



**HAL**  
open science

# UTAUT4-AV: An extension of the UTAUT model to study intention to use automated shuttles and the societal acceptance of different types of automated vehicles

Thierry Bellet, Aurélie Banet

## ► To cite this version:

Thierry Bellet, Aurélie Banet. UTAUT4-AV: An extension of the UTAUT model to study intention to use automated shuttles and the societal acceptance of different types of automated vehicles. *Transportation Research Part F: Traffic Psychology and Behaviour*, 2023, 99, pp.239-261. 10.1016/j.trf.2023.10.007 . hal-04276810

**HAL Id: hal-04276810**

**<https://univ-eiffel.hal.science/hal-04276810>**

Submitted on 9 Nov 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License



ELSEVIER

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

# Transportation Research Part F: Psychology and Behaviour

journal homepage: [www.elsevier.com/locate/trf](http://www.elsevier.com/locate/trf)

## UTAUT4-AV: An extension of the UTAUT model to study intention to use automated shuttles and the societal acceptance of different types of automated vehicles

Thierry Bellet<sup>a,\*</sup>, Aurélie Banet<sup>b</sup><sup>a</sup> Université Gustave Eiffel (LESCOT Laboratory), France<sup>b</sup> Université Gustave Eiffel (LMA Laboratory), France

## ARTICLE INFO

## Keywords:

Automated shuttles  
Automated vehicles  
Acceptance  
Intention to Use  
UTAUT model

## ABSTRACT

The aim of this study was to develop a model to analyse the acceptance of Automated Shuttles (AS) in order to predict and explain individuals' intentions to use and adopt this new type of automated vehicle. Based on a review of the literature, we proposed an extension of the widely used UTAUT model of Venkatesh et al. (2003), named UTAUT4-AV (for *Unified Theory of Acceptance and Use of Technology 4 [for] Automated Vehicles*) to specifically study AS acceptance. An online survey was conducted among a representative sample of 2,612 French citizens. From the processed data, it appears that UTAUT4-AV may explain 89% of the variance in the intention to use automated shuttles, which is 20–30% higher than existing models. This better explanatory power is likely due to the inclusion of new constructs related to the mean of transport currently used by the participants, whether in terms of satisfaction with this mode of transport or regarding mobility performance increasing thanks to AS. The inclusion of individual factors, such as attitudes towards new technologies and innovation, also contributed to this highest explanatory power. Moreover, the results obtained also show that UTAUT4-AV is robust enough to be applied to three other types of automated vehicles (i.e., Automated Cars, Robotaxis, and Autonomous Air Mobility Vehicles), with an ability to explain from 90% to 92% of the variance in the intention to use these other automated vehicles. Additional studies will be however required to evaluate the validity of the UTAUT4-AV model among populations of different countries or regarding acceptance of other types of new technologies, to support a better generalization of these results.

### 1. Introduction

#### 1.1. Context and objectives

This study focuses on the acceptance and the intention to use Automated Shuttles (AS) among a representative sample of French citizens. With the recent development of vehicle automation, a new range of mobility solutions based on automated and shared vehicles are currently emerging, and could soon radically change the way to travel. However, for this technological transformation to take place, it is crucial to consider the willingness of individuals to use such automated vehicles. Hence, it is essential to study the

\* Corresponding author.

E-mail address: [thierry.bellet@univ-eiffel.fr](mailto:thierry.bellet@univ-eiffel.fr) (T. Bellet).

<https://doi.org/10.1016/j.trf.2023.10.007>

Received 21 April 2023; Received in revised form 4 July 2023; Accepted 6 October 2023

Available online 29 October 2023

1369-8478/© 2023 The Author(s).

Published by Elsevier Ltd. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

Published by Elsevier Ltd. This is an open access article under the CC BY license

societal and individual acceptance of these new mobility options before their implementation on public roads. This matter is particularly important for AS since people will be constrained to use them if they are deployed to support public transportation systems, unlike other private automated vehicles that people are free to purchase and use.

This research takes place in a French research program called ENA (for *Expérimentation Navettes Autonomes*) aiming to deploy Automated Shuttles in France. The main objective of this study was to define a model based on existing literature about new technology acceptance however specifically tailored to AS and liable to predict and explain individuals' intention to use this new type of automated vehicles. Through this model, it is expected to identify the key factors and user characteristics that could influence the future adoption of AS from the users' perspective. Additionally, the aim was also to evaluate the robustness and generalizability of this new model across various types of Automated Vehicles (AV), by collecting additional data on their acceptance to support comparative analyses.

Given that autonomous shuttles were not available for public use at the beginning of this study, this research focuses on the *a priori* acceptance of this new mode of transportation (i.e., before their effective use; cf. Distler et al., 2018).

### 1.2. Theoretical models about acceptance of new technologies

Acceptance of a New Technology (NT) refers to the individual's attitudes, beliefs and judgments about the intention to use this new technology when available. According to the literature, there are two main models developed during the last decades to study the acceptance and adoption of a NT: the Technology Acceptance Model (TAM) of Davis et al (1989, 1992) and the Unified Theory of Acceptance and Use of Technology (UTAUT) proposed by Venkatesh et al (2003, 2012).

The TAM model is based on the Theory of Reasoned Action of Fishbein and Ajzen (1975) and argues that the behavioural "Intention to Use" (IU) a NT derives from the perception of two main functional qualities: (1) its "Perceived Usefulness", which is defined as "the degree to which a person believes that using this NT would enhance his or her performance", and the (2) perceived "Ease of Use", as "the degree to which a person believes that using a technology would be free of effort" (Davis, 1989, p. 319). According to the TAM, these two determinants directly influence the individual's "Attitude" towards the use behaviour of NT, which in turn determines the IU and then their "actual use". In other words, the more a technology is perceived as useful and easy to use by individuals, the more positive their attitude towards this NT will be, the higher their intention to use it will be, and the more likely they will, at last, actually use it. The TAM model has been applied to a wide variety of new technologies and consistently explains approximately 40% of the variance in individual's intention to use an information technology (Venkatesh et Davis, 2000). The TAM was later extended into TAM2 and then TAM3, including additional factors related to social influence and subjective norms. According to Venkatesh and Bala (2008), the TAM2, is able to explain from 34 to 52% of the variance in intention to use a NT (depending on when the questionnaire is administered), and the TAM3 would explain from 40 to 53% of this variance.

The UTAUT model was developed by Venkatesh et al (2003) as an expansion of the TAM by integrating several theories about user acceptance into a unified model (like the *Theory of Reasoned Action* of Fishbein and Ajzen [1975], the *Theory of Planned Behaviour* (TPB) of Ajzen [1991], the *Model of PC Utilization* of Thompson, Higgins, & Howell [1991], the *Motivational Model* of Davis, Bagozzi, & Warshaw [1992], the *Innovation Diffusion Theory* of Rogers [1995] and the *Social Cognitive Theory* of Compeau & Higgins [1995]). Synthetically, UTAUT assumes that the actual use of a new technology will depend of "Intentions to Use" the NT and "Facilitating Conditions" (i.e., external factors or resources that can affect the individual's ability to use a new technology, like its availability on the market, for instance). Moreover, the IU is in turn influenced by (1) the "Performance Expectancy" (quite similar to the perceived usefulness of the TAM model), defined by Venkatesh et al. (2003, p. 447) as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance", (2) the "Effort Expectancy" (quite similar to the perceived ease of use of the TAM), defined as "the degree of ease associated with use of the system" (p. 450), and (3) the "Social Influence", defined as "the degree to which an individual perceives that important others believe he or she should use the new system" (p. 451). The model also includes four individual's factors such as gender, age, experience with NT and voluntariness to use it (i.e. is this use *voluntary* against *constrained*), which can influence behavioural intentions and the actual use of the new technology.

According to Venkatesh et al (2003, p. 467), UTAUT could explain up to 70% of the variance in intention to use an information technology, and 50% of their actual use. However, to improve the model abilities to predict IU, Venkatesh et al (2012) proposed an extension of the model named UTAUT2 which includes three new constructs: Hedonic Motivation, Price Value and Habit. "Hedonic Motivations" is defined "as the fun or pleasure derived from using a technology" (p. 161). In the consumer context, this motivation has been found to directly influence the decision to purchase a new technology (e.g. Childers et al, 2001). Moreover, the hedonic quality of a NT is also an important factor in User eXperiences (UX) studies, where it is considered as a key support of "positive experiences" (as defined by Hassenzahl, 2001, 2008) and, in turn, of the technology acceptance and use. "Price Value" is related to the cost of the new technology and the value for money. This is defined by Venkatesh et al (p. 161) as a "cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them". Finally "Habit" is related to the individuals' experience of NT use (e.g. "the use of NT has become a habit for me" [p. 178]) and about the attitude towards this NT (e.g. "I am addicted to using it"; p. 178). In a study dedicated to acceptance of mobile internet, Rondan-Cataluna et al. (2015) found that UTAUT2 obtains a better explanatory power of 4.5% than the initial version of UTAUT.

While UTAUT is considered as a robust model to study users' acceptance of NT, it was initially developed in the context of information and communication technologies in organisations. However, recent studies have used (e.g. Kaye et al, 2020, comparing UTAUT and TPB to study acceptance of AV) or adapt this model in the specific frame of vehicle automation. It is typically the case of the CTAM model (*Car Technology Acceptance Model*) proposed by Osswald et al (2012) as an extension of TAM and UTAUT. Compared to UTAUT, these authors added four additional determinants of IU in the specific context of Automated Vehicles (AV) acceptance:

Perceived Safety, Anxiety, Self-Efficacy and Attitude towards using the AV technology. Osswald et al. (2012, pp. 54–55) defined “Perceived Safety” as the degree to which individuals believe that using the AV will affect their road safety and increase/reduce their risk of accident. “Attitude towards using AV” is defined as an individual’s overall affective reaction upon using this technology, while “Self-Efficacy” refers to a “person’s belief in his/her ability and competence to use a technology” like driving aid systems or automated vehicles, for instance. Finally, “Anxiety” is defined as the degree to which a person feels apprehensive or aroused by a situation or the use of AV.

Moreover, UTAUT was also recently used in the specific context of public transportation based on automated shuttles. In a first study implemented by Madigan et al. (2016) for the project CityMobile2, the initial version of the UTAUT was tested to study AS acceptance among a sample of 349 users. Given that existing studies had shown that the effect of facilitating conditions does not explain any variance in IU, they considered the factors *voluntariness* and *facilitating conditions* out of scope for their research about AS. The results obtained from this study indicate that three UTAUT constructs have a significant impact on the intention to use AS, with *Performance Expectancy* being the strongest predictor. This means that how well people believe the AS will perform is an important factor of acceptance. In addition, *Effort Expectancy* and *Social Influence* did have an impact as well, but more moderate. However, results of this study (i.e. linear regression analyses) showed that UTAUT only explained 22% of the variance of intentions to use automated shuttles. This indicates that this version of the model is not capturing all of the factors that influence individual’s IU of this new type of vehicles. Then, a 2nd study, building upon the findings of the first one, was conducted by Madigan et al (2017) by using this time the UTAUT2 model. The results obtained showed that Hedonic Motivations significantly increased the predictive power of the model, which was then able to explain up to 57.8% of the variance regarding UI of AS. In a complementary analysis of the same data (Nordhoff, Madigan, Happee et al, 2017), additional individual factors such as user’s profiles (car drivers vs. public transport users) and participants’ attitudes towards new technologies were also taken into account, leading to an even higher explanatory power of the model (up to 68.2%). Recent research by Farooq et al (2017) also identified attitude towards new technologies as an influencing factor of IU and proposed an extended version of the model (UTAUT3) that introduced *personal innovativeness*, which relates to individuals’ desire to test new technologies. Two recent studies based on UTAUT3 confirmed that such attitude towards NT significantly affects

