



HAL
open science

Factors of acceptability, acceptance and usage for non-rail autonomous public transport vehicles: A systematic literature review

Caroline Pigeon, Aline Alauzet, Laurence Paire-Ficout

► **To cite this version:**

Caroline Pigeon, Aline Alauzet, Laurence Paire-Ficout. Factors of acceptability, acceptance and usage for non-rail autonomous public transport vehicles: A systematic literature review. Transportation Research Part F: Traffic Psychology and Behaviour, 2021, 81, pp.251-270. 10.1016/j.trf.2021.06.008 . hal-03288473

HAL Id: hal-03288473

<https://hal.science/hal-03288473v1>

Submitted on 2 Aug 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 - NonCommercial 4.0 International License

1 Title: Factors of acceptability, acceptance and usage for non-rail autonomous public transport
2 vehicles: a systematic literature review

3 Authors: Caroline Pigeon, Aline Alauzet, Laurence Paire-Ficout

4 Transportation Research – Part F: Traffic, Psychology and Behaviour

5 Abstract:

6 Non-rail autonomous public transport vehicles have emerged over the last few years. Technical
7 progress in automation has resulted in a growing number of autonomous shuttle pilot experiments.
8 Although these systems are technologically feasible, determining the extent to which they
9 correspond to users' needs and expectations remains a major issue. In order to answer that question,
10 we conducted a systematic review which synthesizes the literature regarding the acceptability and
11 willingness to use this type of autonomous public transport. This literature review allowed us to
12 identify 39 documents addressing 70 factors of acceptability, acceptance and usage of non-rail
13 autonomous public transport vehicles. The most cited factors in the literature concern service
14 characteristics (times, schedules, fares) and safety issues (road-safety, on-board security). Factors
15 related to automation level, comfort and access to the vehicle feature appear to a lesser extent.
16 Acceptance is also related to personal factors, such as socio-demographics, travel habits, and
17 personality. This review could be of interest to designers and manufacturers of non-rail autonomous
18 public transport vehicles, as well as policy makers, and assist with the successful implementation of
19 autonomous public transport services which are better adapted and meet the needs of all potential
20 users.

21 Keywords: autonomous vehicle; autonomous shuttle; public transit; willingness to use; user needs

22 1 Introduction

23 The development of autonomous vehicles is currently booming and has been the subject of a
24 growing number of scientific publications over the last fifteen years (Gandia et al., 2019). However,
25 non-rail autonomous public transport vehicles (APT_V) have received less interest than the
26 autonomous personal automobile (Azad et al., 2019). Excessive use of autonomous personal
27 automobiles may increase traffic congestion and greenhouse gas emissions (Harb et al., 2018). APT_Vs
28 are seen as a more appropriate response to the challenges of global warming. They could improve
29 mobility services, and in doing so, lead to an increase in the use of public transport, and therefore
30 decrease reliance on personal automobiles (Millonig & Froehlich, 2018). In this paper, as it is the case
31 in the reviewed literature, the term autonomous is used to refer to completely autonomous vehicles
32 as well as systems which are supervised.

33 However, if APT_Vs are to be implemented on a large scale and adopted for future use in daily travel,
34 people need to have a positive attitude towards them. Attitude can be defined as a mental state of
35 readiness, positively or negatively associated with a particular object. It is acquired through
36 experience and is a precursor of behaviour related to the object. Two concepts, "acceptability" and
37 "acceptance", are commonly used to study the general attitude towards a new technology. In the
38 literature, the distinction between these two notions is not always done. In this article we refer
39 **acceptability** to the prospective judgment of potential users towards a technology to be introduced
40 in the future (here the APT_V). This implies that the potential users have not yet experienced this new
41 technology (Schade & Schlag, 2003). **Acceptance** corresponds to judgements, attitudes and
42 behavioural reactions of potential users towards a product after they have tried it (Schade & Schlag,
43 2003, Schuitema, Steg & Forward, 2010). Potential users have experience of the technological object

1 in an experimental context, but have not used it regularly or spontaneously. The *usage* of a
2 technology refers to the appropriation of this technology by users after its introduction into their
3 daily life. In that case, the technology is available and people opt to use it.

4 In a recent review (Nordhoff, Kyriakidis, et al., 2019), acceptance of autonomous vehicles was found
5 to be the result of four decision-making steps: exposure to an automated vehicle, formation of a
6 positive attitude towards it, a decision to adopt it and actual use of it. These authors found that
7 acceptance was determined by 28 factors, including socio-demographic characteristics, experience of
8 autonomous vehicles and personality. Other factors, related to personal perception of autonomous
9 vehicles, such as performance expectancy, effort expectancy or social influence, were found to
10 influence acceptance.

11 Performance expectancy, or perceived usefulness, can be defined as an individual's personal
12 perception that using an innovation would improve his/her performance (Davis, 1989). Effort
13 expectancy, or perceived ease of use, can be described as the degree to which people think that a
14 technology can be used without effort (Davis, 1989). Social influence, also known as the subjective
15 social norm, can be defined as the perception that other significant relatives or influencers have a
16 positive or a negative attitude towards the new technology (Fishbein & Ajzen, 1977).

17 Most of the articles emerging from our review focused on autonomous vehicles in general, or on
18 private autonomous vehicles. The main aim of the present paper is to present how users and
19 potential users accept autonomous vehicles in the specific context of public transport. In particular,
20 our aim was to identify within the literature the APTV characteristics which users and potential users
21 need or require, and which therefore increase acceptability and acceptance, and encourage their
22 use. In documenting users' needs and requirements for APTVs, we hope that our findings will provide
23 insight for APTV designers, manufacturers and policy makers, and will help to improve APTV design
24 and in doing so meet the needs of all potential users.

25 This article focuses on non-rail vehicles, which can operate in automated mode on limited sections of
26 road (level 4 according to the classification of the Society of Automotive Engineers; SAE International,
27 2018) or which can operate in automated mode on all publicly accessible roadways (SAE level 5).

