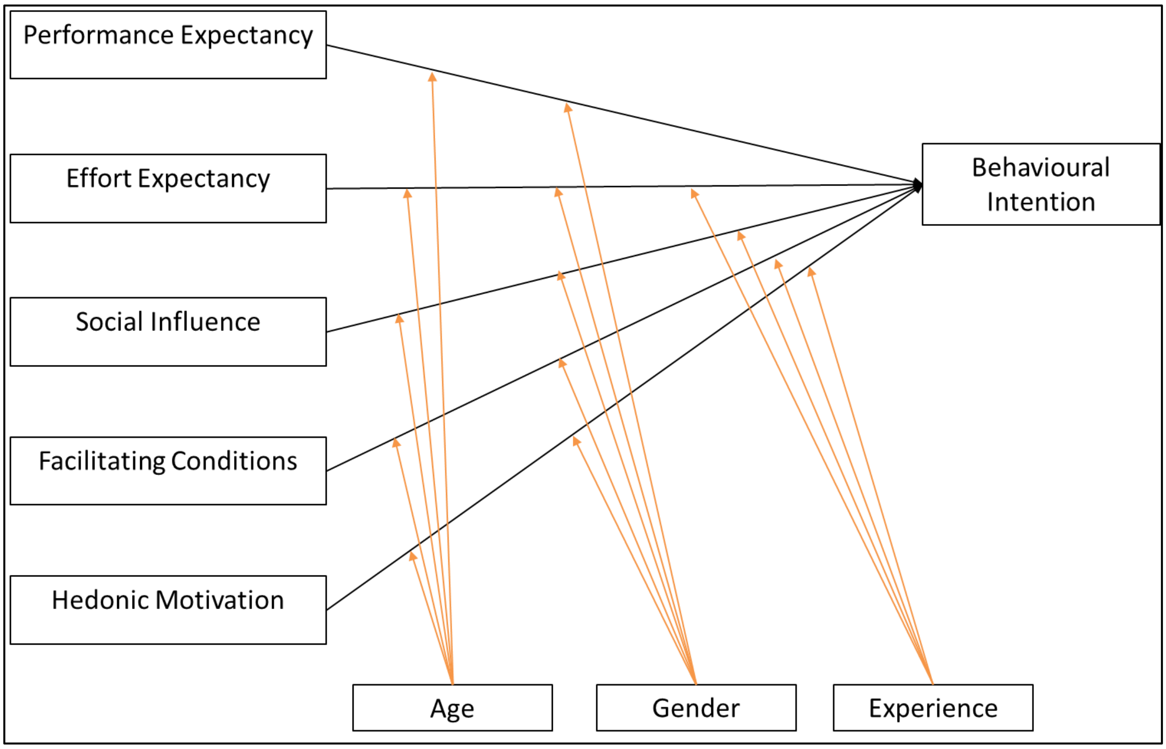

Figure 2: Model to be investigated based on UTAUT2 (Venkatesh et al., 2012)

UTAUT has traditionally been applied to understanding intentions to use information systems, such as online banking (Zhou, Lu, & Wang, 2010), e-government services (AlAwadhi & Morris, 2008), and mobile devices/services (Carlsson, Carlsson, Hyvönen, Puhakainen, & Walden, 2006; Venkatesh et al., 2012). In recent years, a number of studies have incorporated elements of UTAUT into their understanding of user acceptance of vehicle technology (e.g. Park, Junghwan, Changi, & Seongcheol, 2013; Osswald Wurhöfer, Trosterer, Beck & Tscheligi, 2012; Zmud, Sener & Wagner, 2016). However, despite the strong predictive power of UTAUT in other contexts, only two previous studies have applied the full model in a transport context. Adell (2010) used the original version of UTAUT (Venkatesh et al., 2003) to investigate driver acceptance of a "Safe Speed and Safe Distance" function as part of a field trial of a driver support system. The results showed that although Performance Expectancy and Social Influence affected intentions to use the system, Effort Expectancy did not. However, the model only accounted for 20% of the variance in Behavioural Intentions towards this support system, a figure much lower than that found in other industries. Madigan et al. (2016) also used the original UTAUT to investigate users' acceptance of ARTS as part of the CityMobil2 trials in La Rochelle, France, and Lausanne, Switzerland. Results indicated that Performance Expectancy, Effort Expectancy, and Social Influence all impact on users' Behavioural Intentions towards ARTS in these locations. However, the explanatory power of the model was only 22%, suggesting that this model failed to capture many of the factors influencing users' decisions around uptake and use of automated transport systems.