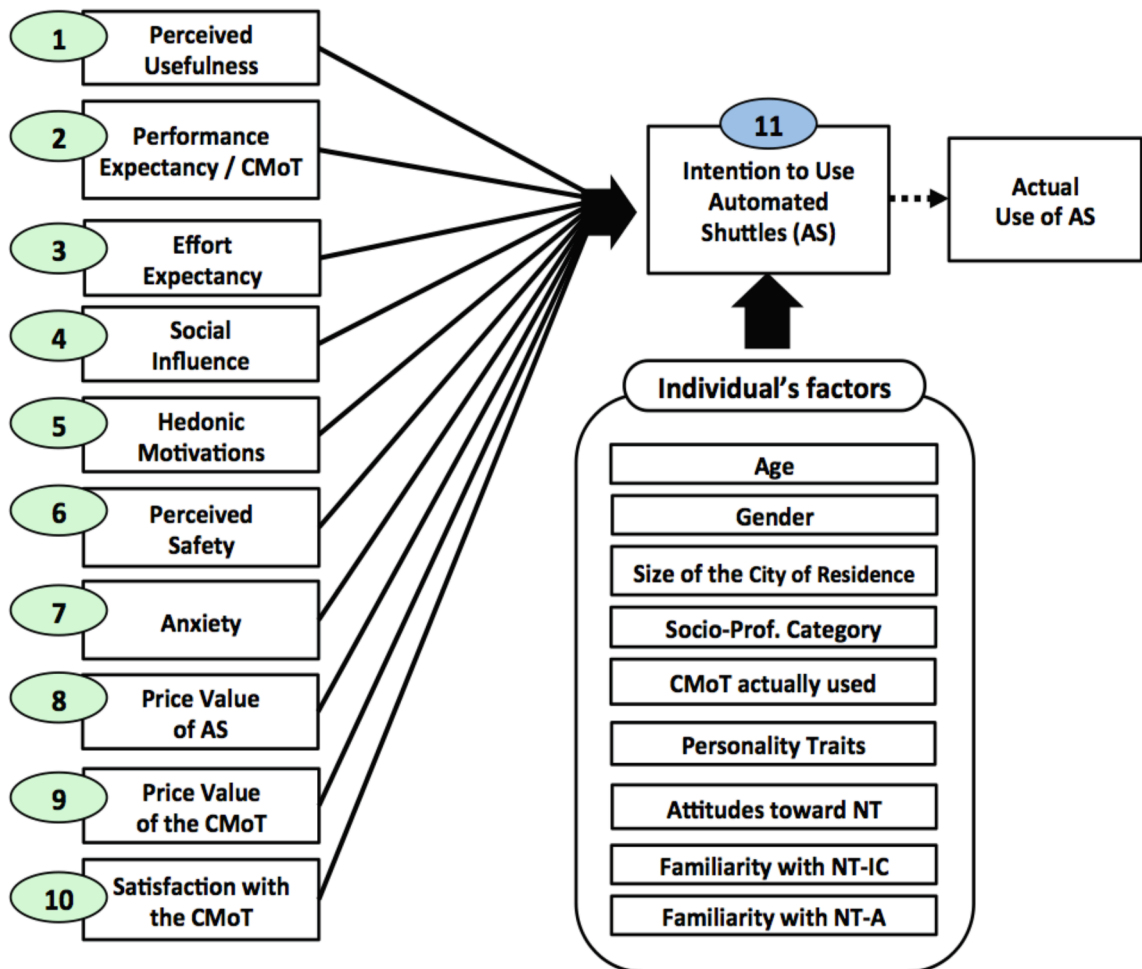


Fig. 1. UTAUT4-AV, an extension of the Unified Theory of Acceptance and Use of Technology for [i.e. “4”] application to Automated Vehicles.

intention to use NT dedicated to e-learning (Kamalaseena & Sirisena, 2021) and mobile technologies (Khan et al., 2022). Therefore, it seems relevant to consider “attitude towards NT and innovation” as a potential predictor of AS acceptance in this study.

### 1.3. A key limit of the existing acceptance models

Despite the many dimensions that have been considered to explain acceptance and intention to use new technologies, including automated vehicles, one important factor has been overlooked in previous studies and models: individuals’ satisfaction with the technology they currently use. In our study, this corresponds to participants’ satisfaction with the Current Mean of Transport (CMoT) actually used for their own mobility. While previous studies have considered mobility practices to profile participants, as proposed by Nordhoff et al. (2017), it is also important to understand to what extent a CMoT solution is well accepted and judged satisfactory by their users. We assume that the more satisfied users are with their CMoT, the less likely they should be to switch to an alternative solution like Automated Shuttles, and the less their intention to use AS. Conversely, if users are dissatisfied with their CMoT and/or expect a better performance of AS compared to this CMoT to support their mobility, they should be more likely to change to another mode of transportation, and therefore more likely to intend to use AS. To our knowledge, this issue has not yet been explored in the literature. This will be another original approach in our survey, proposing accordingly a new extension of UTAUT3 to UTAUT4.

### 1.4. UTAUT4-AV: An extension of the UTAUT model to study acceptance of automated shuttles and vehicle automation

In light of this literature review focused on existing acceptance models and their limitations, we propose an extension of the UTAUT model, named UTAUT4-AV (for Unified Theory of Acceptance and Use of Technology for [i.e. “4”] Automated Vehicles), to study acceptance of Automated Shuttles and other types of automated vehicles in a more comprehensive way. Fig. 1 provides an overview of this UTAUT4-AV model.

#### 1.4.1. Constructs of UTAUT4-AV and related hypotheses

The UTAUT4-AV model is made of 10 constructs that should influence the Intention to Use automated shuttles and other types of automated vehicles:

- 1) **Perceived Usefulness**: comes from the TAM model (Davis, 1989), and is focused on how users perceive the benefits of using automated shuttles to support their mobility in the future. This includes whether AS will be useful for their mobility practices, whether it will promote their autonomy, and whether AS will respond appropriately to their mobility needs. **As hypothesis (H1)**, it is expected that the more useful the AS is perceived, the higher their IU.
- 2) **Performance Expectancy compared to the Current Mean of Transport**: Performance Expectancy is a construct coming from the UTAUT that relates to how individuals assess the future performance of a new technology. Due to the close similarity between Performance Expectancy and the Perceived Usefulness of the TAM, they were combined in the UTAUT model (Venkatesh et al., 2003). However, we propose to adapt this construct in the UTAUT4-AV model by comparing the expected performance of AS to the perceived performance of the CMoT actually used by the participant. This will help determine whether AS meets participant’s mobility needs better or worse than their CMoT, whether they think it will be more efficient or provide a greater comfort. **As hypothesis (H2)**, it is assumed that the higher the perceived performances of the AS compared to the used CMoT will be expected, the higher the IU of AS.
- 3) **Effort Expectancy**: comes from the UTAUT model but is equivalent to Ease of Use in the TAM model. In this study, it refers to users’ estimation of the ease or difficulty they expect to experience in understanding and using shuttles, as well as the related learning efforts required to use them. **As hypothesis (H3)**, it is assumed that the higher the effort required to use AS is expected, the lower the IU of AS.
- 4) **Social Influence**: this construct refers to the theory of planned behaviour of Ajzen (1991) as integrated in UTAUT2. Synthetically, it refers to the influence of subjective norms and social pressure on the IU. One way to measure social influence is to ask individuals whether they think that people around them (like their family members, colleagues or friends) would be supportive of their use of AS, and/or whether their relatives’ use of AS would encourage them to also use these vehicles. Social influence also refers to the self-image and the value that using an AS may represent for the individual. Several studies, such as Bansal et al. (2016), Liu et al. (2018), and Panagiotopoulos and Dimitrakopoulos (2018), pointed out peers’ experience or opinions on individual’s acceptance of automated vehicles. **As hypothesis (H4)**, we assume that the more favourable peers will be towards the use of AS and the higher the value of that use is positive for individuals (in their own eyes and those of their relatives), the higher the intention to use AS.
- 5) **Hedonic Motivations**: the origin of this construct is the second version of UTAUT2 (Venkatesh et al., 2012), but it is also a key factor considered for the evaluation of technological innovations in UX design (e.g. Hassenzahl, 2001; 2008). Synthetically, hedonic motivations refer to the pleasure that the use of AS could bring, as well as to the entertaining, playful or enjoying dimensions that could be provided by the interaction with this new type of vehicle. **As hypothesis (H5)**, it is expected that the more positive the hedonic motivations toward AS, the higher their IU.
- 6) **Perceived Safety**: missing in the TAM and UTAUT models, this dimension seems however particularly important in the context of AS and vehicle automation acceptance. This construct was introduced in the CTAM (Osswald et al., 2012). The question here is whether individuals will trust automated shuttles to ensure their safety, and whether they believe that using AS will be risk-free regarding road safety. **As hypothesis (H6)**, it is assumed that the higher the perceived safety of AS, the higher their IU.

- 7) **Anxiety towards the use of AS:** this construct also comes from the CTAM model and relates in UTAUT4-AV to a negative affect or a source of concerns about the use of AS and/or the absence of a human driver on board. As **hypothesis (H7)**, the more the use of AS or the lack of human driver on board will be a source of worries, the lower the intention to use AS.
- 8) **Price Value of the AS:** this construct was introduced by Venkatesh et al (2012) in the UTAUT2 model. Price Value refers in UTAUT4-AV to the travel cost estimation (i.e. “cheapness”) and the “value for money of AS” in terms of mobility offer. As **hypothesis (H8)**, it is expected that the higher the price value of AS will be perceived, the higher the intention to use them.
- 9) **Price Value of the CMoT:** From our point of view, the price value of AS is only one side of the coin and should also be compared to the price value of the CMoT actually used by the participant. To be really attractive and to motivate individuals to change of Mean of Transport, the AS price value should be assessed as better than the price value of the CMoT. As **hypothesis H9**, it is assumed that the higher the price value of the CMoT will be assessed, the lower the intention to use AS.
- 10) **Satisfaction with the CMoT:** unlike the other constructs extracted or tailored from the acceptance models of the literature, this construct is a totally new factor introduced by UTAUT4-AV. We believe that the existing models do not adequately address the issue of users’ satisfaction (or dissatisfaction) with their CMoT in terms of how well it meets their mobility needs, and how efficient, comfortable, enjoyable, and safe it is. This factor may influence their willingness to switch to an alternative solution like AS for their mobility. As **hypothesis (H10)**, we assume that the higher the satisfaction with the CMoT, the lower the IU of AS.

#### 1.4.2. Individual’s factors liable to impact acceptance of AS and related hypotheses

In addition to the 10 preceding constructs aiming at explaining the intention to use AS, the UTAUT4-AV model also assumes the existence of two main types of individual factors liable to impact AS acceptance: socio-demographic factors and users’ profiles.

##### (A) Socio-demographic factors:

- (1) **Age:** while the effect of age on the IU of New Technologies of Information and Communication is well established in the literature (younger people being more inclined to use and adopt them than elderly people), the results are more contrasted regarding acceptance of NT for Automotive: some studies shown that younger people are more open toward automated vehicles than seniors (e.g., Schoettle and Sivak 2014; Hulse et al, 2018; Shabanpour et al, 2018; Liu et al, 2019), although other are more contrasted in this respect (Kyriakidis et al, 2015; Nordhoff et al, 2018a, b). However, as **hypothesis (H11)** we assume that younger people will be more inclined than older to accept and use automated shuttles or other types of AVs.
- (2) **Gender:** Several studies shown a higher interest and intention to use or purchase an automated vehicle among men than women (e.g., Zmud, Sener, & Wagner, 2016; Piao et al, 2016; Hohenberger, Spörrle, & Welpel, 2016; Robertson et al 2017; Hulse et al, 2018; Acheampong & Cugurullo, 2019). As **hypothesis (H12)**, it is assumed that IU of AS should be higher for men than for women.
- (3) **Socio-Professional Category (SPC):** as far as we know, no study has really dealt with the impact of SPC on the intention to use Automated Vehicles, except the work of Hudson et al (2019) who showed a more limited interest for AV among unemployed or retired people, against a higher interest from people with a professional activity related to driving (such as truck or cab drivers). Despite this lack of the literature, we believe that it is interesting to consider this question in the framework of this study, according to the difference of mobility needs of “active” individuals (e.g., employed or students) and “inactive” individuals (e.g., retired). As **hypothesis (H13)**, we assumed that IU of AS should be higher for people in activity (employed or students) than for inactive individuals like retired.
- (4) **Size of the city of residence:** Given the diversity of the territories studied in the ENA project, it was relevant to examine how the place of residence would influence individuals’ intention to use automated shuttles, with a specific focus on the size of the city in which they are living. Although only a few studies have explored this relationship, it seems that residents of urban areas have a higher interest for vehicle automation than those living in suburban areas (Regan et al., 2017; Hudson et al., 2019). Moreover, the perceived usefulness of AS is also higher among inner-city residents compared to suburban inhabitants (Bansal et al, 2016; Lee and Mirman, 2018). Therefore, we **hypothesize (H14)** that individuals living in larger cities would be more likely to adopt AS than people living in small cities and/or in rural areas.

##### (B) Users Profiling Factors:

- (5) **Current Mean of Transport (CMoT)** actually used (i.e. private car, public transports, or other modes like bicycle or walking). In accordance with Nordhoff et al (2017) results, it is **hypothesized (H15)** that regular users of public transports should have a more positive acceptance of AS than car drivers, for whom the use of AS would represent a radical change in their mobility practices.
- (6) **Attitudes towards New Technologies (NT) and innovation** seems also being a relevant factor to consider, as recently considered in the literature related to AS acceptance (Nordhoff et al, 2017), or dedicated to the *personal innovativeness* introduced in the UTAUT3 (Farooq et al, 2017). As **hypothesis (H16)**, we assume that the more participants have a positive attitude towards new technologies and innovation, the more Automated Shuttles should be assessed as attractive, and the higher the intention to use them.
- (7) **Familiarity with NT of Information and Communication** (NT-IC), like computer, mobile phone or smartphone. At this level, it is **hypothesized (H17)** that the more familiar peoples are with NT-IC, the less apprehensive they should be toward using AS, and the higher their intention to use AS should be.
- (8) **Familiarity with NT for Automotive** (NT-A), corresponding to different driving assistance systems (from information systems, such as navigation aids, to advanced driving assistances based on vehicle automation, like speed regulators or lane keeping

assistants). As for the previous hypothesis related to NT-IC, the more familiar participants are with NT-A, the less apprehensive they should be about using AS, and the higher should be their IU of AS (H18).

- (9) Finally, some **Personality Traits** were identified in the literature as liable to influence the acceptance of automated vehicles. It is more particularly the case for sensation seeking and attitudes toward risk (e.g. Payre et al, 2014; Payre, 2015). In this respect, it is assumed that sensation-seekers could be more likely to use AS, because of their higher interest for experiencing new situations and sensations (H19).