28 2 Material and methods

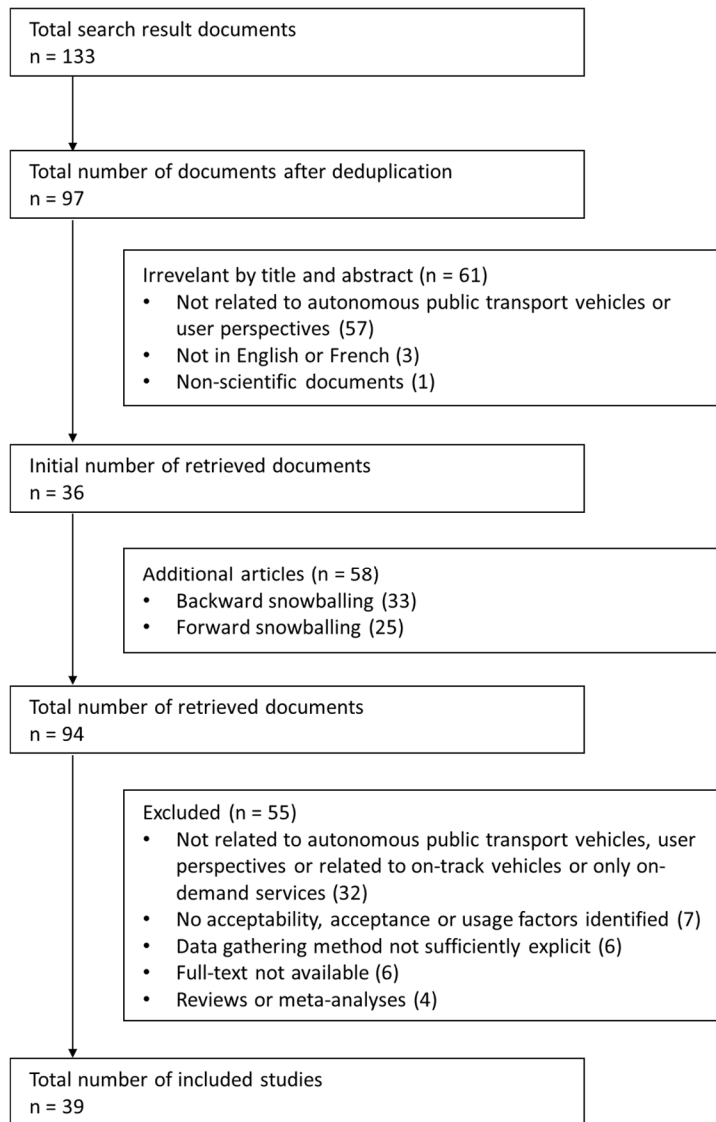
29 2.1 Search strategy and databases

30 The literature search was conducted in April 2019 and updated in January 2020 for studies published
31 between 1999 and 2019. A request relating to APTVs and acceptance, in both English and French was
32 submitted with the search field *title* for the Web of Science, Scopus and PsychInfo databases, and
33 with the search fields *title* and *keywords* for Transport Research International Documentation (TRID).
34 The request was: ((Driverless OR "Self-driv*" OR "Self driv*" OR Automated OR Autonomous OR
35 Intelligent) AND (Shuttle* OR Minibus* OR "Bus" OR "Buses" OR "Busses" OR Autobus* OR Transit*
36 OR Vehicule* OR "Public transport*")) AND (Accept* OR Willing* OR Preference* OR Perception* OR
37 Need* OR Expectation* OR Attitude* OR Adoption OR Readiness OR Interest* OR Opinion* OR
38 Usefulness OR trust ((Decision OR Intention*) AND Use)). Additional searches were performed using
39 Pubmed, Springerlink and Sage for documents containing the same terms in the search field *abstract*
40 or *all*, and using Taylor & Francis Online content platform for terms relating to autonomous vehicles
41 in the search field *keywords*. CAIRN and Revue.org were also used, but no results relating to
42 autonomous vehicles were found. In order to retrieve the maximum number of relevant documents,
43 we used backward snowballing to investigate the reference lists of the studies we included, and

1 forward snowballing on articles citing these studies. This search, carried out in March 2020, yielded
2 additional documents.

3 2.2 Document selection and data extraction

4 We retrieved journal publications, conference proceedings, theses, reports and books or book
5 chapters. 133 records from database research were reviewed for eligibility (Figure 1). Exclusion
6 criteria were as follows: unrelated to APTV or user perspectives, not in English or French, non-
7 scientific documents, related to on-track-vehicles or only on-demand services, no acceptability,
8 acceptance or use factors identified, data gathering method not sufficiently explicit, full-text
9 unavailable, reviews or meta-analyses. Thirty-six duplicate records were removed, and, based on title
10 and abstract, 61 documents did not fulfil the search criteria, resulting in 36 initially reviewed
11 documents. The three authors of the present paper participated in the screening process, and each
12 document was independently screened by two of them. The independent reviewers initially agreed
13 on 92/97 documents (95%; Cohen's kappa coefficient of 0.89) and then met to reach agreement on
14 the remaining five documents. Fifty-eight additional documents were reviewed with backward and
15 forward snowballing, leading to a total of 94 documents retrieved. Finally, after the removal of 49
16 documents which did not fulfil the inclusion criteria and 5 documents for which the full text was not
17 available, 39 studies were retained.



1

2 *Figure 1. Review procedure flowchart*

3 2.3 Analysis

4 Firstly, the 39 studies included in this review were described according to their type (journal
 5 publications, conference proceedings, reports, theses, books or book chapters), the kind of vehicle
 6 involved (autonomous shuttle, bus shuttle or APTV in general), the methods used (quantitative,
 7 qualitative or mixed) and their focus (acceptability, acceptance or usage). Secondly, all acceptability,
 8 acceptance or usage factors investigated in these studies were extracted and categorized. The factor
 9 extraction was performed by one author, and a second author independently checked the data
 10 extraction forms for accuracy in a sample of the documents.

11 3 Results

12 3.1 Description of included studies

13 The 39 documents included 19 journal publications, 16 conference proceedings, two master's theses,
 14 one doctoral thesis and one report. Thirty studies focused on autonomous shuttles, 4 on buses
 15 (including one on school buses) and 5 on APTVs in general. There were 27 quantitative studies and 8

1 qualitative studies, including 5 with individual interviews, 3 with collective interviews or focus groups
2 and 1 study involving individual and collective interviews. Three studies combined several methods: 1
3 study used surveys and qualitative interviews, 2 studies combined surveys, focus groups and
4 observations.

5 3.2 Factors described in the literature

6 Several studies pointed out that a multitude of combined factors play a crucial role in the process of
7 acceptability, acceptance or usage of APTVs.