Table 1: UTAUT Construct Definitions adapted from Venkatesh et al. (2012)

Construct	Definition
Performance Expectancy (PE)	The degree to which using an ARTS vehicle will provide benefits to consumers in their travel activities
Effort Expectancy (EE)	The degree of ease associated with ARTS use
Social Influence (SI)	The extent to which consumers perceive that important others (e.g. family and friends) believe that they should use ARTS
Facilitating Conditions (FC)	*Consumers' perceptions of the resources and support available to use ARTS* e.g. infrastructure design and implementation strategies
Hedonic Motivation (HM)	The fun or pleasure derived from using ARTS

The aim of the current study was, therefore, to build on the research outlined in Madigan et al. (2016) by extending the UTAUT model to include the effects of Facilitating Conditions and Hedonic Motivation on intention to use ARTS vehicles (see Table 1 for a list of the definitions used in this study). Based on the previous research in both driving (Adell, 2010; Madigan et al., 2016) and other domains (e.g. Venkatesh et al., 2012), it was expected that all of the factors included would have a positive impact on Behavioural Intentions to use ARTS.

The impact of Facilitating Conditions and Hedonic Motivation on acceptance of automation has rarely been explored, but in the most relevant study available, Park et al. (2013) found a strong positive relationship between Facilitating Conditions and drivers' intention to use car connectivity services. Similarly, it is highly likely that the resources provided to support the implementation of ARTS, including infrastructure design, implementation strategy, and consideration of social, economic and environmental impacts, will all influence user uptake of these systems (Sessa, Pietroni, Alessandrini, Stam, Delle Site, & Holguin, 2015). User enjoyment is also likely to play a role in such a new and innovative environment. Indeed, Hedonic Motivation has been shown to be the strongest predictor of consumer acceptance of technology across a variety of sectors (van der Heijden, 2004; Venkatesh et al., 2012).

Thus, in the current study it was expected that each of the five UTAUT2 variables (see Table 1) would have a significant, positive relationship with Behavioural Intentions towards ARTS; with each variable expected to make a unique contribution to the overall predictive capability of the model. The influence of the moderated relationships proposed by Venkatesh et al. (2012; see Figure 2) were also investigated.

Finally, the value of this study to decisions on deployment and implementation of ARTS is thought to be particularly important, because this paper reports the first study of its kind where a social-psychological model is used to investigate Behavioural Intentions and user acceptance of automated systems during their actual demonstration. This is of particular relevance, as research has shown that there is a change in ratings of acceptability of transport systems before their implementation and their acceptance after actual use (Schuitema, Steg & Forward, 2010).

2. Method

2.1 Procedure

The results reported in this study were part of a larger, 57 item questionnaire, administered to users of the ARTS demonstration vehicles in Trikala, Greece between December 2015 and February 2016. The demonstration involved six Robosoft ARTS vehicles operating alongside different traffic modes on a dedicated lane in Trikala city centre (see Figure 3). Each vehicle had capacity for up to 10 passengers and travelled along a 2.5km route including 8 station stops. The average speed of the ARTS vehicles was approximately 13 km/h. For legal and safety reasons, an operator travelled on board at all times and had the power to intervene in the operation and maneuvering of the vehicle, if and when required.

Figure 3: CityMobil2 vehicles in Trikala, Greece

Informed by a series of one to one interviews in Leeds, UK and Braunschweig, Germany (see Merat, Louw, Madigan, Dziennus, & Schieben, 2016) the 52 item questionnaire was administered by members of staff from E-Trikala, using a tablet-based application. The questionnaire items were translated into Greek by the E-Trikala team, and independently checked for accuracy by the Institute of Communication and Computer Systems (ICCS) in Greece, and a bilingual colleague in England. Questionnaires were largely self-administered but staff could help with capturing responses if required.

To ensure that respondents had some knowledge of the vehicles, only members of the public who had used the ARTS at least once during the demonstrations were asked to complete the questionnaire. Each questionnaire took between 8 and 10 minutes to complete. Data was collected in blocks of 30 minutes to 11 hours on 27 dates between 16th December 2015 and 26th February 2016. The information was recorded anonymously and no compensation was offered.