In accordance of the different components of the UTAUT4-AV model (i.e. the 10 constructs of the model completed by the 9 individual's factors), the three objectives of the survey implemented for this study will be (1) to identify which factors actually influence the IU of automated shuttles, (2) to evaluate the explanatory power of this extended version of the UTAUT model to study acceptance of AS, and then (3) to explore the robustness of UTAUT4-AV when applied to different types of automated vehicles.

## 2. Method

The survey implemented for this study consists of 6 complementary questionnaires, comprising a total of 166 items divided into 3 main blocks: socio-demographic factors (12 items), the acceptance questionnaire based on the 11 constructs of UTAUT4-AV (32 items, with 4 replications of 24 of them to explore the acceptance of 4 different types of automated vehicles), and a set of other individual profiling factors (50 items). Data were collected online, via a personal computer or a smartphone. During the pre-tests carried out to validate the questionnaire among a sample of 18 participants, the mean time taken to complete the survey was of 30 min, ranged from 21 (achieved by a young man of 22 years old who was highly familiar with completing online surveys using his smartphone) to 43 min (achieved by an elderly woman of 82 years old, who was unfamiliar with online surveys, and who completed the questionnaire from her personal computer).

### 2.1. Questionnaires of the survey

#### 2.1.1. The socio-demographic questionnaire (12 items)

This questionnaire aims to collect participants' characteristics in terms of age, gender, socio-professional category, French Region and size of the city of residence. These data were also used to check the representativeness of the sample of French Citizens involved in this study.

#### 2.1.2. The UTAUT4-AV acceptance questionnaire (32 items)

The UTAUT4-AV acceptance questionnaire as a whole is based on 32 items (presented in Appendix A.1): 29 of them are focused on the 10 potential determinants of Intention to Use Automated Shuttles, which is assessed through 3 additional items. This acceptance questionnaire was administrated 4 times, in order to collect participant's opinion on AS and then about 3 other types of Automated Vehicles: Automated Car (private), Robotaxi, and Autonomous Air Mobility Vehicles (both shared). Once the questionnaire was completed for a given vehicle (like AS), the participant cannot go back and compare their new answers (e.g. for automated car) with the previous one. Therefore, responses for each questionnaire replication were completed independently.

All these acceptance items were collected from 0 to 100 continuous scales supported by the Visual Analogue user Interface presented in Fig. 2, based on Chimi et Russell's (2009) recommendations. For each item (e.g. "Automated Shuttles would improve my mobility and increase my autonomy" or "Using an AS would make my travel enjoyable"), participants were asked to move a slider along the visual scale for providing a numerical value ranging from 0 (i.e., "Fully Disagree") to 100 (i.e., "Fully Agree"). The visual scale uses percentage as the measurement unit, and the value associated with the slider position is displayed to the participant on the interface. By default, the slider is positioned in the middle of the scale (i.e. 50%).

To provide their answers, participants received the following instructions:

« To provide your answer, you have to move the slider on the « 0–100 » scale:

- « 100 » means that you are « Fully Agree » with the proposal.
- « 0 » means that you are « Fully Disagree » with the proposal.
- If you are « Rather Agree », your answer should be a value from 51 to 99%.
- If you are « Rather Disagree », your answer should be a value from 49 to 1%.
- The slider cannot stay on 50: it is mandatory to move it for validating your answer » (This last choice was made to avoid that some participants automatically validate their response without considering the proposal).

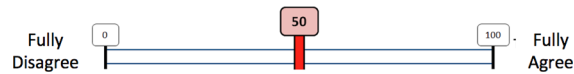


Fig. 2. Visual Analogue Scales (ranging from 0 to 100) used for the survey.

The motivation for using such 0–100 scales for this on-line survey, instead of the more commonly used 5 or 7-point Likert scales in human sciences, was to collect individual's assessments expressed as continuous numerical values, that are better suited for statistical analyses that rely on standard linear procedures such as factorial analyses or linear regressions (Chimi and Russell, 2009; Yusoff and Mohd Janor, 2014, Bellet et al, 2018).<sup>1</sup> Mathematically speaking, thanks to the continuous metric based on the % unit, it is possible to implement parametric tests, including for only one item.<sup>2</sup>

Moreover, continuous scales using a visual analogue interface are now widely used for web-based questionnaires and online surveys (e.g. Funke and Reips, 2012). In a comparative study, Yusoff and Mohd Janor (2014) also shown that 0–100 scales (p.13) “performed better than data from 7-point Likert scales in terms of number of items per construct, factor loadings, squared multiple correlations, higher internal reliability, higher internal consistency of the items representing a construct, and higher percentage of variance explained by the items in a construct”.

Finally, continuous scales based on a visual interface are also more user-friendly and attractive to respondents, who find them easy to understand and use, without the need for complicated explanations or training (Guyatt et al., 1987; Dolnicar and Grun, 2007; Stone and Stenner, 2012; Bellet et al., 2018). This usability issue was particularly important for the long online survey used in this study, because it was needed to take care about participant's demotivation factors (Yusoff and Mohd Janor, 2012). Therefore, a visual interface based on a slider was chosen to increase the attractiveness of the online survey.

### 2.1.3. Questionnaires about other individual profiling factors (50 items)

This part of the survey comprises the following 5 complementary questionnaires related to:

- (A) **Attitudes towards New Technologies and Innovation** (presented in Appendix A.2): 12 items, also collected from the Fig. 2 continuous Likert scales, ranging from 0 (*fully disagree*) to 100 (*fully agree*).
- (B) **Familiarity with New Technologies of Information and Communication (NT-IC)**: 11 items related to the actual use and the frequency of use of 5 NT-ICs (i.e., personal computer, smartphone, web, emails and social networks).
- (C) **Familiarity with New Technologies for Automotive (NT-A)**: 13 items related to the actual use and the frequency of use of 6 different driving aid systems (Navigation System, Blind Spot Detection, Automated Parking System, Automated Cruise Control, Automatic Emergency Braking, and Lane Keeping Assistant).
- (D) **Current Mean of Transport actually used (CMoT)**: 10 items related to the main means of transport currently used (i.e., types of CMoT and frequency of use).
- (E) **Personality traits related to Sensation Seeking and risk acceptance**: to categorize the participants according to their personality traits, they were asked to rate their level of agreement with the following four sentences using continuous Likert scales (cf. Fig. 2) ranged from 0 (*fully disagree*) to 100 (*fully agree*):

*“In a general way, I consider myself to be someone who....*

*Prof1) ... is a sensation seeker and enjoys thrill-seeking,*

*Prof2) ... likes unexpected situations and improvisation,*

*Prof3) ... is a risk taker,*

*Prof4) ... often worry about my health and my safety.*

## 2.2. Participants involved and sample representativeness

On-line data collection was carried out from October to December 2020. A total of 2,612 persons participated to this survey (1,252 males and 1,360 females). For legal issues, all the participants were aged of 18 years old and more.

The sample of participants was formed on the basis of 5 demographic criteria: age, gender, socio-professional category, size of the

<sup>1</sup> As highlighted by Chimi et Russell (2009): « *the fundamental problem with Likert-type item is the response they generate qualitative data consisting of a count of responses in each category. The resulting analysis is inherently limited, primarily to a frequency table, typically with relative and cumulative relative frequencies computed. Summary statistics can only be inferred using expectancies, and then only if there is some numeric basis for the each response category; however the assumption is often made that the Likert item is interval in nature, and estimated means are commonly computed. It is our argument that this assumption is incorrect. The data generated by an instrument based on Likert items simply cannot be subjected to the more robust, more powerful and more subtle analyses available with quantitative data* ».

<sup>2</sup> The existence of a standardized metric associated with a scale of 5 or 7 points is questionable, especially when associated with semantic values. For instance, is the distance between “Partially Agree” and “Fully Agree” equivalent to the distance between “Partially Disagree” and “Fully Disagree”? Moreover, how similar are the use of semantics like “Moderately” versus “Partially”? And how much these semantic alternatives will impact the assumed underlying metric, when associated with “Agree” or “Disagree”?



city of residence and French area of residence (i.e. among the 5 French “Regions”). The quotas used to ensure the representativeness of the sample were based on the INSEE statistical data for the year 2020 (i.e. French National Institute of Statistics and Economic Studies). Table 1 shows the representativeness of the sample, in comparison with the distribution of the French population (aged of 18 + ) according to the INSEE data.

### 3. Results

#### 3.1. Evaluations of the reliability of the UTAUT4-AV constructs

To check the internal consistency of UTAUT4-AV constructs, a test of homogeneity of the variables (i.e. Cronbach’s Alpha) was implemented to the items of the acceptance questionnaire. In case of a Cronbach’s  $\alpha$  of less than 0.70, part of items has been removed to increase the homogeneity of the related construct.

Results presented in Table 2 show the good reliability (from 0.701 to 0.945) for the 11 constructs of the UTAUT4-AV model (when Effort-AS 3 is removed).

#### 3.2. Individual’s profiling according to their attitude towards new technologies

The questionnaire presented in appendix A.2 was used to categorise the participants according to their attitudes towards New Technologies and Innovation. From the data collected, a Principal Component Analysis (PCA) was implemented. The results obtained are presented in Table 3 and permit to identify 3 main components that cumulatively explain 68.23% of the variance (the KMO index validates the factorial solution and Bartlett’s test of sphericity is significant at a risk of 5)

From these PCA results, it is thus possible to distinguish 3 contrasted “individual profiles” according to their attitudes towards new technologies and innovation:

- 1) “**Technophile**” (Component 1 of the PCA, from NT1 to NT5), corresponding to people who have a positive attitude towards NT (NT are important for them and contribute to their social image). The Cronbach’s  $\alpha$  for these 5 items is 0.913.
- 2) “**Technophobe**” (Component 2 of the PCA, from NT6 to NT9), corresponding to people who are conversely reluctant towards NT use (NT are frighten them and their use is a source of worry). Cronbach’s  $\alpha$  of 0.89 for these 4 items.

**Table 1**  
Representativeness of the sample (compared to INSEE data).

Socio-demographic categories		N =	%	Distribution of the French population (according to the INSEE census on 01/01/2020)
		2,612		
Gender	Men	1,252	47.90%	48.35%
	Women	1,360	52.10%	51.65%
Age	18–24 years old	260	10%	10.25%
	25–34 years old	383	14.70%	14.72%
	35–44 years old	456	17.50%	15.75%
	45–54 years old	427	16.30%	16.92%
	55–64 years old	413	15.80%	16.04%
	65 and more years old	673	25.80%	26.32%
City Size	Less than 2,000 inhabitants	514	19.70%	22%
	From 2,000 to 19,999 inhabitants	463	17.70%	17%
	From 20,000 à 99,999 inhabitants	386	14.80%	14%
	100,000 inhabitants and more (Paris excluded)	774	29.60%	29%
	Parisian agglomeration	475	18.20%	18%
Area of Residence (i.e. 5 French “Regions”)	<i>Ile-de-France</i> (i.e. Parisian area)	518	19.80%	18.90%
	<i>Nord-Ouest</i> (Normandie, Bretagne, Pays de Loire, Centre-Val de Loire)	522	20%	20%
	<i>Nord-Est</i> (Hauts-de-France, Grand-Est, Bourgogne-Franche-Comté)	561	21.50%	22%
	<i>Sud-Ouest</i> (Nouvelle Aquitaine, Occitanie)	502	19.20%	18.40%
	<i>Sud-Est</i> (Auvergne-Rhône-Alpes, PACA, Corse)	509	19.49%	20.70%
CSP (Socio-professional category)	Employed	1,339	50.90%	54.60%
	Without any professional activity (unemployed and persons without any professional activity, including long term Sick Leave [SL], not taken into account by INSEE)	272 (42)	10.40% (including 1.6% SL)	5.10% (SL: information not available)
	Students, pupils, or people in training	203	7.80%	7.80%
	Retired	798	30.60%	32.50%

**Table 2**  
Consistency of the UTAUT4-AV model constructs.

UTAUT4-AV Constructs (31 items*)	Consistency (Cronbach's $\alpha$ )
Perceived Usefulness (3 items)	0.945
Performance Expectancy of AS compared to the CMoT (3 items)	0.943
Social Influence (3 items)	0.855
Effort Expectancy (2 items only: <i>Effort-AS3*</i> was removed, because of the inconsistency of this construct with the 3 initial items)	0.701
Hedonic Motivations (3 items)	0.923
Perceived Safety (2 items)	0.894
Anxiety (2 items)	0.742
Price Value of the AS (2 items)	0.855
Price Value of the CMoT (2 items):	0.831
Satisfaction with the CMoT (6 items)	0.919
Intention to Use the AS (3 items)	0.922

**Table 3**  
Principal Component Analysis (PCA) applied to the 12 items of the “Attitude Towards New Technologies and Innovation” questionnaire.

Items of the questionnaire “Attitudes towards NT and Innovation”	Components		
	1	2	3
NT1. I know more than others about new products and the latest innovations in new technologies	0.860	0.014	0.159
NT2. I usually try new technologies before my friends or relatives	0.851	-0.001	0.137
NT3. Owning or using the latest technological innovations makes me feel good in my own eyes and in the eyes of others	0.844	0.084	0.179
NT4. I often buy new technologies, even if they are expensive	0.828	0.041	0.225
NT5. I value the new technologies I buy or use, as they contribute to my image and social identity	0.801	0.007	0.262
NT6. With the new technologies, I feel like I don't have full control over what I do	0.017	0.849	0.008
NT7. I am suspicious about new technologies because they do not always protect my privacy	-0.133	0.825	0.075
NT8. New technologies frighten me	0.118	0.806	-0.140
NT9. If I could, I would not use NT, but I am constrained by to use them by the society	0.117	0.781	-0.245
NT10. New technologies are useful to me in my daily life	0.166	-0.169	0.819
NT11. I could not carry out my daily activities (personal or professional) without using new NT	0.240	0.037	0.754
NT12. New technologies improve living conditions	0.354	-0.134	0.658

3) “**Techno-Pragmatic**” (Component 3 of the PCA, from NT10 to NT12), corresponding to people having a neutral attitude towards NT but who are frequently using them in their everyday life, and who are also convinced of their usefulness. Cronbach’s  $\alpha$  of 0.793 for these 3 items.