8 The model proposed by Acheampong & Cugurullo (2019), based on confirmatory factor analyses
9 indicates that attitude towards public transport (environmental benefits and their effectiveness) is a
10 relevant predictor of intention to use APTVs. The authors also found that other factors, such as
11 attitudes to ecology and technology, behavioural control, social influence and the image associated
12 with using an autonomous car, concerns about autonomous vehicles, perceived benefits, effort
13 expectancy, age, gender and education level, were all also predictors of intention to use APTVs.

14 In their initial study based on the UTAUT model (Unified Theory of Acceptance and Use of technology
15 of Venkatesh et al., 2003), Madigan et al. (2016) looked at whether the variables performance
16 expectancy, social influence and effort expectancy predict the intention to use an autonomous
17 shuttle. These factors accounted for 22% of the variance, suggesting that they were predictors of
18 intention to use, but that other variables also have an influence. Age, gender and exposure to
19 technology were not found to be moderating variables of intention to use.

20 In a subsequent study, Madigan et al. (2017) found that perceived pleasure, usefulness, social
21 influence and facilitating conditions (i.e. having the resources and knowledge to use the shuttle)
22 were predictors of intention to use an autonomous bus, and accounted for 58.6% of the variance.
23 Effort expectancy did not predict intention to use, nor did age, gender or the number of times the
24 autonomous shuttle was used.

25 Motak et al. (2017) found that 55% of the variance of intention to use an autonomous shuttle was
26 accounted for by perceived usefulness, social influence, perceived pleasure, and prior experience.

27 Our objective of reviewing all the factors influencing acceptability, acceptance and usage of APTVs,
28 leads us to extract 70 different factors from the 39 studies included in the present literature review.
29 The 70 factors found were classified on the basis of the taxonomy proposed by Nordhoff et al. 2019
30 in their Multi-level model on Automated Vehicle Acceptance (MAVA) resulting from their literature
31 review. The MAVA model, built on Unified Theory of Acceptance and Use of Technology (UTAUT3,
32 Venkatesh et al., 2016) and the Car Technology Acceptance Model (CTAM, Osswald et al., 2012),
33 include a four-stage decision-making process. This process ranges from the exposure of the individual
34 to automated vehicles (AVs) in Stage 1, the formation of favourable or unfavourable attitudes
35 towards AVs in Stage 2, making the decision to adopt or reject AVs in Stage 3, to the implementation
36 of AVs into practice in Stage 4. According to the authors, MAVA incorporates acceptance factors
37 distributed in two levels: the meso-level, composed of the exposure of individuals to autonomous
38 vehicles, instrumental domain-specific, symbolic-affective and moral-normative factors, and the
39 micro-level, composed of individual difference factors (sociodemographics, personality and travel
40 behaviour). In the present study, in contrast to the choice of Nordhoff et al. 2019, factors were
41 retained even though they had only been found in a few studies.

1 3.2.1 Factors at the meso-level

2 Each of the factors presented at the meso level are summarized in Table 1.

3 3.2.1.1 Exposure to autonomous vehicles

4 Level of knowledge and experience of autonomous vehicles can have an impact on acceptance of
5 APTVs. For example, **previous experience** of autonomous vehicles raised willingness to use APTVs in
6 the future (Pakusch & Bossauer, 2017), enhanced the feeling that autonomous shuttles are safe
7 (Salonen & Haavisto, 2019) and increased the likelihood of choosing an autonomous shuttle over
8 several other means of transport (Wicki et al., 2019). Previous experience of APTVs, even on guided
9 tracks, can have a positive impact on feelings of safety prior to traveling by autonomous shuttle
10 (Eden et al., 2017). One study indicated that frequent users of autonomous shuttles have a more
11 positive attitude towards autonomous vehicles than non-users. They also have a greater preference
12 for full automation, and are more likely to think that autonomous shuttles are safer than manually-
13 operated vehicles than non-users (Portouli et al., 2017). Perception of ease of use of autonomous
14 shuttles was greater in participants who had previous experience of this mode of transport than in
15 non-users (Dekker, 2017), and their intention to use an autonomous shuttle was greater (Motak et
16 al., 2017). One study showed that traveling on an autonomous shuttle improved perceived ease of
17 use, confidence in, and attitude towards the vehicle, but did not modify its perceived usefulness or
18 intention to use (Wintersberger et al., 2018). However, in another study (Monéger, 2018), willingness
19 to use APTVs, perception of control and of the usefulness of the vehicle increased after traveling on
20 an autonomous shuttle. When people were offered the opportunity of trying an APTV, acceptance
21 and use were both seen to rise (Nordhoff, de Winter, et al., 2019). However, the number of times
22 participants used or interacted with autonomous shuttles was not seen to have any effect on their
23 degree of willingness to use this type of vehicle (Madigan et al., 2017, 2016). Prior **knowledge of**
24 **autonomous vehicles** also increases the probability of being willing to use an autonomous bus (Dong
25 et al., 2017; Kostorz et al., 2019). People who had never heard of autonomous shuttles were more
26 concerned about the interaction of these vehicles with other road-users, and perceived APTVs as
27 being more difficult to understand, than people with previous experience (ranging from one trial to
28 regular weekly use) of an autonomous shuttle (Dekker, 2017). However, in the same study, exposure
29 was not seen to have any significant effect on performance, security (in terms of data-hacking and
30 fears about other passengers), trust in APTVs or preference for this means of transport over another.
31 **Knowing that an autonomous shuttle had caused an accident** prior to trying an APTV has a negative
32 impact on willingness to use this type of vehicle (Salonen & Haavisto, 2019) and raises concerns
33 about safety (Eden et al., 2017). **Media coverage** of autonomous vehicles can improve familiarity and
34 consequently, feelings of confidence (Salonen & Haavisto, 2019). However, it can also give rise to
35 unrealistic expectations, therefore decreasing positive perception of an autonomous shuttle tried
36 subsequently (Nordhoff, de Winter, et al., 2019).

37 Exposure does therefore have an effect on acceptance, and it depends on whether the knowledge of,
38 and the experience in relation to the APTV was positive or negative.