2.2 Participants

A total of 315 participants (54.6% Male, 45.4% Female) completed the questionnaire. Participant age ranged from 9.18 to 65.83 years (M=33.35, SD=10.76). All participants had used the ARTS vehicles at least once (M=2.22, SD=1.39), with 14 participants having used it more than 5 times.

2.3 Measures

In order to understand whether respondents' expectancies around the ARTS vehicles were related to their intention to use it, we developed measures of Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, Hedonic Motivation and Behavioural Intentions, based on the relevant constructs identified by Davis (1989) and Venkatesh et al. (2012). The measurement scales built upon the items used in an earlier UTAUT-based questionnaire, which was administered at ARTS demonstrations in La Rochelle in France and Lausanne in Switzerland (Madigan et al., 2016). Based on the results of that study and a further literature review, a refined 20-item questionnaire was developed, with all items measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The final items developed to measure each of the UTAUT2 constructs are shown in Table 2.

Table 2: UTAUT Questionnaire Items

Construct	Adapted Item
Performance Expectancy	PE1: I find the ARTS a useful mode of transport
	PE2: Using the ARTS to travel helps me to achieve things that are important to me
	PE3: Using the ARTS will help me reach my destination more quickly
Effort Expectancy	EE1: My interaction with the ARTS is clear and understandable
	EE2: I find the ARTS easy to use
	EE3: Learning to use an ARTS is easy for me
Social Influence	SI1: People who are important to me think that I should use ARTS.
	SI2: People who influence my behavior think that I should use ARTS
	SI3: People whose opinions I value would like me to use ARTS
	SI4: In general the authority would support the use of ARTS
Facilitating Conditions	FC1: I have the resources necessary to use ARTS
	FC2: I have the knowledge necessary to use ARTS
	FC3: The ARTS is compatible with other forms of transport I use
	FC4: I can get help from others when I have difficulties using ARTS
Hedonic Motivation	HM1: Using ARTS is fun
	HM2: Using ARTS is entertaining
	HM3: Using ARTS is enjoyable
Behavioural Intentions	BI1: Assuming that I had access to ARTS, I predict that I would use it in the future
	BI2: If ARTS become available permanently, I plan to use it
	BI3: I intend to use ARTS again during the demonstration period.

3. Results

This section outlines the results of the UTAUT analysis. A factor analysis was first conducted to ensure the divergent and convergent validity of all of the scale items. Thereafter, correlational analyses were used to explore the interrelationships between the scales and their individual relationships with Behavioural Intentions. Finally, in order to assess the additional effects of the moderating variables, a hierarchical multiple regression analysis was used to test the UTAUT model outlined in Figure 2 (see Aiken and West, 1991).

3.1 Behavioural intentions towards ARTS

To ensure that the six UTAUT dimensions investigated were distinct, a factor analysis was conducted, using maximum likelihood extraction and varimax rotation (Costello & Osborne, 2005). Four items did not have the expected loadings. Firstly, item FC4 and SI4 (see Table 2) both loaded most strongly onto the Effort Expectancy construct, while item FC3 was most strongly linked to Hedonic Motivation and PE3 cross-loaded strongly onto Social Influence. Similar to previous studies, these cross-loading items were deleted for the remaining analyses (Venkatesh et al., 2012).

After removing cross-loading items, a second factor analysis was conducted. Six clear factors emerged as expected, with all factor loadings greater than 0.4, indicating high construct validity (Field, 2013; see Table 2). The Cronbach's alpha values were all above 0.70, indicating high internal consistency for each of the scales (Nunnally, 1989).