According to these 3 different profiles, we can update our initial **Hypothesis H16** (cf. 1.4.2). On the one hand (**H16a**), the more individuals are “Technophobe”, the lower their IU of shuttles. Conversely (**H16b**), the more individuals are “Technophile” or “Techno-pragmatic”, the highest their intention to use AS.

**Table 4**  
Regression table to explain the Intention to Use Automated Shuttles (N = 2,612).

Regression table ( $R^2 = 0.891$ )			
Coefficients (Dependent Variable: Intention to Use AS)			
Model 1	Standardized $\beta$ Coefficients	t	Sig.
(Constant)		4.316	0.000
Perceived Usefulness	0.347	19.936	0.000
Hedonic Motivations	0.221	14.395	0.000
Performance Expectancy compared to the CMoT	0.199	11.462	0.000
Social Influence	0.133	10.633	0.000
Perceived Safety	0.088	6.189	0.000
Price Value of the AS	0.041	4.085	0.000
Effort Expectancy	0.020	2.378	0.017
Satisfaction with the CMoT	-0.036	-5.167	0.000
Price Value of the CMoT	-0.020	-2.846	0.004
Anxiety toward the use of AS	-0.017	-1.292	0.018

3.3. Individual’s profiling regarding sensation seeking

From the statistical analysis of data collected with the personality traits questionnaire (cf. Section 2.3), no consistency was found between the 4 initial items. However, a good reliability was found for 2 of them ( $\alpha = 0.701$ ), which are directly related to the *sensation seeking* concept as defined by Zuckerman (1996):

“ In a general way, I consider myself to be someone who....

- Prof1) .... is a sensation seeker liking thrill-seeking,
- Prof2)..... likes unexpected situations and the improvisation.

3.4. Linear regression analysis to explain the intention to use automated shuttles

To identify the predictors of the IU of AS (i.e. dependent variable), we performed a linear regression analysis by implementing a one-way procedure, using SPSS IBM Statistics version 26. The 10 independent variables composing the UTAUT4-AV model were integrated simultaneously. The results are presented in the regression Table 4.

The first result to be highlighted here is that the regression model applied to the UTAUT4-AV constructs explains 89.1% of the IU of Automated Shuttles. This result means that the 10 constructs contribute significantly, to a greater or lesser extent, to the explanation of the variance of the IU of AS.

In this respect, it is nevertheless necessary to distinguish two groups of constructs, i.e. those contributing positively and those influencing negatively to the Intention to Use AS. On the one hand, we observe a significant positive contribution for the following constructs (in order of importance): Perceived Usefulness, Hedonic Motivations, Performance Expectancy, Social Influence, Perceived

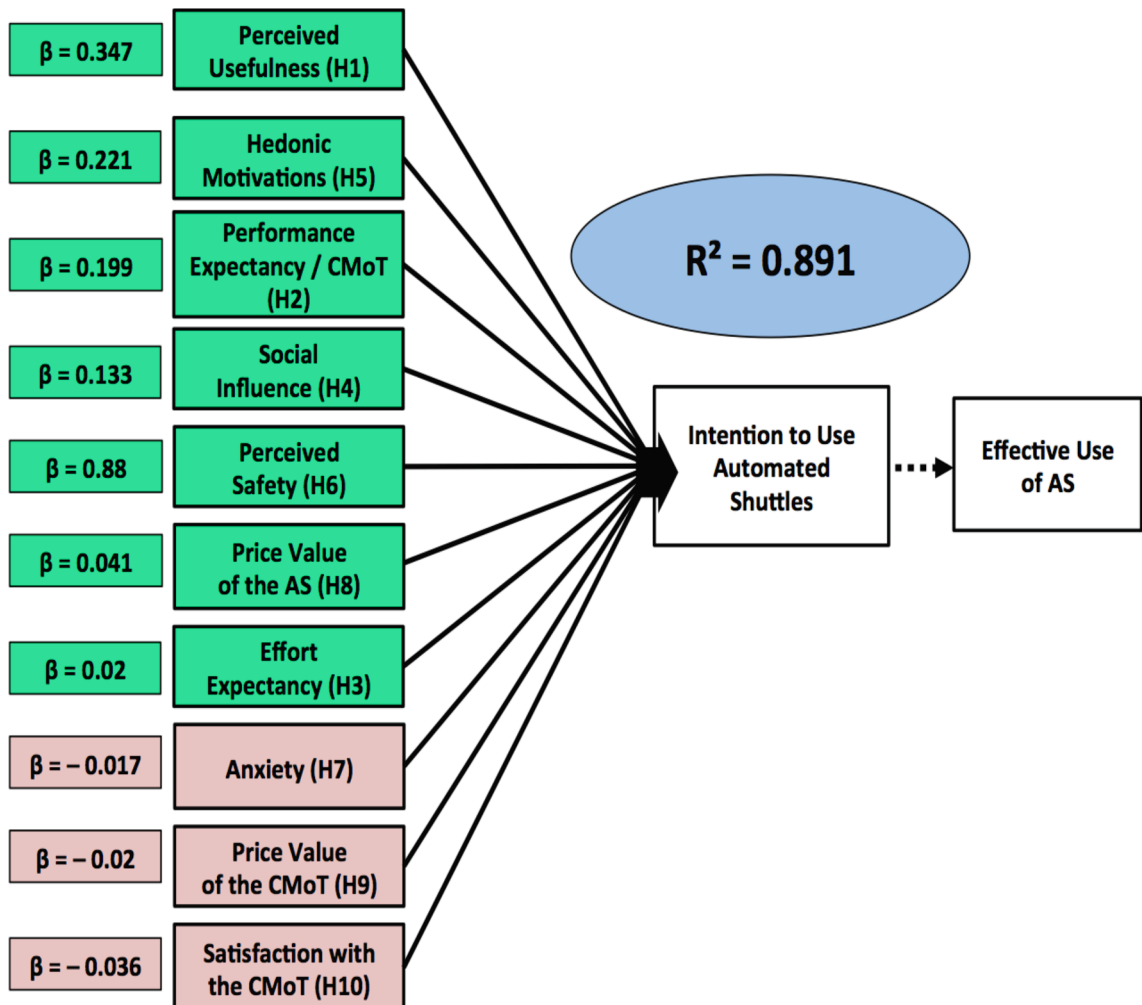


Fig. 3. UTAUT4-AV ability to explain Intention to Use Automated Shuttles.

Safety and finally, in a more moderate way, Price Value of the AS and Effort Expectancy. Thus, for this set of constructs, the more positive judgments, the higher the intention to use AS. These results allow us to validate 6 of our initial hypotheses formulated in 1.4.1, aimed at identifying the factors of UTAUT4-AV that positively influence the intention to use automated shuttles: H1, H2, H4, H5, H6 and H8.

On the other hand, 3 constructs have a negative influence on the IU of AS: Satisfaction with the CMoT, Price Value of the CMoT and Anxiety towards the use of AS. The more positive participants are about these 3 dimensions, the lower their intention to use AS. These results allow us to validate 3 of our initial hypotheses (H7, H9 and H10) related to the factors of the UTAUT4-AV model that negatively influence the Intention to Use Automated Shuttles.

Finally, the only one hypothesis that is not validated concerns Effort Expectancy. As hypothesis H3, it was assumed that the highest the effort to use AS, the lower the IU. Regression analysis results show the contrary for automated shuttles.

Fig. 3 summarizes these findings and schematically presents the UTAUT4-AV acceptance model as it has been validated from this study in its ability to explain the Intention to Use Automated Shuttles (values of standardised  $\beta$  coefficients come from the Table 4).

### 3.5. Individual's factors influencing the intention to use automated shuttles

Individual factors refer to the different user profiles, whether in (1) their Attitudes towards New Technologies and innovation (i.e. “Technophobe”, “Technophile” and “Techno-pragmatic” profiles), (2) their familiarity with New Technologies of Information and Communication or (3) related to Vehicle Automation, (4) their “Transport User” profiles (i.e. private car drivers, users of public transports, or using other modes of mobility) or (5) their personality traits as “Sensation Seeker”.

To assess the influence and the respective weights of these eleven individual factors on the Intention to Use AS (i.e., dependent variable), a two-step hierarchical linear regression was implemented. In step 1 of the analysis, the 11 independent variables (corresponding to the individual factors) were entered simultaneously. Then, as a 2nd step, the 10 constructs of the UTAUT4-AV model were introduced also simultaneously, to evaluate the joint influence of the individual factors and the UTAUT4-AV constructs on the IU of AS.

Results are presented in the Table 5. The cells coloured in green correspond to the factors that positively contribute to explain the intention to use AS. The cells coloured in red correspond to the factors that have a negative influence on this IU. Finally, the white cells

**Table 5**  
Hierarchical regression analysis (2 steps) to study the effect of Individual factors and UTAUT4-AV constructs on Intention to Use AS.

Model		Standardised $\beta$ coefficients Step 1	Standardised $\beta$ coefficients Step 2	R <sup>2</sup>	$\Delta$ R <sup>2</sup>
Step 1	<i>Introduction of Individual's factors:</i>			0.242***	0.242***
	Age	-0.042***	-0.040***		
	Gender	-0.018	-0.010		
	Socio-Professional Categories (from <i>Employed</i> [1] and <i>Students</i> [2] to <i>Unemployed</i> [3] and <i>Retired</i> [4])	-0.047***	-0.003		
	City size (from -2000 to Paris agglom.)	0.107***	-0.008		
	CMoT (from “private car” to “public transports”, through “other modes”)	0.089***	-0.009		
	Personality trait: “Sensation Seeker”	0.088***	0.001		
	Technophile profile	0.263***	0.026***		
	Techno-pragmatic profile	0.113***	0.018***		
	Technophobe profile	-0.087***	-0.027***		
	Familiarity with NT-IC	-0.031	-0.009		
	Familiarity with NT-A	0.063***	0.001		
Step 2	<i>Introduction of UTAUT4-AV Constructs:</i>			0.894***	0.652***
	Perceived Usefulness		0.348***		
	Hedonic Motivations		0.217***		
	Performance Expectancy of AS / CMoT		0.211***		
	Social Influence		0.119***		
	Perceived Safety		0.092***		
	Price Value of the AS		0.033***		
	Effort Expectancy		0.017*		
	Satisfaction with the CMoT		-0.032**		
	Anxiety		-0.021*		
	Price Value of the CMoT		-0.017*		

a. Dependent Variable: Intention to Use AS  
\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$

indicate the absence of a significant effect on the IU. When the cells associated with the same factor are coloured differently depending on the step (from “green” in step 1 to “white” in step 2, for instance), this means that the influence of this factor on the IU is different at either step.

Focusing on the results obtained at the step 1, it appears that the eleven individual’s factors introduced explain 24.2% of the variance of the intention to use AS.

Six of them positively influence the IU. From the most to the least impacting, these factors are the size of the city of residence, the Mean of Transport currently used, the Sensation Seeking personality trait, the Familiarity with NT for Automotive and, at last but not least, attitudes towards new technologies in terms of “Technophile” and “Techno-pragmatic” profiles). This first set of results validates 5 of our initial hypotheses: H14, H15, H16b, H18 and H19.

Conversely, three factors have a negative influence on the intention to use AS: Age, Socio-Professional Category, and the “Technophobe” profile. This second set of results validates 3 of our hypotheses: H11, H13 and H16a.

Finally two of them, Gender and Familiarity with NT-IC, have no influence on the IU. Thus, Hypotheses H12 and H17 are rejected regarding the linear regression results.

However, many of these variables lost their predictive power when the variables of the 10 constructs of UTAUT4-AV model are integrated at the 2nd step of the hierarchical regression analysis (because their effect is “absorbed” by the 10 other constructs introduced at step 2). In fact, only 4 of these individuals’ factors remain to influence the intention to use automated shuttles at step 2: Age, Technophobe, Technophile and Techno-Pragmatic profiles.

From this set of findings, it is possible to complete the UTAUT4-AV model by adding the individual factors investigated in this study, as summarized in Fig. 4 (values of standardised  $\beta$  coefficients come from the Table 5; i.e., “step 1” for individual’s factors and “step 2” for UTAUT4-AV constructs).