39 3.2.1.2 Domain specific system evaluation

40 3.2.1.2.1 Performance and effort expectancies

41 **Performance expectancy** of APTVs is an important factor in their acceptance. Nordhoff et al. (2017)
42 revealed that both performance expectancy of an autonomous shuttle and the fact that autonomous
43 shuttles constitute an important part of the public transport system foster intention to use APTVs for
44 daily travel. Performance expectancy has also been found to be associated with positive attitudes

1 towards APTVs (Chen, 2019; Herrenkind et al., 2019) and intention to use this type of vehicle
2 (Acheampong & Cugurullo, 2019; Monéger, 2018; Motak et al., 2017). The perception that
3 autonomous shuttles are useful and more efficient than current transport modes also increases
4 intention to use them (Madigan et al., 2017, 2016). Attitudes towards autonomous shuttles and their
5 perceived utility depend on the perception that they have more advantages than other modes of
6 transport (Herrenkind et al., 2019; Nordhoff, de Winter, et al., 2019). Participants in the study by
7 Nordhoff, de Winter, et al. (2019) indicated that outwith the context of the experiment (in normal
8 circumstances), they would have made the journey on foot. This decreased acceptance and lowered
9 their intention to use the shuttle.

10 **Effort expectancy** has been found to be an acceptance factor in several studies. When expectancy
11 that the effort involved in using an autonomous shuttle is low, positive attitude towards this means
12 of transport increases, as does its perceived usefulness (Chen, 2019). Herrenkind et al. (2019) also
13 observed that effort expectancy had an effect on attitude towards using APTVs. This was, however,
14 less pronounced than the effect of performance expectancy. An association has been demonstrated
15 between APTV effort expectancy, attitude, performance expectancy and intention to use APTVs
16 (Acheampong & Cugurullo, 2019). Low effort expectancy (Kostorz et al., 2019; Monéger, 2018) and
17 ease of learning how to use an autonomous shuttle (Madigan et al., 2016) have been associated with
18 a greater intention to use APTVs. When effort expectancy for using an autonomous shuttle is lower
19 than for other current means of transport, willingness to use APTVs for everyday journeys increases
20 (Nordhoff et al., 2017). However, Madigan et al. (2017) did not find any significant effect of low effort
21 expectancy (described by the authors as human-machine interfaces which are clear and easily-
22 understandable on the shuttle), perceived ease of use, and ease of learning how to use an
23 autonomous shuttle) on intention to use the shuttle.

24 3.2.1.2.2 Safety

25 **Safety** factors discussed here relate to safety issues, and to concerns about traffic safety, difficulties
26 introduced by the absence of a driver, fear of assault, incivilities or invasion of data privacy. In this
27 section, we present vehicle characteristics related to these themes, as well as suggested preventive
28 counter-measures.

29 Fears and **concerns** about automation have been found to negatively influence attitude towards
30 APTVs, although they do not modify their perceived benefits (Acheampong & Cugurullo, 2019).
31 Concerns about the **safety of the vehicle** and **incivilities** decrease willingness to use an autonomous
32 bus (Dong et al., 2017; Monéger, 2018). Before and after trying an autonomous shuttle, participants
33 reported that fear of a **technology failure** resulted in a negative opinion about autonomous vehicles
34 (Fernández Medina & Jenkins, 2017). Potential users require **personal data protection** (Stark et al.,
35 2019), and concerns about this have been found to negatively impact the perceived usefulness of
36 autonomous shuttles, but not attitude towards them (Herrenkind et al., 2019).

37 Dong et al. (2017) found that the **absence of a driver** leads to concerns about assistance to people
38 with disabilities and access to information. These concerns negatively impact willingness to use
39 autonomous buses. The absence of a driver also raises questions about the resolution of technical
40 problems, the provision of information to passengers, the prevention of incivilities and supervision of
41 compliance with regulations (López-Lambas & Alonso, 2019). It also emerged that public transport
42 drivers carry out tasks unrelated to driving, such as providing information, ensuring passenger safety
43 and handling unexpected situations (Fernández Medina & Jenkins, 2017). Fears associated with **the**
44 **night service** is another issue (Piao et al., 2016), and this seems to affect women more than men
45 (Stark et al., 2019). Women are also more worried than men about traffic safety, incivilities, assault,

1 terrorism and personal data protection (Roche-Cerasi, 2019). Concerns about the **decision-making**
2 **algorithm**, in situations where a collision is unavoidable have also been voiced (Salonen & Haavisto,
3 2019).

4 In response to these concerns, and to improve safety, countermeasures have been proposed. The
5 presence of **seat belts** (Eden et al., 2017; Vöge & McDonald, 2003) and **child safety seats** (Stark et al.,
6 2019), and **the prohibition of standing** inside the vehicle (Vöge & McDonald, 2003) have all been
7 cited as ways of preventing falls during braking. Divergences were found on passenger **registration**
8 and **video and audio surveillance** to prevent incivilities and assaults, because they raised concerns
9 about personal data protection (Stark et al. 2019). Certain studies have identified the need for a **stop**
10 **button** (Nordhoff, de Winter, et al., 2019) or a **means of communication** in case of emergency,
11 vehicle dysfunction or incivility, in the form of an on-vehicle system application (Vöge & McDonald,
12 2003). **Autonomous medical emergency management** has also been proposed (Vöge & McDonald,
13 2003). More globally, the need to **respect current security standards** was expressed in a study by
14 Stark et al. (2019).

15 3.2.1.2.3 Service characteristics

16 Mobility service characteristics have been assessed in a number of APTV studies. **High frequency**
17 services and short **waiting times** emerge as positive factors for APTVs acceptability or acceptance
18 (Alessandrini, Delle Site, Gatta, et al., 2016; Alessandrini et al., 2014; Dekker, 2017; Papadima et al.,
19 2020; Ramseyer et al., 2018; Salonen & Haavisto, 2019; Stark et al., 2019; Vöge & McDonald, 2003;
20 Wicki et al., 2019). A median waiting time of 10 minutes was defined as acceptable in the study
21 conducted by Hinderer et al. (2018), and an average of 6.4 minutes for flexible services and 5.4 for
22 fixed routes in the study by Földes et al. (2018). A lengthy **travel time** on an autonomous shuttle
23 results in a negative assessment (Dekker, 2017). When travel time is shorter, an autonomous shuttle
24 is more likely to be chosen over an equivalent manual vehicle (Alessandrini, Delle Site, Gatta, et al.,
25 2016; Alessandrini et al., 2014), or over another means of transport (Wicki et al., 2019;
26 Wintersberger et al., 2018). Similarly, long travel time seems to be less acceptable for an
27 autonomous shuttle than for a regular bus, but a long waiting time has been found to be more
28 acceptable for an autonomous shuttle than for a regular bus (Wien, 2019; K. Winter et al., 2019). In
29 terms of **service schedules**, the participants in a study in which an autonomous shuttle operated
30 from 1:00 to 6:00 p.m. found that the service needed to be extended (Eden et al., 2017), and another
31 study suggested that autonomous mobility services should operate 24 hours a day (Salonen &
32 Haavisto, 2019).