Table 3: UTAUT Items, factor loadings, and scale reliabilities

Construct	Adapted Item	Factor Loading
Performance Expectancy ($\alpha = 0.773$)	Using the ARTS to travel helps me to achieve things that are important to me	0.719
	I find the ARTS a useful mode of transport	0.582
Effort Expectancy ($\alpha = 0.885$)	I find the ARTS easy to use	0.844
	Learning to use an ARTS is easy for me	0.569
	My interaction with the ARTS is clear and understandable	0.510
Social Influence ($\alpha = 0.891$)	People who influence my behavior think that I should use ARTS	0.850
	People who are important to me think that I should use ARTS	0.776
	People whose opinions I value would like me to use ARTS	0.803
Facilitating Conditions ($\alpha = 0.844$)	I have the knowledge necessary to use ARTS	0.874
	I have the resources necessary to use ARTS	0.529
Hedonic Motivation ($\alpha = 0.867$)	Using ARTS is fun	0.700
	Using ARTS is entertaining	0.666
	Using ARTS is enjoyable	0.642
Behavioural Intentions ($\alpha = 0.895$)	Assuming that I had access to ARTS, I predict that I would use it in the future	0.825
	If ARTS become available permanently, I plan to use it	0.682
	I intend to use ARTS again during the demonstration period.	0.584

Table 4: Correlations between the UTAUT scales

	M	SD	1.	2.	3.	4.	5.	6.	7.	8.
1. Age	33.35	10.76	1							
2. No. times using ARTS	2.23	1.39	-0.65	1						
3.Performance Expectancy	3.62	0.84	-0.21**	0.02	1					
4. Effort Expectancy	3.92	0.71	-0.19**	-0.05	0.66**	1				
5.Social Influence	3.37	0.79	-0.21**	0.13*	0.44**	0.38**	1			
6. Facilitating Conditions	3.91	0.75	-0.13**	-0.05	0.54**	0.68**	0.33**	1		
7. Hedonic Motivation	3.82	0.74	-0.24**	0.02	0.51**	0.69**	0.45**	0.64**	1	
8. Behavioural Intentions	3.74	0.74	-0.24**	0.08	0.60**	0.59**	0.51**	0.59**	0.68**	1

*p<0.01, **p<0.001

Prior to evaluating the model as a whole, correlational analysis were run to check for multicollinearity. As shown in Table 4, there were no correlations larger than 0.70, and the Tolerance statistics computed as part of the regression indicate that none of the values were less than 0.1, which is sufficient to rule out multicollinearity (Laerd, 2015).

Hierarchical multiple regression was used to test the moderated research model (see Figure 2), as recommended by Aiken and West (1991). Prior to entry into the regression model, the independent variables were centred to reduce multicollinearity (Stevens, 1986); the product terms to test moderation were also created from these centred independent variables. The categorical variables of gender and experience (i.e. number of times using ARTS) were dummy coded, consistent with previous studies (Venkatesh et al., 2003, 2012). Variables were then entered in three steps: (1) the predictor variables (Performance Expectancy, Effort Expectancy, Social Influence, Facilitating Conditions, and Hedonic Motivation); (2) the moderator variables (age, gender, and experience); and (3) the interaction terms for moderation analysis. As none of the predicted moderated relationships reached significance, only the main predictor variables (excluding interactions) are presented in Table 5.

Table 5: Hierarchical multiple regression results

Step		Step 1 β	Step 2 β	R^2	ΔR^2
1	Performance Expectancy	0.24**	0.23**	0.586	0.586**
	Effort Expectancy	-0.01	-0.003		
	Social Influence	0.19**	0.18**		
	Facilitating Conditions	0.18*	0.18**		
	Hedonic Motivation	0.37**	0.35**		
2	Age		-0.05	0.59	0.005
	Gender		-0.01		
	No. times using ARTS		0.05		

*p<0.01, **p<0.001

The first step of the equation shows the individual effects of each of the UTAUT predictors. Together, the variables accounted for 58.6% of variance in Behavioural Intentions, with Hedonic Motivation being the strongest predictor (β=0.37, p<0.001), followed by Performance Expectancy (β=0.24, p<0.001), Social Influence (β=0.19, p<0.001), and Facilitating Conditions (β =0.18, p<0.01). However, Effort Expectancy did not predict Behavioural

Intentions (β=0.003, p=0.96). In the second step of the model, none of the demographic variables had a significant effect, suggesting that any impact of these variables disappears once all of the other factors are taken into consideration. In addition, none of the proposed moderated relationships reached significance, and their inclusion did not increase the predictive power of the model.