Although personal factors related to socio-demographic characteristics (except age) no longer contribute to the IU in Step 2 of the

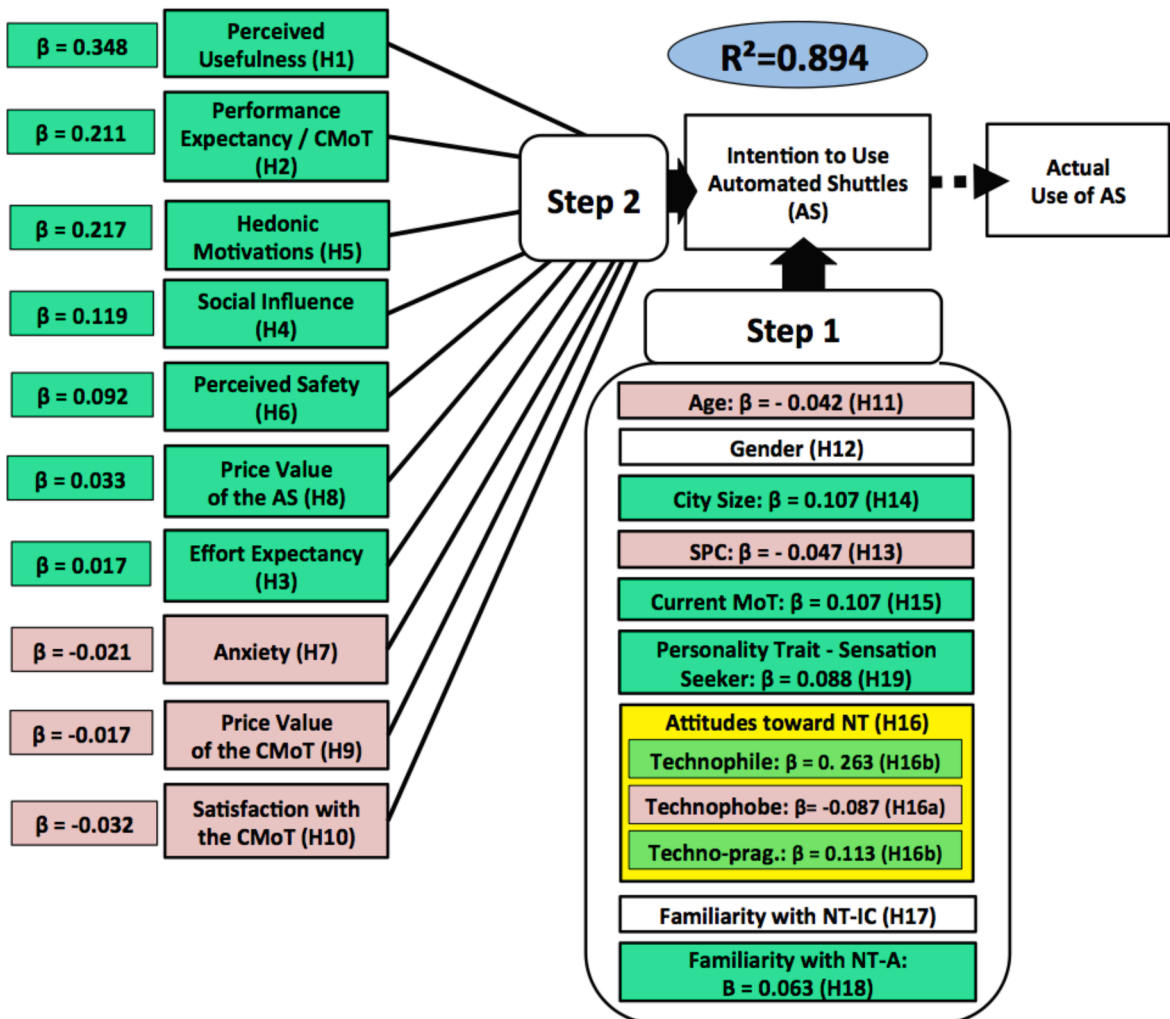


Fig. 4. UTAUT4-AV model, including individual factors effects on IU (at step1 and 2).

hierarchical regression analysis, additional statistical analyses may be implemented to explore potential significant differences according to the gender, the Socio-Professional Categories, the type of Mean of Transport currently used, and the size on the city of residence. They will be presented in the next section.

### 3.6. Intention to use automated shuttles: Opinions and profiling of the French citizens

#### 3.6.1. General results about the French citizens' acceptance of automated shuttles

When considering the distribution of French citizens according to their *a priori* Intention to Use automated shuttles (Fig. 5), it appears that almost half of the participants (48%) have a positive judgement about the use of AS for their own mobility (IU scoring  $\geq 60/100$ ), 15% have a “neutral” opinion (IU between [40 and 60]), and one third (37%) are more “negative” towards this intention of use AS (IU less than 40/100).

#### 3.6.2. Profiles of users most “favourable” versus “reluctant” to use shuttles

To further investigate the acceptance of AS according to the socio-demographic characteristics of the participants and the mean of transport they currently use, a set of parametric tests were implemented (using the IBM SPSS Statistics 26.0 statistical processing software).

For the “Gender” variable (Table 6), it appears that men are significantly more likely to use AS than women (Student’s *t*-test). This result confirms hypothesis H12.

For the other socio-demographic variables, results of the analyses of variance (ANOVA, associated with Bonferroni post-hoc tests) presented in Table 7 show several significant differences according to the participants’ characteristics:

- 1) **Age:** people of 18 to 44 years old have the highest intention to use AS, and people aged of 65 years and more are the most reluctant to this idea. These results confirm hypothesis H11.
- 2) **Socio-Professional Categories:** Retired people are significantly more reluctant to use shuttles than the other groups (employed, students or unemployed). With the exception of the unemployed, this result confirms hypothesis H13.
- 3) **Mean of Transport currently used:** drivers of private cars have a significantly lower intention to use AS than the other groups. In contrast, public transport users have the highest IU of AS. These results confirm hypothesis H15.
- 4) **Size of the City of residence:** people who live in the Paris metropolitan area are more interested in using AS than the other groups. In addition, people living in smaller cities are less likely to use AS. Finally, residents of large cities with more than 100,000 inhabitants have an intermediate opinion. These results confirm hypothesis H14.

#### 3.6.3. Extreme “Personas” regarding intention to use automated shuttles

Similar statistical analyses based on the socio-demographic characteristics of the participants were also carried out for all the constructs of the UTAUT4-AV model (i.e., not only for the Intention to Use AS), and they made possible to identify two extreme profiles or “Personas” (cf. Cooper, 1999) of users, according to their level of acceptance of automated shuttles (Fig. 6).

On the one side, participants who are most “favourable” towards the use of AS are younger (aged from 25 to 44 years), use public transports while being moderately satisfied with this mean of transport, are employed, live in a large city (+100,000 inhabitants) or in the Paris metropolitan area, and are more “Technophiles”.

At the other end of the spectrum, corresponding to the profile of participants who are most “reluctant” to use automated shuttles, we find the oldest individuals (aged 65 and over), retired, private car drivers who are highly satisfied with this mean of transport, living in small agglomerations with fewer than 2,000 inhabitants, particularly in rural areas, and are more “Technophobes”.

### 3.7. Consolidation of the UTAUT4-AV model to explain the intention to use of different types of automated vehicles

To assess the explanatory power of the UTAUT4-AV model and support its generalization to different types of automated vehicles,

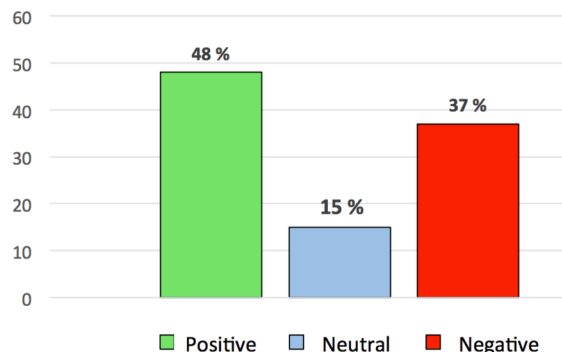


Fig. 5. Percentage of the French citizens having a “Positive”, a “neutral” or a “Negative” attitude towards the use of Automated Shuttles.

**Table 6**  
gender differences regarding the Intention to Use AS.

	Gender	N	Mean	S.D.	Significance ( <i>Student t test</i> )
Intention to Use Automated Shuttles	Men	1,252	53.12	30.24	t(2610) = 3.512 ; p = 0.000
	Women	1,360	48.95	30.34	

**Table 7**  
Socio-demographic differences regarding the Intention to Use AS.

Construct: IU of AS	Socio-demographic characteristics	N	Mean	S. D.	Significance	
					Post-hoc test (Bonferroni)	Anova
Age	18-24 years old	260	57.47	25.03	≠ 55-64 & +65	F(5, 2606)= 39.130 ; η²=0.000
	25-34 years old	383	60.48	25.69	≠ 45-54 & 55-64 & +65	
	35-44 years old	456	59.29	28.82	≠ 45-54 & 55-64 & +65	
	45-54 years old	427	50.82	30.4	≠ 25-34 & 35-44 & +65	
	55-64 years old	413	47.23	31.9	≠ 18-24 & 25-34 & 35-44 & +65	
	65 and more	673	39.73	30.69	≠ All other groups	
	<b>Mean for All</b>	2,612	50.95	30.36		
Socio-Professional Categories	Socio-Prof. Categories	N	Mean	S. D.	Significance	
	Employed	1,339	55.88	29.53	Post-hoc test (Bonferroni)	Anova
	Students	203	58.91	23.66	No Sig. difference between these groups	
	Unemployed	272	52.89	29.06	F(3,2608)= 54.698 ; η²=0.000	
	Retired	798	40	30.78	≠ All other groups	
	<b>Mean for All</b>	2,612	50.95	30.36		
Mean of Transport currently used (CMoT)	CMoT	N	Mean	S. D.	Significance	
	Individual Car	1,811	47.28	30.49	Post-hoc test (Bonferroni)	Anova
	Public Transports	492	61.55	26.83	≠ All other groups	
	Other Modes	309	55.56	30.35	≠ All other groups	
	<b>Mean for All</b>	2,612	50.95	30.36	F(2,2609)= 48.487 ; η²=0.000	
Size of the City of residence	City Size	N	Mean	S. D.	Significance	
	Less than 2,000 inhabit.	514	43.96	30.92	Post-hoc test (Bonferroni)	Anova
	from 2,000 to 20,000	463	46.76	29.97	≠ +100,000 city & Paris	
	from 20,000 to 99,999	386	47.59	30.01	F(4,2607)= 28.170; η²=0.000	
	+ 100,000 inhabitants	774	52.93	29.49	≠ All other groups	
	Paris Metropolitan Area	475	62.10	28.38	≠ All other groups	
	<b>Mean for All</b>	2,612	50.95	30.36		

we performed the same statistical analyses as we did for automated shuttles. This included checking the homogeneity of variables for each construct followed by linear regression analyses, but this time applied to the data collected for acceptance of (1) Automated Cars, (2) Robotaxis, and (3) Autonomous Air Mobility Vehicles, respectively. Table 8 summarizes the final results of the regression analyses obtained for these 4 types of AVs (results for Automated Shuttles come from Table 4).

The first result to be highlighted is that UTAUT4-AV constructs may explain from 89.1% to 92% of the variance in the Intention to Use Automated Vehicles, depending on the type of AV. These high scores confirm and validate the UTAUT4-AV model for studying the acceptance of AVs in general, and its ability to explain their respective IU in particular.

If we now consider the results in a more detailed way, we can distinguish 3 groups of constructs, according to their influences on the intention to use of AVs:

- 1) Seven constructs contribute positively to this IU for all the 4 types of AVs (cells coloured in green in the Table 8).
- 2) Three constructs (Anxiety, Satisfaction with the CMoT and Price Value of the CMoT), contribute negatively to the IU for some AVs (cells coloured in red), or have no impact for the others (white cells).
- 3) One construct, Effort Expectancy, contributes positively for AS and Robotaxi, negatively for Automated Car, and has no impact on the IU for autonomous AMV.

Finally, these results allow us to validate the following initial hypotheses (cf. 1.4.1) related to the influence of the UTAUT4-AV constructs on the Intention to Use, respectively, the different types of Automated Vehicles:



Fig. 6. Extreme profiles (i.e. Personas) of the French citizens with the highest versus the Lowest Intention to Use Automated Shuttles.

1) **For the Automated Shuttle:** 9 of the 10 initial hypotheses are validated. The only one that is not validated is H3 related to the influence of Effort Expectancy on Intention to Use AS (a significant positive effect is observed, against a negative effect initially assumed).



**Table 8**  
Regression Analyses to explain IU of different types of Automated Vehicles.

UTAUT4-AV Constructs	IU of AV (i.e. dependante variable) (Significance : * $p < 0,05$ , ** $p < 0,001$ )			
	Automated Shuttle $R^2 = 0,891$	Automated Car $R^2 = 0,901$	Robotaxi $R^2 = 0,908$	Autonomous Air Mobility Vehicle $R^2 = 0,92$
Perceived Usefulness	0.347**	0.33**	0.338**	0.513**
Performance Expectancy compared to CMoT	0.199**	0.27**	0.261**	0.116**
Hedonic Motivations	0.221**	0.228**	0.141**	0.077**
Social Influence	0.133**	0.098**	0.152**	0.128**
Perceived Safety	0.088**	0.113**	0.108**	0.13**
Price Value of the AV	0.041**	0.055**	0.037**	0.045**
Effort Expectancy	0.020*	- 0.018*	0.041**	- 0.004
Anxiety	- 0.017*	- 0.028*	- 0.001	- 0.033**
Satisfaction with CMoT	- 0.036**	- 0.011	- 0.019*	- 0.011
Price Value of the CMoT	- 0.020*	- 0.023*	- 0.004	- 0.009

a. Dependent Variable: Intention to Use AS  
\*  $p < .05$ ; \*\*  $p < .001$

a. Dependent Variable: Intention to Use AS.