33 Studies indicated that attractiveness of APTVs can be improved when **fares are** lower than for other
34 means of transport (Alessandrini, Delle Site, Gatta, et al., 2016; Alessandrini et al., 2014; Dekker,
35 2017; Herrenkind et al., 2019; Papadima et al., 2020; Piao et al., 2016; Stark et al., 2019; Wicki et al.,
36 2019) or when the service is free of charge (Hinderer et al., 2018; Vöge & McDonald, 2003).
37 However, 54% of respondents in another study were willing to pay the same price for an
38 autonomous bus as for a conventional bus, and 21.5% of respondents were prepared to pay 0.50 €
39 more (Portouli et al., 2017). Fares can also be customized in line with the service provided (Stark et
40 al., 2019). Some studies have addressed the importance of the **integration of autonomous vehicles**
41 **into the traditional public transport offer**, and **intramodality with other means of transport**
42 (Madigan et al., 2017; Stark et al., 2019; Vöge & McDonald, 2003). People are willing to pay higher
43 fares for flexible services than for fixed routes, in peak hours, and if they can select fellow
44 passengers; they expect to pay lower fares for a flexible service ordered 30 minutes in advance and
45 for daily use (Földes et al., 2018). People are also willing to pay higher fares on an autonomous
46 shuttle when it reduces on-vehicle time (Wien, 2019; K. Winter et al., 2019).

1 **Travel information**, for example about routes and connections (Földes et al., 2018; Nordhoff, de
2 Winter, et al., 2019), and about vehicle speed and congestion is seen to be important for potential
3 APTV users (Fröhlich et al., 2019), and its provision in real time on smartphone applications has been
4 promoted (Papadima et al., 2020; Stark et al., 2019). Provision of on-board information about the
5 current position of the vehicle is also necessary (Vöge & McDonald, 2003). Another study found that
6 information should be easily visible for passengers, and therefore two screens are preferable when
7 seating is bi-directional. These should not, however, obstruct passengers' view from the vehicle
8 (Fröhlich et al., 2019). **Reliability** of service and information provided is also a requirement of users
9 and potential users (Nordhoff, de Winter, et al., 2019; Stark et al., 2019).

10 With regards to the vehicle **location context**, several studies (Alessandrini, Delle Site, Gatta, et al.,
11 2016; Alessandrini, Delle Site, Stam, et al., 2016; Alessandrini et al., 2015, 2014) found that
12 preference for autonomous shuttles over traditional shuttles was greater in major facility
13 infrastructures (technological park, university campus), than in city centers, at transport public nodes
14 or in residential areas. In one survey, 28.8 % of respondents stated that autonomous shuttles would
15 be useful between residential areas and public transport connections, while 12.3 % replied in favour
16 of autonomous shuttles between workplaces and public transport connections (Roche-Cerasi, 2019).
17 Other studies report that a service on a dedicated line (Dekker, 2017; Vöge & McDonald, 2003) and
18 in a context of calm traffic is preferred (Salonen & Haavisto, 2019). However, pedestrian areas are
19 not seen as a suitable context for autonomous shuttles, while autonomous shuttles for connections
20 to places such as railway stations or airports are perceived as being more useful (Eden et al., 2017).
21 Autonomous shuttle services in locations which currently have insufficient public transport links, for
22 example rural areas, have been promoted in several studies (Hinderer et al., 2018; Nordhoff, de
23 Winter, et al., 2019; Stark et al., 2019). The itinerary of the autonomous vehicle must meet the needs
24 of users (Salonen & Haavisto, 2019).

25 **Flexibility** of service has been identified as a positive factor of intention to use an autonomous
26 shuttle (Nordhoff, de Winter, et al., 2019; Salonen & Haavisto, 2019; Vöge & McDonald, 2003).
27 However, there is also a certain reluctance to use this type of service, because it involves actively
28 ordering a vehicle, and can therefore be perceived as being less spontaneous and independent than
29 just going to a stop and waiting for a vehicle (Stark et al., 2019; Wien, 2019; K. Winter et al., 2019).

30 3.2.1.2.4 Vehicle characteristics

31 The issue of **vehicle speed** leads to contrasting appreciations, depending on whether safety or
32 efficiency is the priority. Low speed has been associated with a negative appreciation of autonomous
33 vehicles in a number of studies (Fernández Medina & Jenkins, 2017; Nordhoff, de Winter, et al.,
34 2019; Nordhoff et al., 2018; Ramseyer et al., 2018; Wintersberger et al., 2018), and has been both
35 positively and negatively assessed in others (Eden et al., 2017; Salonen & Haavisto, 2019; Vöge &
36 McDonald, 2003). Abrupt and frequent **braking** was assessed negatively in some studies (Eden et al.,
37 2017; Fernández Medina & Jenkins, 2017; Nordhoff, de Winter, et al., 2019; Ramseyer et al., 2018).
38 However, participants' opinion of autonomous shuttles improved after they experienced that vehicle
39 stopped when pedestrians or cyclists came too close to it (Fernández Medina & Jenkins, 2017).