4. Discussion

Although there is much excitement surrounding the introduction of various forms of vehicle automation, there is little understanding of the factors which will influence the uptake of these systems. While the acceptance of private vehicle automation has received some research attention (e.g. Adell, 2010; Kyriakidis, Happee, & de Winter, 2015; Roberts et al., 2012; Schoette & Sivak, 2014), only one previous study has investigated Behavioural Intentions to use automated forms of public transport, such as the low speed ARTS currently being demonstrated as part of the CityMobil2 project in cities across Europe (Madigan et al., 2016). In addition, much of the research to date has focused on respondents' views of proposed automation ideas rather than actual experience of the automated systems. Thus, the purpose of the current study was to use the comprehensive UTAUT model as a framework to gain a more detailed understanding of the factors that will affect intentions to use such systems in the future. Results indicate that the model was successful in predicting Behavioural Intentions towards ARTS vehicles, accounting for 58.6% variance.

Four of the model's predicted relationships were supported, with Performance Expectancy, Social Influence, Facilitating Conditions, and Hedonic Motivation all making unique, positive, contributions to users' Behavioural Intentions towards ARTS vehicles. Similar to Venkatesh et al. (2012), Hedonic Motivation was the strongest predictor, suggesting that the most important factor influencing intentions to use ARTS is how enjoyable they find it. As these vehicles are new and innovative, this result is perhaps not surprising. However, it is imperative that developers keep this factor in mind as the systems advance and become a more common sight. A Stated Preference survey administered prior to one of the CityMobil1 demonstrations in Rome found that variables such as on-board comfort were very important in determining users' preference towards automated transport (Delle Site, Filippi, & Giustiniani, 2011), and, over time, this may well be a factor which supersedes the technology's novelty factor. In addition, Nordhoff, van Arem, and Happee (2016) suggest that one of the ways in which automated driving can become more enjoyable relates to how people choose to spend their newly available time, and indeed how automated vehicles can be designed to promote work or social networking.

Performance Expectancy also had a strong impact on Behavioural Intentions to use ARTS, emphasizing the importance of ensuring high system performance, particularly in relation to helping the public to achieve their transport goals in an efficient and effective manner. Related to this, the reliability of the vehicles and their connectivity with other transport services is likely to be of great importance in guaranteeing their use (see Sessa et al., 2015). Furthermore, the positive impact of Facilitating Conditions on Behavioural Intentions highlights the need to supply the right resources to support the effective use of ARTS. Designers and developers need to consider issues such as providing the correct infrastructure for implementing such systems, along with ensuring public engagement and awareness of the vehicle's capabilities, for example by using appropriate Human Machine Interface (HMI) on the ARTS to promote safe and effective interaction and communication. Indeed, results of a focus group study conducted with residents of La Rochelle (Merat et al., submitted), highlighted the desire for clearly demarcated sections for these ARTS, along with providing recommendations for how these vehicles might communicate with other road users. Finally, the significant impact of Social Influence on Behavioural Intentions suggests that the opinions of others will have an effect on whether the public will choose to use ARTS. This finding supports previous research on road pricing, which found that social norms had the highest impact on the acceptability of road pricing strategies (Schade & Schlag, 2003). Therefore, through effective marketing campaigns, developers need to focus on generating social norms that include the use of ARTS as a valid alternative to other public transport modes.

Effort Expectancy failed to reach significance in this study, suggesting that effort was not a factor in users' Behavioural Intentions towards ARTS. It is unclear whether this is because they found the system easy to use, or whether they did not mind exerting more effort to use this novel form of transport. This finding may also be related to the fact that the ARTS worked in a similar fashion to regular public transport, and, therefore, did not require any new skills or expertise. This result is in contrast to our findings from the La Rochelle and Lausanne demonstrations, where Effort Expectancy did have a significant, albeit weak, impact on Behavioural Intentions (Madigan et al., 2016). However, a related study in vehicle automation also failed to find a relationship between Effort Expectancy and Behavioural Intentions (Adell, 2010). The authors suggest that this is due to the fact that vehicle automation does not require continuous input/effort from the user to run effectively (Adell, 2010), unlike studies considering the use of IT/mobile technology systems (e.g. Venkatesh et al., 2012; Carlsson et al., 2006). Taken together, these results suggest that the vehicles are well-designed for public understanding, and that the level of effort required is unlikely to be a deciding factor in the public's decision to use ARTS.