\*  $p < .05$ ; \*\*  $p < .001$ .

- 2) **For the private Automated Car:** 9 of the 10 hypotheses are validated. The only one that is not validated is H10 related to the influence of the Satisfaction with the CMoT on Intention to Use AC (i.e. no influence of this factor on the IU for AC).
- 3) **For the Robotaxi:** 7 of the 10 hypotheses are validated, and 3 are not: hypotheses H7 (Anxiety) and H9 (Price Value of the CMoT), because we have no impact of these constructs on the IU of the Robotaxi, and H3 (Effort Expectancy), which has a positive influence on the IU, against a negative effect initially assumed.
- 4) **For the Autonomous Air Mobility Vehicle:** 7 of the 10 hypotheses are validated and 3 are not (because no effect of these constructs on the IU): hypotheses H3 (Effort Expectancy), H9 (Price Value of the CMoT) and H10 (Satisfaction with the CMoT).

#### 4. Discussion

The objective of this study was to propose a model that accurately explains individuals’ intentions to use Automated Shuttles, a new type of automated vehicle, by adapting the existing literature on New Technology acceptance. To achieve this objective, we proposed an extension of the widely used Unified Theory of Acceptance and Use of Technology model of Venkatesh et al (2003, 2008, 2012) specifically tailored to AS *a priori* acceptance (i.e. before their effective use; Distler et al., 2018).

Through this new model, called UTAUT4-AV, we aimed to identify the key factors and user characteristics that may influence the future adoption of AS from the users’ perspective. Furthermore, the aim was also to evaluate the robustness of UTAUT4-AV for different types of Automated Vehicles, and thereby proposing a more comprehensive model that can be applied to the acceptance of all types of AVs.

Data collected from the online survey implemented among a representative sample of 2,612 French citizens were used to explore the validity and the explanatory power of this extended version of the UTAUT model. In this aim, we successively examined (1) the reliability of the UTAUT4-AV constructs, (2) the model’s ability to explain the intention to use automated shuttles, (3) the impact of individual factors, and (4) the UTAUT4-AV’s robustness to study acceptance of other types of automated vehicles.

##### 4.1. Consistency and reliability of the UTAUT4-AV model constructs

Regarding the 11 constructs of UTAUT4-AV, all of them have a sufficient consistency to validate their homogeneity (according to Cronbach, 1951):

- 1) Five constructs have an *Excellent* reliability ( $\alpha$  coefficient greater than 0.90): Perceived Usefulness, Performance Expectancy compared to the CMoT, Hedonic Motivations, Satisfaction with the CMoT and Intention to Use the AS.
- 2) Four constructs have a *Good* reliability: Perceived Safety, Social Influence, Price Value of the AS, and Price Value of the CMoT.
- 3) Two constructs have an *Acceptable* reliability: Anxiety towards the use of AS and Effort Expectancy.

In addition, regarding individual factors, a new set of reliable constructs impacting the intention to use AS has been also identified, including 1 focused on the personality trait of *Sensation Seeking*, and 3 related to the individual’s Attitudes towards New Technologies and Innovation, i.e. *Technophobe*, *Technophile*, and *Techno-pragmatic*.

#### 4.2. Explanation of intention to use automated shuttles from the UTAUT4-AV constructs

Linear regression analyses presented in Table 4 allowed us to validate 9 of the 10 initial hypotheses formulated in Section 1.4.1. In short, 6 constructs of UTAUT4-AV positively contribute to the Intention to Use shuttles: Perceived Usefulness, Hedonic Motivations, Performance Expectancy compared to the CMoT, Social Influence, Perceived Safety, and Price Value of the AS. For these 6 factors, the more positive judgments individuals make, the higher their IU of AS. These findings confirm 6 of our initial Hypotheses (H1, H2, H4, H5, H6 and H8). On the other side, 3 constructs negatively influence the Intention to Use AS: Satisfaction with the CMoT, Anxiety and Price Value of the CMoT. For these 3 factors, the more the participants have a positive opinion, the lower their Intention to Use AS. These findings confirm our initial hypotheses H7, H9 and H10. Finally, only the hypothesis H3 is not confirmed in this study, as there is a positive influence of Effort Expectancy in Intention to Use AS. However, it is worth noting that the average level of Effort Expectancy is very low for a large part of the population (25.13/100, S.D. 25.53), meaning that most French people believe that using AS will be very easy. Therefore, the difficulty to use did not appear to be a barrier to the IU of AS, and people with a higher intention to use AS are willing to make an effort to use them because the effort required is assessed as moderate.

Moreover, by examining the  $\beta$  coefficients provided by the regression analysis for each one of the 10 constructs of UTAUT4-AV to explain the IU (Table 4), it is also possible to rank the effect of these different factors. Ultimately, the three main factors that have the highest impact on the intention to use automated shuttles ( $\beta$  coefficient from 0.2 to 0.35) are Perceived Usefulness, Hedonic Motivations and Performance Expectancy compared to the Current Mean of Transport. The other UTAUT4-AV constructs also have a significant effect, although to a more moderate extent.

Finally, another important finding from the linear regression analyses applied to the constructs of the UTAUT4-AV is that the model may explain 89.1% of the variance in the Intention to Use AS. This explanatory power is 20–30% higher than that of existing models, such as the UTAUT2 applied to AS acceptance by Madigan et al. (2017) and Nordhoff et al. (2017). This finding suggests that the UTAUT4-AV model includes more constructs that significantly contribute to the explanation of the variance in the Intention to Use AS, even if some of them do so only modestly. Additionally, UTAUT4-AV also considers the benefits of AS in two complementary ways: as the perceived usefulness of this new mode of transport, but also as an expected opportunity to increase individuals' mobility performances compared to the mean of transport they currently used, both highly impacting the intention to use automated shuttles. Overall, with an explanation power of the IU of AS close to 90%, we can conclude that this new version of the UTAUT model takes into account a large part of the factors liable to influence the acceptance of this new type of automated vehicles.

#### 4.3. Impact of individual factors on the intention to use automated shuttles

The inclusion of individual's factors improves the predictive power of the UTAUT4-AV model for the intention to use automated shuttles, although this improvement is limited to 0.3% ( $R^2 = 0.894$ ). This limited impact is due to the strength of the other UTAUT4-AV constructs, which alone explain more than 89% of the variance in the IU. However, from the hierarchical regression analysis results presented in Table 5, it was possible to investigate the respective effects of the individual factors investigated in this study. Five factors significantly contribute to explain the IU of AS at the first stage of the regression: Socio-Professional categories, CMoT used, size of the city of residence, familiarity with driving aid systems, and sensation seeking personality trait. These results validate 5 of the initial hypotheses assumed in 1.4.2: H13, H14, H15, H18, and H19. However, their impact is then absorbed at step 2 by the stronger effect of the 10 UTAUT4AV constructs.

Per contrast, 4 individual factors have a more resilient effect and continue to impact the intention to use AS at the 2nd stage of the linear regression: "Age", which has a negative influence on the IU (meaning that the older the user, the less likely they are to use AS), and the 3 profiles related to "Attitudes towards new technologies", namely the "Technophobe" profile (contributing negatively to the IU of AS and thus indicating that individuals who are more technophobic will be more reluctant to use AS), the "Technophile" and the "Techno-pragmatic" profiles (both contributing positively, meaning that individuals with a positive or a pragmatic attitude towards New Technologies and innovation are more likely to use AS). These results validate 3 of our hypotheses: H11 (cf. 1.4.2), H16a and H16b (cf. 3.3). Resilient effect at step 2 of the regression analysis of this 4 factors also confirm earlier findings that attitudinal factors are generally better predictors of the acceptance and use of AVs than socio-demographic factors, except age (e.g., Nordhoff et al, 2018a, b; Sener et al., 2019; Rahim et al., 2023).

Finally, although personal factors related to socio-demographic characteristics (except age) no longer contribute to the IU in Step 2 of the hierarchical regression analysis, it is worth noting that comparative statistical analyses presented in Tables 6 and 7 shown several significant differences according to gender, age, socio-professional categories, type of CMoT used, and size on the city of residence. In addition, we also identified (Fig. 6) two extreme individual's profiles according to their acceptance of AS: on the one hand, young residents (25–44 years old) of large cities, employed, technophiles and using public transports as main CMoT, who are the most favourable towards the use of AS and, on the other hand, older people (65 years old and more), retired, technophobes, living in rural areas and using a private car as CMoT, who are conversely more reluctant to use this new type of automated vehicle.

#### 4.4. UTAUT4-AV robustness and generalisation to other types of automated vehicles

The results of the linear regression analyses presented in Table 8 show that the UTAUT4-AV model can explain from 89.1% (for Automated Shuttle) to 92% (for autonomous Air Mobility Vehicle) of the variance in the intention to use Automated Vehicles. These high levels of explanatory power for the three other types of AVs reinforce the findings obtained from UTAUT4-AV regarding automated shuttle and support a generalisation of the model to study the acceptance of various types of AVs in a comprehensive way.

If we now consider the results in more detail, we can distinguish 3 groups of UTAUT4-AV constructs based on their influences on the Intention to Use AVs.

Firstly, 6 constructs have a significant positive influence on the intention to use AVs (organised according the importance of their effect on the IU from the values of  $\beta$  coefficients presented in the Table 8): (1) *Perceived Usefulness* which is undoubtedly the most influencing factor on the intention to use AVs and explaining a large part of the variance in the IU of autonomous Air Mobility Vehicles, (2) *Performance Expectancy compared to the Current Mean of Transport* whose effect on the Intention to Use is significant for all the types of AVs, although more limited for the autonomous Air Mobility Vehicle, (3) *Hedonic Motivations* more impactful for the Automated Shuttle and the Automated Car than for the other two vehicles, (4) *Social Influence* which is slightly less impactful for the Automated Car, (5) *Perceived Safety* which is less impactful for the AS and more impactful for the autonomous Air Mobility Vehicle, and (6) *Price Value of the AV*, which contributes more modestly to the IU than the 5 other previous factors. For these 6 constructs, the more individuals make positive judgments about them (i.e., the more the AV is perceived as useful, capable of highest performances compared to the currently used mean of transport, a source of pleasure, accepted by peers, safe, and with a good value for money), the higher their intention to use the automated vehicle will be.

Secondly, 3 constructs have a negative impact (generally significant, but always modest) on the intention to use automated vehicles: (1) *Anxiety* towards the use of the AV whose effect remains moderate and does not significantly influence the IU for the Robotaxi, (2) *Satisfaction with the Current Mean of Transport* whose effect is also moderate and that does not significantly influence the IU for the Automated Car and the Autonomous Air Mobility Vehicle, and (3) *Price Value of the Current Mean of Transport* which has a moderate influence on the IU for the Automated Shuttle and the Automated Car, but having no significant effect for the Robotaxi and the autonomous Air Mobility Vehicle. For these three constructs, the more positively individuals judge them (i.e. the more anxious the use of the AV is perceived, the more satisfactory the Current Mean of Transport is judged and the better the price value of this CMoT is perceived), the lower their intention to use the considered automated vehicle will be.

Finally, the last construct is “*Effort Expectancy*”. This factor is similar to TAM’s “*Ease of Use*” (Davis, 1989) or Nielsen’s “*Perceived Usability*” (1994). It has a limited and fluctuating influence on the Intention to Use AVs, contributing alternately negatively for the Shuttle and the Robotaxi, and positively for the Automated Car, while not contributing significantly to the IU for the autonomous Air Mobility Vehicle. Although the influence of this factor on the intention to use is limited, it may indicate that the “*Ease of Use*” is more important for AC than for AS and AMV or, alternatively, it may suggest that “*Effort Expectancy*” is not a significant barrier towards the use for AS or AMV, but could be for the Automated Car. However, the respective effects of this factor, whether negative or positive, still very moderate in this study for all types of AVs.

Moreover, according to the  $\beta$  coefficients provided by the regression analysis for each one of the 10 constructs of UTAUT4-AV to explain the Intention to Use automated vehicles (presented in Table 8), it is also possible to rank the effect of these different factors, as summarized in Fig. 7: those having a high ( $\beta$  from 0.2 to 0.51), a medium ( $\beta$  of 0.077 to 0.152) and a low ( $\beta$  less than 0.056) positive influence, against those having no significant effect or a low negative influence ( $\beta$  from  $-0.017$  to  $-0.036$ ).

Based on the presented and discussed results, we can conclude that UTAUT4-AV seems to be a reliable model for predicting the acceptance of different types of automated vehicles. Fig. 7 provides an overview of this model as updated from the main findings of this study regarding UTAUT4-AV’s ability to explain the Intention to Use various types of AVs.

## 5. Conclusion: Main findings, limitations and perspectives

The objective of this study was to propose a model able to explain individuals’ intentions to use Automated Shuttles by tailoring the UTAUT model of Venkatesh et al (2003, 2008, 2012) to this new type of vehicles. We gathered data from an online survey implemented among a representative sample of 2,612 French citizens, which allowed us to evaluate an extended version of the UTAUT model to study AV acceptance. Linear regression analyses showed that UTAUT4-AV model is capable to explain 89.1% of the variance in the intention to use automated shuttles. This is 20–30% higher than other existing models such as UTAUT2 used by Madigan et al. (2017) and Nordhoff et al. (2017). This better explanatory power may be explained by the inclusion of 3 constructs related to the Mean of Transport currently used in terms of satisfaction towards it, mobility performance increasing thanks to automated shuttles, and price value. The inclusion of individual factors like attitudes towards new technologies and innovation also significantly contributed to this highest explanatory power.