40 Comfort factors, which refer to the physical and aesthetic characteristics of a vehicle, and options
41 aimed at improving passenger satisfaction, have been mentioned in several studies. Good **visibility of**
42 **the exterior**, via large windows is important for users (Eden et al., 2017; Ramseyer et al., 2018), as
43 are road-facing seats (Fernández Medina & Jenkins, 2017; Nordhoff, de Winter, et al., 2019). **Free**
44 **internet access** on the vehicle was perceived positively in three studies (Földes et al., 2018; Nordhoff,
45 de Winter, et al., 2019; Vöge & McDonald, 2003). Other studies have addressed the question of

1 **seats**, which have to be comfortable (Eden et al., 2017; Nordhoff, de Winter, et al., 2019) and in a
2 configuration which facilitates discussion between passengers (Ramseyer et al., 2018). A low **noise**
3 **level** inside the vehicle has also been requested: the hydraulic compressor noise of a shuttle (Eden et
4 al., 2017) and an audible warning device used to warn other road users of the electric vehicle's
5 presence (Fernández Medina & Jenkins, 2017) were found by participants to be irritating. Shuttle
6 **appearance** has also been studied. Potential users require an attractive interior (Nordhoff, de
7 Winter, et al., 2019), and an external appearance similar to that of a traditional shuttle (Vöge &
8 McDonald, 2003). Vehicle **cleanliness** is also a requirement (Vöge & McDonald, 2003). Users and
9 potential users have also suggested that **air-conditioning** should be a feature of the vehicle
10 (Nordhoff, de Winter, et al., 2019). Finally, for participants who tried an autonomous shuttle, the
11 presence of an **humanoid voice** decreased their willingness to use the vehicle, its perceived
12 usefulness, its social influence and their perceived pleasure (Monéger, 2018).

13 Several factors relating to physical access to the vehicle were found to influence APTVs acceptability.
14 Firstly, **vehicles need to be sufficiently large in size**, with enough seats for users (Stark et al., 2019)
15 and with room for wheelchairs, strollers and luggage (Eden et al., 2017; Nordhoff, de Winter, et al.,
16 2019; Nordhoff et al., 2018; Vöge & McDonald, 2003). Secondly, **access with no physical obstacles**,
17 (for example with low floors, large sliding doors and access ramps) has been found to influence
18 APTVs acceptability, in particular for users with disabilities (Nordhoff, de Winter, et al., 2019; Stark et
19 al., 2019; Vöge & McDonald, 2003). A high vehicle **occupancy rate** decreases willingness to use an
20 autonomous shuttle (Wicki et al., 2019). Proposals aimed at **preventing overloading** of the vehicle
21 via an access control system have been put forward (Vöge & McDonald, 2003). Finally, participants
22 have stated that **access to the vehicle with a bicycle or a dog** should also be possible (Hinderer et al.,
23 2018). **Access to shuttle stops and their characteristics** have also been considered. Stops with a
24 shelter, lighting and seats are preferred to stops without these facilities. A short walking distance to
25 and from a bus stop (<200 m) was also declared to be an important attribute (Papadima et al., 2020).

26 Some factors found in the present literature review relate to automation characteristics, i.e. vehicle
27 behaviour and capabilities. These include supervision of the vehicle, presence of a means of manual
28 control, automation level and information provided to users about automated driving. Inconsistent
29 results were found regarding vehicle **supervision**. Some studies reveal a preference for an on-board
30 supervisor (Dong et al., 2017; López-Lambas & Alonso, 2019; Piao et al., 2016; Salonen & Haavisto,
31 2019). External supervision was preferred in others (Dekker, 2017; Nordhoff et al., 2018) and no
32 supervision in other studies (Papadima et al., 2020). The same discrepancies can also be found within
33 a single study. In several studies, some of the participants appreciated the presence of a supervisor
34 on the shuttle, while others would have preferred not to have a supervisor on board (Ramseyer et
35 al., 2018; Wien, 2019; K. Winter et al., 2019). The need for supervision (via an external or an on-
36 board supervisor) was expressed by 20 % of the sample in the study by Nordhoff, de Winter, et al.
37 (2019), and a lack of supervision was perceived as being a barrier to autonomous shuttle use by 18 %
38 of participants in Monéger's study (2018). Finally, preference for an on-board supervisor on shuttles
39 was found to be more important for non-users than for regular users of an autonomous shuttle
40 (Portouli et al., 2017). Four studies have highlighted the interest for users of having a means of
41 **manual control** over the vehicle. This should take the form of an emergency stop button (Nordhoff,
42 de Winter, et al., 2019), which also opens the doors when pressed (Vöge & McDonald, 2003), or of a
43 joystick which allows the supervisor to take control of the vehicle (Ramseyer et al., 2018). However, a
44 user-operated horn to warn other road users of the approach of the autonomous shuttle was rated
45 less well than an autonomous horn (Monéger, 2018). The importance of providing passengers with
46 **information about the autonomous functioning of the shuttle** has been pointed out, in particular in
47 relation to the vehicle's 'awareness' of its surroundings (obstacles) and its 'intentions' (turning,
48 braking, avoiding obstacles). This information could be relayed by an auditory warning signal (Vöge &

1 McDonald, 2003), or displayed at eye-level on the windscreen (Fröhlich et al., 2019). However, it has
 2 not been clearly demonstrated if visually-displayed information should contain text, icons or come in
 3 an augmented reality format, although a combination of these formats might be more
 4 comprehensible (Fröhlich et al., 2019). Concerning the **automation level**, participants in one study
 5 preferred traditional buses, or buses with a low level of autonomy to fully-autonomous buses
 6 (Roche-Cerasi, 2019). In other research, after trying an autonomous shuttle, participants negatively
 7 assessed both the shuttle’s inability to automatically bypass obstacles, and manual interventions by a
 8 supervisor (Nordhoff, de Winter, et al., 2019).

9 3.2.1.3 Symbolic-affective system evaluation

10 Social influence and perceived pleasure are symbolic-affective factors which can play a role in the
 11 acceptance of autonomous vehicles. Studies on **social influence** have indicated that an individual’s
 12 intention to use an autonomous shuttle is affected by the opinion of significant relatives (Madigan et
 13 al., 2017, 2016), or of people living in the same region (Motak et al., 2017). Intention to use an APTV
 14 is also associated with significant others adopting the same behaviour (Acheampong & Cugurullo,
 15 2019). In this context, a study conducted by Herrenkind et al. (2019) indicates that the reputation of
 16 autonomous shuttles has an impact on their perceived utility, and that social influence is associated
 17 with the perceived utility of the shuttles, attitude towards them and intention to use them. Nordhoff
 18 et al. (2017) showed that use of an autonomous shuttle by significant relatives had an effect on
 19 willingness to use shuttles in a rural context, but not in an urban context. **Perceived pleasure**, also
 20 referred to as hedonic motivation, was positively associated with the intention to use an
 21 autonomous shuttle (Madigan et al., 2017; Motak et al., 2017), with perception of usefulness and a
 22 positive attitude to autonomous shuttles (Herrenkind et al., 2019), and with positive attitude to
 23 autonomous shuttles and the intention to use them (Chen, 2019).