The relationship between the predictor variables and Behavioural Intentions was not found to be affected by moderating factors such as age, gender or experience in this study. This is in contrast to previous studies by Venkatesh et al. (2003, 2012), who found evidence for the effects of all of the moderators. However, other studies have also failed to find any effects of these moderating variables on users' interactions with automated systems (Madigan et al., 2016; Adell, 2010). Recently, Zmud et al. (2016) found that the only demographic variable associated with intention to use an automated vehicle was having a physical condition that prohibits driving. Taken together, these results suggest that age, gender, and experience may not be relevant in the context of automated transport, per se. Although this result was not predicted by UTAUT2, research from a range of sources suggest that personal beliefs and preferences are often better predictors of technological adoption than demographic variables (e.g. Kyriakidis et al., 2015; Osswald et al., 2010; Zmud et al., 2016), and these type of variables might provide additional insights into the factors affecting the uptake of automated vehicles. In conclusion, results from this study imply that the effect of Hedonic Motivation, Facilitating Conditions, Performance Expectancy, and Social Influence all occur independently of any demographic differences, and targeted campaigns to increase the usability/acceptability of ARTS for specific groups are unlikely to be required. However, it should be noted that the sample sizes in all of these studies was significantly smaller than the 1,512 responses collected by Venkatesh et al. (2012), and therefore, greater numbers may be required to capture these effects.

4.1 Adapting UTAUT for Automated Vehicles

The results reported in this study provide evidence that the UTAUT model is a valuable framework for increasing our understanding of user acceptance of automated road transport systems. The framework accounted for over half of the variance in Behavioural Intentions towards ARTS. One of the strengths of the UTAUT model outlined in the introduction is its adaptability to suit different contexts (Ghazizadeh et al., 2012) and the results of this study suggest that a number of modifications are required for the model to be used in studies of vehicle automation. For example, Effort Expectancy does not appear to be an important predictor of users' Behavioural Intentions towards automated road transport systems, and could be excluded from future studies in this context. In addition, it seems that demographic variables such as age and gender do not significantly impact on people's intentions towards ARTS, suggesting that broader societal acceptance is more important than targeting specific groups. However, more research is required to understand the impact of other demographic variables such as income or education, as these first mile/last mile solutions are likely to be targeted at marginalised groups who are not catered for by current public transport provisions.

According to a recent study by Zmud et al., (2016) current adoption of both public and private vehicles is likely to have an impact on future use of automated public transport systems, and several studies have shown the impact of financial costs on attitudes towards technology (e.g. Chan, Gong, Xu & Thong, 2008; Kuo & Yen, 2009; Venkatesh et al., 2012). Unfortunately, these factors could not be included in the current study as the ARTS demonstrations were temporary and free-to-use, and thus accurate knowledge on current habit patterns and the effects of cost could not be collected. Therefore, in order to increase the predictive power of the model in the context of vehicle automation, the impact of other relevant constructs such as price/willingness to pay and habit should be explored in future studies. Finally, perceived safety is another issue which is likely to be of particular relevance in a transport context (see Kyriakidis et al., 2015), particularly as members of the public are still very much getting used to the idea of travelling in a moving vehicle without a driver present (Zmud et al., 2016). At the moment, the ARTS vehicles travel very slowly (at a maximum speed of around 16 km/h) and include an operator. However, as the speed of these vehicles increases, and the need for an operator is removed, personal safety is likely to become more of an issue for the users of these systems.

4.2 Conclusions

The main aim of this study was to use an adapted version of the UTAUT framework to investigate the social-psychological factors that influence users' acceptance of an automated road transport system (ARTS). Results of our survey, conducted with users of ARTS in the city of Trikala, Greece, provide evidence of the usefulness of this framework for increasing our understanding of public acceptance of these vehicles. In particular, users' enjoyment of the system plays a big part in their desire to use it again, whilst the performance of the system, the resources provided to support its use, and the social popularity of the system all appear to be important factors. It is hoped that in order to maximise system uptake, designers and developers of such automated systems can consider the above issues when implementing more permanent versions of automated public transport. The current findings build on previous research in La Rochelle in France, and Lausanne in Switzerland which suggest that similar factors are likely to have an influence in all three countries (Madigan et al., 2016), although the specific requirements for promoting user enjoyment, performance expectancy etc. may vary across cultures. From a theoretical point of view, a number of modifications to UTAUT are suggested for future use in understanding automated transport. These include the exclusion of the construct of effort expectancy, and the addition of price, public transport habits, and perceived safety.

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