Additionally, we confirmed that UTAUT4-AV is robust enough to be applied to various automated vehicles. Like for AS, linear regression analyses indicate that this model may explain from 90% to 92% of the variance in the intention to use Automated Cars, Robotaxis, and autonomous Air Mobility Vehicles. All these findings suggest that UTAUT4-AV provides a more comprehensive model for explaining people’s acceptance of AVs in general, compared to existing models in the literature.

One limitation of this study is that the UTAUT4-AV model has only been validated among a sample of French citizens, and its validity in other countries cannot be assumed. Public opinion on automated driving may vary by country (Schoettle and Sivak, 2014; Kyriakidis et al., 2015). Indeed, as Kaye et al. (2020, p. 7) pointed out in a recent study on automated car acceptance among Australians, Swedes, and French people, perceptions of AVs may differ across countries: « *Individuals residing in France reported significantly greater intentions to use highly automated cars when they become publicly available compared to individuals residing in Australia and Sweden*” (p.7) although, continue the authors, “*it is not known why participants in France reported significantly greater intentions to use automated cars*”. In this perspective, conducting an international survey should be necessary to evaluate the validity of the UTAUT4-AV model among different populations, and thus required for a better generalization of our results.

Another limitation of this study is that UTAUT4-AV has only been validated for investigating the intention to use automated vehicles, while UTAUT model has been extensively validated to study acceptance of various types of technology (Venkatesh et al., 2016).

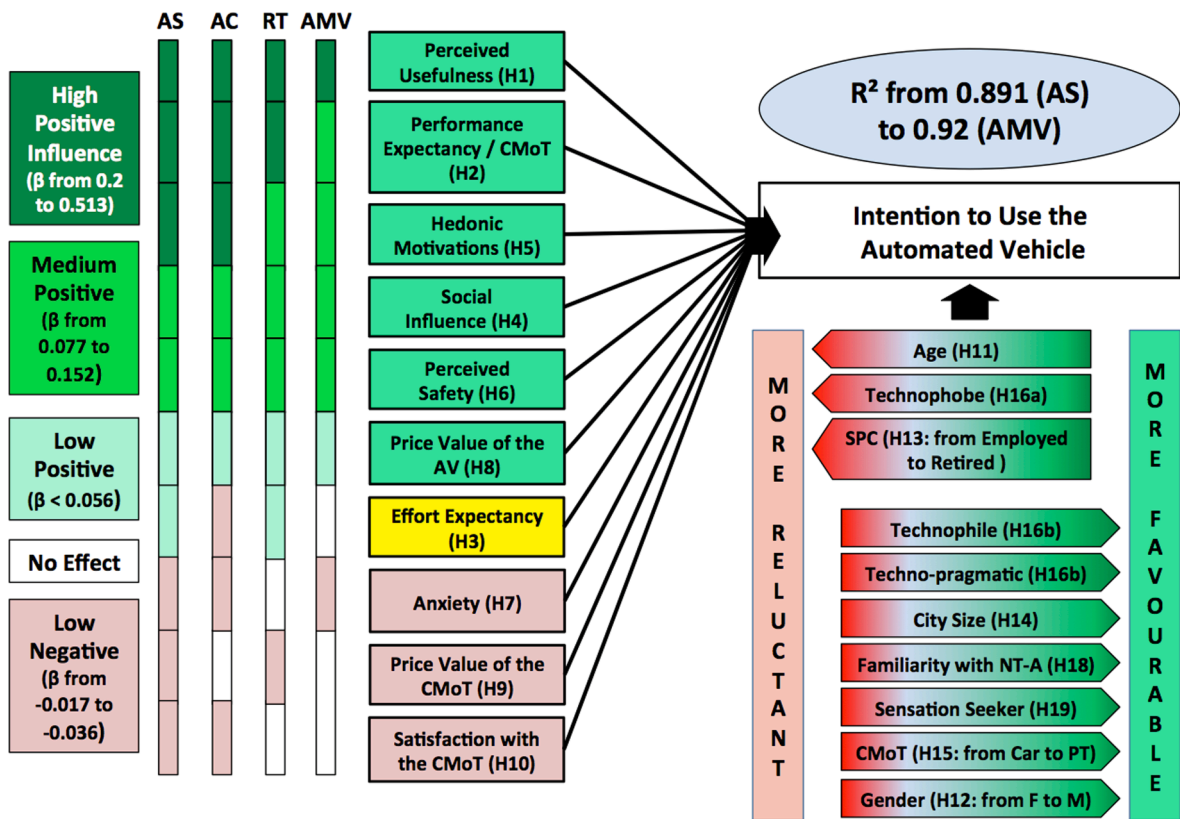


Fig. 7. Consolidated version of UTAUT4-AV to study acceptance of different types of AVs (β values come from Table 8).

Therefore, it is important to determine whether UTAUT4-AV is a relevant extension for studying acceptance of other new technologies, and whether it can truly become a fourth version of the UTAUT theory, continuing the incremental approach of previous UTAUT1, 2, and 3 versions, in order to progress towards a more comprehensive model of users' acceptance. To address this issue, additional studies would be required - by tailoring accordingly the questionnaire presented in Appendix A.2 - to investigate the acceptance of other types of NT, such as smartphones, computers, or web services, for instance. This would be needed to explore the validity of UTAUT4-AV in other domains.

**Ethics statement**

Before its on-line implementation, the survey was reviewed and approved by the Ethical committee of the University Gustave Eiffel.

**Declaration of Competing Interest**

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

**Data availability**

The authors do not have permission to share data.

**Acknowledgement**

This study was preformed in the frame of the French national research project EVRA-ENA. This project was funded by the French Government as part of the "Programme d'investissements d'avenir", now part of "France 2030", and was operated by ADEME. It was also labelled by the CARA European Cluster for Mobility Solutions.

## Appendix A. UTAUT4-AV questionnaires

### A.1. UTAUT4-AV acceptance questionnaire (11 constructs and 32 items)

#### A.1.1. English version

---

#### UTAUT4-AV Constructs (32 Items)

---

##### Perceived Usefulness (3 items):

- PU-AS 1) Automated Shuttles (AS) would be useful in my daily mobility
- PU-AS 2) AS would improve my mobility and increase my autonomy
- PU-AS 3) AS would meet my personal mobility needs well

##### Performance Expectancy compared the Current Mean of Transport (3 items):

- PE/CMoT-AS 1) Compared to my CMoT, an AS would meet my personal mobility needs better
- PE/CMoT-AS 2) Compared to my CMoT, an AS would be a more efficient / faster
- PE/CMoT-AS 3) Compared to my CMoT, an AS would be more comfortable

##### Effort Expectancy (or Perceived Ease of Use): 3 items

- Effort-AS 1) It would be difficult for me to understand how to use an AS
- Effort -AS 2) It would take a lot of time and effort for me to learn how to use an AS
- Effort -AS 3) To know how to use an AS, I would need someone to help me or to explain how to do so

##### Social Influence (3 items):

- SI-AS 1) People around me (relatives, family or friends) think that I should use an AS
- SI-AS 2) I would be more likely to use an AS if my friends and family also used it
- I-AS 3) Using an AS would make me proud, in my own eyes and towards the others

##### Hedonic Motivations (3 items):

- HM-AS 1) Using an AS would be a source of pleasure
- HM-AS 2) Interaction with AS would be fun
- HM-AS 3) Using an AS would make my travel enjoyable

##### Perceived Safety (2 items):

- Safe-AS 1) AS would make my travel safe and risk free
- Safe-AS 2) I would trust in AS technology to ensure my safety

##### Anxiety (2 items):

- Anx-AS 1) I have concerns/worries about using an AS
- Anx-AS 2) I would definitely refuse to use an AS if there is no human driver on board

##### Price Value of AS (2 items):

- PV-AS 1) The use of an AS would be cheap
- PV-AS 2) AS would offer a good value for money, in terms of mobility

##### Price Value of CMoT (2 items):

- PV-CMoT 1) My CMoT is cheap
- PV-CMoT 2) My CMoT offers a good value for money, in terms of mobility

##### Satisfaction toward the CMoT (6 items):

- Sat\_CMOT.1) I am satisfied with the use of this CMoT
- Sat\_CMOT.2) This CMoT meets my personal mobility needs well
- Sat\_CMOT.3) This CMoT is efficient / fast
- Sat\_CMOT.4) This CMoT is enjoyable
- Sat\_CMOT 5) This CMoT is comfortable
- Sat\_CMOT.6) I trust in this CMoT to ensure my safety

##### Intention to Use an AS (3 items):

- IU-AS 1) I would like to use an AS for my daily travels
  - IU-AS 2) If I could, I would change my CMoT for an AS
  - IU-AS 3) I would be satisfied with the use of an AS for my mobility
-

## A.1.2. Original French version

**UTAUT4-AV Construits (32 Items)****Utilité Perçue (3 items):**

- PU-AS 1) *Je pense que les Navettes Autonomes (NA) me seraient utiles dans mes pratiques personnelles de mobilité*
- PU-AS 2) *Les NA pourraient améliorer ma mobilité et accroître mon autonomie*
- PU-AS 3) *Je pense que les NA répondraient bien à mes besoins personnels de mobilité*

**Attente de Performance, comparativement au Moyen de Transport (MdT) utilisé Actuellement (3 items):**

- E/CMoT-AS 1) *Les NA répondraient mieux à mes besoins de mobilités que le(s) moyen(s) de transport que j'utilise actuellement*
- PE/CMoT-AS 2) *Les NA seraient un moyen plus efficace / rapide que les moyens de transports que j'utilise actuellement pour me déplacer*
- PE/CMoT-AS 3) *L'utilisation des NA pour mes déplacements serait plus confortable que la manière dont je me déplace actuellement*

**Attente d'Effort (ou Utilité Perçue): 3 items**

- Effort-AS 1) *Je pense qu'il me serait difficile de comprendre comment utiliser une NA*
- Effort -AS 2) *Cela me demanderait beaucoup de temps et d'efforts pour apprendre à utiliser une NA*
- Effort -AS 3) *Pour savoir comment utiliser une NA, il faudrait que quelqu'un m'aide ou m'explique comment faire*

**Influence Sociale (3 items):**

- SI-AS 1) *Je pense que mon entourage (proches, famille, amis) serait favorable à ce que j'utilise les NA*
- SI-AS 2) *Je serais plus enclin à utiliser une NA si mes amis et ma famille en utilisaient aussi*
- SI-AS 3) *L'utilisation de NA me valoriserait, à mes yeux et aux yeux des autres*

**Motivations Hédoniques (3 items):**

- HM-AS 1) *Je pense que l'utilisation d'une NA pourrait être source de Plaisir*
- HM-AS 2) *L'interaction avec une NA devrait être ludique ou amusante*
- HM-AS 3) *L'utilisation des NA rendrait mes déplacements plus agréables*

**Sécurité Perçue (2 items):**

- Safe-AS 1) *Les NA rendraient mes déplacements plus sûrs et sans risqué*
- Safe-AS 2) *Je pense que j'aurais confiance dans la technologie des NA pour garantir ma sécurité*

**Anxiété envers l'usage des Navettes Autonomes (2 items):**

- Anx-AS 1) *L'utilisation d'une NA serait source d'inquiétudes pour moi*
- Anx-AS 2) *Je refuserai catégoriquement de monter dans une NA s'il n'y a pas de chauffeur humain à bord*

**Valeur de Prix des NA (2 items):**

- PV-AS 1) *Je pense que l'utilisation de NA pour se déplacer sera « bon marché »*
- PV-AS 2) *Je pense les NA devraient offrir un bon rapport « Qualité / Prix », en matière de mobilité*

**Valeur de Prix du Moyen de Transport (MdT) utilisé Actuellement (2 items):**

- PV-CMoT 1) *Ce moyen de transport est « bon marché »*
- PV-CMoT 2) *Ce MdT offre un bon rapport « Qualité / Prix », en matière de mobilité*

**Satisfaction envers le Moyen de Transport (MdT) utilisé Actuellement (6 items):**

- Sat\_CMoT.1) *D'une manière générale, je suis satisfait(e) par l'utilisation de ce MdT*
- Sat\_CMoT.2) *Ce moyen de transport répond bien à mes besoins personnels de mobilité*
- Sat\_CMoT.3) *Ce moyen de transport est efficace / rapide*
- Sat\_CMoT.4) *Ce moyen de transport est agréable*
- Sat\_CMoT 5) *Ce moyen de transport est confortable*
- Sat\_CMoT.6) *J'ai confiance dans ce moyen de transport pour garantir ma sécurité*

**Intention d'Usage des NA (3 items):**

- IU-AS 1) *Je souhaiterais pouvoir utiliser des NA pour mes déplacements quotidiens (travail, école...)*
- IU-AS 2) *Si je le pouvais, je changerais mes / mon moyen de transport actuel pour une NA*
- IU-AS 3) *Je pense que je serais satisfait(e) par l'utilisation d'une NA pour réaliser mes déplacements*