24 *Table 1. Factors of acceptability, acceptance or usage related to the meso-level and number of studies that investigated*
 25 *them (n)*

| Themes | Factors | n |
|-------------------------------------|---|--|
| Exposure to autonomous vehicles | Previous experience | Acceptance studies: 8 Acceptability/acceptance studies: 3 Acceptability/usage studies: 1 |
| | Previous knowledge | Acceptability studies: 2 Acceptance studies: 1 |
| | Awareness of an accident | Acceptance studies: 2 |
| | Media coverage | Acceptance studies: 2 |
| - Domain specific system evaluation | Performance expectancy | Acceptability studies: 1 Acceptance studies: 8 |
| | Effort expectancy | Acceptability studies: 2 Acceptance studies: 6 |
| | Safety - concerns: road-safety of the vehicle, incivilities, technology failures, personal data protection, absence of a driver, night services, decision-making algorithm | Acceptability studies: 5 Acceptance studies: 4 Acceptability/acceptance studies: 1 |
| | - Countermeasures: seat belts, child safety seats, prohibition of standing, | Acceptability studies: 2 Acceptance studies: 2 |

| | | |
|--|---|--|
| | <p>registration of passengers and audio and video surveillance, emergency stop button, communication means, medical emergency management, respect of current security standards</p> | |
| | <p>Mobility service characteristics</p> <ul style="list-style-type: none"> - Times and schedules: frequency/waiting time, travel time, schedules | <p>Acceptability studies: 8 Acceptance studies: 4 Acceptability/acceptance studies: 2 Acceptability/acceptance/usage studies: 1</p> |
| | <ul style="list-style-type: none"> - Fares, integration with public transport and intramodality | <p>Acceptability studies: 8 Acceptance studies: 2 Acceptability/acceptance studies: 3 Acceptability/usage studies: 1 Acceptability/acceptance/usage studies: 1</p> |
| | <ul style="list-style-type: none"> - Location context | <p>Acceptability studies: 8 Acceptance studies: 3 Acceptability/acceptance studies: 1</p> |
| | <ul style="list-style-type: none"> - Travel information and reliability | <p>Acceptability studies: 4 Acceptance studies: 3 Acceptability/acceptance/usage studies: 1</p> |
| | <ul style="list-style-type: none"> - Flexibility | <p>Acceptability studies: 3 Acceptance studies: 2 Acceptability/acceptance studies: 1</p> |
| | <p>Vehicle characteristics</p> <ul style="list-style-type: none"> - Vehicle speed | <p>Acceptability studies: 2 Acceptance studies: 6</p> |
| | <ul style="list-style-type: none"> - Braking behaviour | <p>Acceptance studies: 4</p> |
| | <ul style="list-style-type: none"> - Automation factors: supervision, manual control means, automation level, information about autonomous functioning | <p>Acceptability studies: 8 Acceptance studies: 5 Acceptability/acceptance studies: 2 Acceptability/usage studies: 1 Acceptability/acceptance/usage studies: 1</p> |
| | <ul style="list-style-type: none"> - Comfort : visibility of the outside, Free internet access, seats (comfortable and with a configuration facilitating discussion), noise, internal and external appearance, air-conditioning, cleanliness, humanoid voice | <p>Acceptability studies: 2 Acceptance studies: 4</p> |
| | <ul style="list-style-type: none"> - Access to the vehicle: vehicle size, obstacle-free access, occupancy rate and overloading prevention, | <p>Acceptability studies: 3 Acceptance studies: 3 Acceptability/acceptance studies: 1 Acceptability/acceptance/usage studies:</p> |

| | | |
|--------------------------------------|--|---|
| | access to the vehicle with a bicycle or a dog, access and characteristics of stops | 1 |
| Symbolic-affective system evaluation | Social influence | Acceptability studies: 5 Acceptance studies: 1 |
| | Perceived pleasure | Acceptance studies: 4 |

1

2 3.2.2 Factors at the micro-level

3 Factors at the micro-level can be classified into three categories: socio-demographics, travel
4 behaviour, and personality. They will be presented below and summarized in Table 2.

5 3.2.2.1 Socio-demographic factors

6 Several studies have measured the effects of socio-demographic variables such as age, gender,
7 education level and income, on acceptance of APTVs.

8 The effect of **age** on acceptance is not consistent across the literature. Several studies found no
9 significant age effect on willingness to use an autonomous shuttle (Kostorz et al., 2019; Madigan et
10 al., 2017, 2016; Motak et al., 2017), or an APTV (Pakusch & Bossauer, 2017), on the probability of
11 choosing an autonomous shuttle over another means of transport (Alessandrini, Delle Site, Gatta, et
12 al., 2016; Wien, 2019), on feelings of safety onboard the vehicle, traffic safety or emergency
13 management (Salonen, 2018) or on trust in autonomous shuttles (Dekker, 2017). Age was not found
14 to have any effect on intention to use public transport more when autonomous shuttles provided
15 mobility services between public transport and car parks, or the workplace and residential areas.
16 Younger people appeared to be more willing to use autonomous buses with high levels of
17 automation (Roche-Cerasi, 2019). Other studies also showed that acceptance was higher in younger
18 people. A negative correlation between age and a positive attitude towards technology, intention to
19 use APTVs and the perceived benefits of APTVs has been demonstrated (Acheampong & Cugurullo,
20 2019). Participants aged 18-35 were found to be more willing to use an autonomous bus than those
21 aged 45 years or more (Dong et al., 2017). 42% of students surveyed were prepared to use a fee-
22 based APTV service, compared to 20% of retired people surveyed (Hinderer et al., 2018). In addition,
23 regular users of an autonomous shuttle were found to be younger than non-users (Portouli et al.,
24 2017), and perceived ease of use was found to be higher in younger participants than in older ones
25 (Nordhoff et al., 2017). However, in one study, acceptance of an autonomous shuttle was found to
26 be higher in older than in younger participants, although the former viewed the autonomous shuttle
27 as less efficient than their current mode of transport (Nordhoff et al., 2018). Another study showed
28 that social influence was more important for older participants (Nordhoff et al., 2017). Age also has a
29 moderating influence on some factors. The effect of perceived ease of use of an autonomous shuttle
30 on attitude was seen to be greater in participants over 40, whereas the effect of trust on attitude
31 was significant only in participants of 40 and under (Chen, 2019).