## A.2. Questionnaire related to Attitude towards New Technologies (NT) and Innovation

### A.2.1. English version

- 
- NT1. I know more than others about new products and the latest innovations in new technologies  
 NT2. I usually try new technologies before my friends or relatives  
 NT3. Owning or using the latest technological innovations makes me feel good in my own eyes and in the eyes of others  
 NT4. I often buy new technologies, even if they are expensive  
 NT5. I value the NT I buy or use, as they contribute to my image and social identity  
 NT6. With the new technologies, I feel like I don't have full control over what I do  
 NT7. I am suspicious about new technologies because they do not always protect my privacy  
 NT8. New technologies frighten me  
 NT9. If I could, I would not use NT, but I am constrained to use them by the society  
 NT10. New technologies are useful to me, in my daily life  
 NT11. I could not carry out my daily activities (personal or professional) without using NT  
 NT12. New technologies improve living conditions
- 

### A.2.2. Original French version

- 
- NT1. Je connais mieux que les autres les nouveaux produits et les dernières innovations en matière de nouvelles technologies  
 NT2. En général, j'essaie les nouvelles technologies avant mes amis ou mes proches  
 NT3. Posséder ou utiliser les dernières innovations technologiques me valorise, à mes yeux et aux yeux des autres  
 NT4. J'achète souvent des nouvelles technologies, même si elles sont chères  
 NT5. J'accorde de l'importance aux NT que j'achète ou utilise, car elles contribuent à mon image et mon identité sociale  
 NT6. Avec les NT, j'ai l'impression de ne pas tout maîtriser ou de ne plus avoir le contrôle complet sur ce que je fais  
 NT7. Je me méfie des nouvelles technologies, car elles ne préservent pas toujours ma vie privée  
 NT8. Les nouvelles technologies me font peur  
 NT9. Si je le pouvais, je n'utiliserais pas les nouvelles technologies, mais j'y suis contraint par la société  
 NT10. Les nouvelles technologies me sont utiles, dans le cadre de ma vie quotidienne  
 NT11. Je ne pourrais pas exercer mes activités quotidiennes (personnelles ou professionnelles) sans utiliser les NT  
 NT12. Les nouvelles technologies améliorent les conditions de vie
- 

## References

- Acheampong, R. A., & Cugurullo, F. (2019). Capturing the behavioural determinants behind the adoption of autonomous vehicles: Conceptual frameworks and measurement models to predict public transport, sharing and ownership trends of self-driving cars. *Transportation Research Part F*, 62, 349–375.
- Ajzen, I. (1991). The theory of planned behavior. *Organizational behavior and human decision processes*, 50(2), 179–211.
- Bansal, P., Kockelman, K. M., & Singh, A. (2016). Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. *Transportation Research Part C: Emerging Technologies*, 67, 1–4.
- Bellet, T., Paris, J.-C., & Marin-Lamellet, C. (2018). Difficulties experienced by older drivers during their regular driving and their expectations towards Advanced Driving Aid Systems and vehicle automation. *Transportation Research Part F: Traffic Psychology Behaviour*, 52, 138–163.
- Chimi, C. J., & Russell, D. L. (2009). The Likert scale: A proposal for improvement using quasi-continuous variables. In *Proceedings of Information Systems Education Conference*, November 2009, Washington, DC, 1–10 <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.467.646&rep=rep1&type=pdf>.
- Childers, T. L., Carr, C. L., Peck, J., & Carson, S. (2001). Hedonic and utilitarian motivations for online retail shopping behavior. *Journal of retailing*, 77(4), 511–535.
- Compeau, D. R., & Higgins, C. A. (1995). Application of social cognitive theory to training for computer skills. *Information systems research*, 6(2), 118–143.
- Cooper, A. (1999). *The inmates are running the asylum*. Indianapolis, Macmillan Publishing.
- Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, 16(3), 297–334. <https://doi.org/10.1007/bf02310555>
- Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319–340.
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1992). Extrinsic and intrinsic motivation to use computers in the workplace 1. *Journal of applied social psychology*, 22(14), 1111–1132.
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, 35, 982–1003.
- Distler, V., Lallemand, C., Bellet, T. (2018). Acceptability and acceptance of autonomous mobility on demand: The impact of an immersive experience. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, Montreal, Canada, 612–617.
- Dolnicar, S., & Grun, B. (2007). How constrained a response: A comparison of binary, ordinal and metric answer formats. *Journal of Retailing and Consumer Services*, 14, 108–122.
- Farooq, M., Salam, M., Jaafar, N., Fayolle, A., Ayupp, K., Radovic-Markovic, M., & Sajid, A. (2017). Acceptance and use of lecture capture system (LCS) in executive business studies : Extending UTAUT2. *Interactive Technology and Smart Education*, 14(4), 329–348.
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory of research*. Reading, MA: Addison-Wesley.
- Funke, F., & Reips, U. D. (2012). Why semantic differentials in web-based research should be made from visual analogue scales and not from 5-point scales. *Field Methods*, 24(3), 310–327.
- Guyatt, G. H., Townsend, M., Berman, L. B., & Keller, J. L. (1987). A comparison of Likert and visual analogue scales for measuring change in function. *Journal of chronic diseases*, 40(12), 1129–1133.

- Hassenzahl, M. (2001). The effect of perceived hedonic quality on product appealingness. *International Journal of Human-Computer Interaction*, 13(4), 481–499.
- Hassenzahl, M. (2008). User Experience (UX): Towards an experiential perspective on product quality. In *Proceedings of the 20th International Conference of the Association Francophone d'Interaction Homme-Machine (IHM '08)*, Metz, France, 2–5 September, 11–15.
- Hohenberger, C., Spörrle, M., & Welpel, I. M. (2016). How and why do men and women differ in their willingness to use automated cars? The influence of emotions across different age groups. *Transportation Research Part A: Policy and Practice*, 94, 374–385.
- Hudson, J., Orviska, M., & Hunady, J. (2019). People's attitudes to autonomous vehicles. *Transp. Res. Part A Policy Pract.*, 121, 164–176.
- Hulse, L., Xie, H., & Galea, E. R. (2018). Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Safety Science*, 102, 1–13.
- Kamalasesna, B. D. T. M., & Sirisena, A. B. (2021). Factors influencing the adoption of E-learning by university students in Sri Lanka: Application of UTAUT-3 model during covid-19 pandemic. *Wayamba Journal of Management*, 12(2), 99–124.
- Khan, F. M., Singh, N., Gupta, Y., Kaur, J., Banik, S., & Gupta, S. (2022). A Meta-analysis of Mobile Learning Adoption in Higher Education Based on Unified Theory of Acceptance and Use of Technology 3 (UTAUT3). *Vision*, 09722629221101159.
- Kaye, S. A., Lewis, I., Forward, S., & Delhomme, P. (2020). A priori acceptance of highly automated cars in Australia, France, and Sweden: A theoretically-informed investigation guided by the TPB and UTAUT. *Accident Analysis & Prevention*, 137, Article 105441.
- Kyriakidis, M., Happee, R., & de Winter, J. C. (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. *Transportation Research Part F: Traffic Psychol Behav.*, 32, 127–140.
- Lee, Y.-C., & Mirman, J. H. (2018). Parents' perspectives on using autonomous vehicles to enhance children's mobility. *Transp. Res. Part C Emerg. Technol.*, 96, 415–431.
- Liu, P., Yang, R., & Xu, Z. (2018). Public Acceptance of Fully Automated Driving: Effects of Social Trust and Risk/Benefit Perceptions. *Risk Analysis*, 39, 326–341.
- Nordhoff, S., Madigan, R., Happee, R., Van Arem, B., Schönduwe, R., & Merat, N. (2017). Using the 4P model to understand why people choose to use automated vehicles in public transport. *Proceedings of the mobilTUM 2017: International Conference on Intelligent Transport Systems in Theory and Practice*, Munich, Germany.
- Liu, P., Zhang, Y., & He, Z. (2019). The effect of population age on the acceptable safety of self-driving vehicles. *Reliab. Eng. Syst. Safety*, 185, 341–347.
- Madigan, R., Louw, T., Dziennus, M., Graindorge, T., Ortega, E., Graindorge, M., & Merat, N. (2016). Acceptance of automated road transport systems (ARTS): an adaptation of the UTAUT model. *Transportation Research Procedia*, 14, 2217–2226.
- Madigan, R., Louw, T., Wilbrink, M., Schieben, A., & Merat, N. (2017). What influences the decision to use automated public transport? Using UTAUT to understand public acceptance of automated road transport systems. *Transportation Research Part F: Traffic Psychology and Behaviour*, 50, 55–64.
- Nordhoff, S., de Winter, J., Kyriakidis, M., Van Arem, B., & Happee, R. (2018). Acceptance of Driverless Vehicles: Results from a Large Cross-National Questionnaire Study. *Journal of Advanced Transportation*, 2018, 1–22.
- Nordhoff, S., de Winter, J., Madigan, R., Merat, N., van Arem, B., & Happee, R. (2018). User acceptance of automated shuttles in Berlin-Schöneberg: A questionnaire study. *Transportation Research Part F: Traffic Psychology and Behaviour*, 58, 843–854.
- Osswald, S., Wurhofer, D., Trösterer, S., Beck, E., & Tscheligi, M. (2012). Predicting information technology usage in the car: towards a car technology acceptance model. In *Proceedings of the 4th International Conference on Automotive User Interfaces and Interactive Vehicular Applications*, 51–58.
- Panagiotopoulos, I., & Dimitrakopoulos, G. (2018). An empirical investigation on consumers' intentions towards autonomous driving. *Transportation Research Part C: Emerging Technologies*, 95, 773–784.
- Payre, W. (2015). *Conduite complètement automatisée: acceptabilité, confiance et apprentissage de la reprise de contrôle manuel*. Thèse de Doctorat en Psychologie, Université de Paris 8.
- Payre, W., Cestac, J., & Delhomme, P. (2014). Intention to use a fully automated car: Attitudes and a priori acceptability. *Transportation research part F: Traffic psychology and behaviour*, 27, 252–263.
- Piao, J., McDonald, M., Hounsell, N., Graindorge, M., Graindorge, T., & Malhene, N. (2016). Public Views towards Implementation of Automated Vehicles in Urban Areas. *Transp. Res. Proc.*, 14, 2168–2177.
- Rahim, A. N., Fonzone, A., Fountas, G., & Downey, L. (2023). On the Attitudes Toward Automation in Determining the Intention to Use Automated Buses in Scotland. *Transportation Research Record*, 1–3. <https://doi.org/10.1177/03611981231159116>
- Regan, M.; Cunningham, M.; Dixit, V.; Horberry, T.; Bender, A.; Weeraratna, K.; Hassan, A. (2017). Preliminary findings from the first Australian national survey of public opinion about automated and driverless vehicles. *Australia and New Zealand Driverless Vehicle Initiative (ADVI)*. ISBN: 978-1-876592-85-1.
- Robertson, R., Meister, S. R., VanLaar, W., & Hing, M. M. (2017). Automated vehicles and behavioural adaptation in Canada. *Transp. Res. Part A Policy Pract.*, 104, 50–57.
- Rogers, E. M. (1995): *Diffusion of Innovations* (4th edition). The Free Press, New York.
- Rondan-Cataluna, F., Arenas-Gaitan, J., & Ramirez-Correa, P. (2015). A comparison of the different versions of popular technology acceptance models: A non-linear perspective. *Kybernetes*, 44. <https://doi.org/10.1108/K-09-2014-0184>
- Schoettle B. & Sivak M. (2014). A survey of public opinion about connected vehicles in the US, the UK, and Australia. In *Proceedings of the 2014 International Conference on Connected Vehicles and Expo. (ICCVE)*, Vienna, Austria, 3–7 November 2014, 687–692.
- Sener, I. N., Zmud, J., & Williams, T. (2019). Measures of baseline intent to use automated vehicles: A case study of Texas cities. *Transportation research part F: Traffic psychology and behaviour*, 62, 66–77.
- Shabanpour, R., Golshani, N., Shamshiripour, A., & Mohammadian, A. (2018). Eliciting preferences for adoption of fully automated vehicles using best-worst analysis. *Transportation Research Part C: Emerging Technologies*, 93, 463–478.
- Stone, M., & Stenner, J. (2012). On temperature. *Rasch Measurement Transactions*, 26, 1351–1353.
- Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. *MIS quarterly*, 125–143.
- Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision sciences*, 39(2), 273–315.
- Venkatesh, V., & Davis, F. D. (2000). A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies. *Management Science*, 46(2), 186–204. <https://doi.org/10.1287/mnsc.46.2.186.11926>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly*, 425–478.
- Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. *MIS quarterly*, 36(1), 157–178.
- Venkatesh, V., Thong, J. Y., & Xu, X. (2016). Unified theory of acceptance and use of technology: A synthesis and the road ahead. *Journal of the association for Information Systems*, 17(5), 328–376.
- Yusoff, R., & Mohd Janor, R. (2014). Generation of an interval metric scale to measure attitude. *Sage Open*, 4(1), 2158244013516768, <https://journals.sagepub.com/doi/pdf/10.1177/2158244013516768>.
- Yusoff, R., Mohd Janor R. (2012). *A proposed metric scale for expressing opinion*. Proceedings of the International Conference on Statistics in Science, Business and Engineering (ICSSBE 2012), Langkawi, Kedah, Malaysia.
- Zmud, J., Sener, I. N., & Wagner, J. (2016). Self-Driving Vehicles: Determinants of Adoption and Conditions of Usage. *Transportation Research Record*, 2565, 57–64.
- Zuckerman, M. (1996). Item revisions in the sensation seeking scale form V (SSS-V). *Personality and Individual Differences*, 20(4), 515.