32 The effect of **gender** on acceptability and acceptance is unclear. Several studies have found that men
33 are more willing to use an autonomous bus (Dong et al., 2017; S. R. Winter et al., 2018). They are also
34 seen to be more prepared to use APTVs in general (Acheampong & Cugurullo, 2019), to choose an
35 autonomous shuttle over a traditional vehicle (Alessandrini, Delle Site, Gatta, et al., 2016;
36 Alessandrini et al., 2014; Wien, 2019; K. Winter et al., 2019), to use an autonomous bus with a high
37 level of automation (Roche-Cerasi, 2019) and have more trust in autonomous shuttles than women
38 (Dekker, 2017). In addition, while parents are globally unwilling to let their children use a driverless
39 school bus in the United States, mothers are less likely to accept this than fathers (Anania et al.,

1 2018). Men are also less afraid of other passengers on autonomous vehicles than women, but no
2 significant difference has been found on concerns about traffic safety or managing an emergency
3 (Salonen, 2018). Gender was found to have a moderating role on several factors: the effects of
4 perceived ease of use of an autonomous shuttle on its perceived usefulness were found to be greater
5 for females than for males. The effects of perceived usefulness on attitude were found to be greater
6 for males than for females, and the effects of trust on attitude were found to be significant only for
7 females (Chen, 2019). Women are less likely to think that APTVs are useful, have more concerns
8 about them, and subjective norms and ecological values moderate their intention to use APTVs less
9 (Acheampong & Cugurullo, 2019). Finally, people might be more willing to use an autonomous bus
10 than to let their partner or their child use it, and this applies more to women than to men (S. R.
11 Winter et al., 2018). However, other studies did not find significant differences between men's and
12 women's willingness to use an autonomous shuttle (Madigan et al., 2017; Nordhoff et al., 2018,
13 2017), or APTVs in general (Pakusch & Bossauer, 2017), and there is also no significant difference
14 between them for performance expectancy, effort expectancy, and social influence (Nordhoff et al.,
15 2017). No gender effect was found on the intention to use public transport more if autonomous
16 shuttles provided mobility services between public transport and car parks, the workplace and
17 residential areas (Roche-Cerasi, 2019).

18 A high **education level** was associated positively with a preference for autonomous shuttles over
19 traditional ones in three out of twelve cities surveyed (Alessandrini, Delle Site, Gatta, et al., 2016;
20 Alessandrini et al., 2015, 2014). In these three cities, implementation of autonomous shuttles was
21 planned in city centers. An effect of education level was found on willingness to use an autonomous
22 bus (Roche-Cerasi, 2019) on intention to use an APTV, on perceived usefulness of APTVs and
23 perceived ease of use (Acheampong & Cugurullo, 2019). However, no effect of education appeared
24 either on feelings of traffic safety, on-vehicle security and emergency management (Salonen, 2018)
25 or on trust in autonomous shuttles (Dekker, 2017). No effect of education was found between
26 regular users of autonomous shuttles and participants who never used this means of transport
27 (Portouli et al., 2017).

28 **Income** was not found to have an effect on preference for autonomous shuttles over traditional
29 shuttles (Alessandrini, Delle Site, Gatta, et al., 2016), on the intention to use an autonomous shuttle
30 (Kostorz et al., 2019), on feelings about traffic safety, on-vehicle security and emergency
31 management (Salonen, 2018) or on trust in autonomous shuttles (Dekker, 2017). Another study
32 stated that a higher income increases willingness to use an autonomous bus, but this difference
33 exists only between higher and lower incomes, and only when knowledge about autonomous
34 vehicles is not controlled (Dong et al., 2017).

35 **Employment** was not found to have an effect on preference for autonomous shuttles over traditional
36 ones (Alessandrini, Delle Site, Gatta, et al., 2016) or on fears about traffic safety and emergency
37 management (Salonen, 2018). However, students were found to be more regular autonomous
38 shuttle users than employees, or unemployed and retired people (Portouli et al., 2017). This can also
39 be attributed to an age effect.

40 Regarding the **place of residence**, people living in India were more willing to let their children use a
41 driverless school bus than US residents (Anania et al., 2018). There was no difference in willingness
42 to use an autonomous shuttle between residents and visitors to La Rochelle (France) and residents
43 and visitors to Lausanne (Switzerland; Madigan et al., 2016). People living in highly populated areas
44 are more willing to use highly automated buses (Roche-Cerasi, 2019). Intention to use an
45 autonomous shuttle did not differ between Germans living in rural areas and Germans living in urban
46 areas (Kostorz et al., 2019). However, American participants stated that they were more willing to

1 use an autonomous bus in the USA than in Russia, China, India, Nigeria, Indonesia or Brazil (S. R.
2 Winter et al., 2018). Trust in, and willingness to use, an autonomous shuttle was found to be greater
3 in participants living in regions where autonomous shuttle services had been implemented than in
4 regions where no autonomous shuttles were in operation (Dekker, 2017). However, participants
5 working on a German campus rated an autonomous shuttle as less efficient than their current means
6 of transport than participants who did not work on the campus (Nordhoff et al., 2018).

7 3.2.2.2 Travel behaviour factors

8 A number of studies have assessed the effects of travel behaviour, such as travel habits, purpose of
9 travel and weather, mobility difficulties and attitudes towards using public transport.

10 Studies have established that **purpose of travel** and the **weather** have an impact on acceptance.
11 Autonomous transport with fixed schedules appears to be better accepted for fixed travel purposes
12 (work, education) than for flexible travel purposes (for example leisure; Földes et al., 2018).
13 However, in another study, 56% of respondents stated that they were willing to use an autonomous
14 shuttle for leisure trips, and only 41% for business trips (Kostorz et al., 2019). In conditions of bad
15 weather, people would be more willing to use an autonomous shuttle rather than to walk or hire a
16 bicycle (Nordhoff, de Winter, et al., 2019; Wicki et al., 2019).

17 In addition, a positive **attitude towards public transport** was found to be associated with a
18 willingness to use APTVs (Acheampong & Cugurullo, 2019), in particular, autonomous shuttles
19 (Kostorz et al., 2019).

20 Regarding **travel habits**, K. Winter et al. (2019) showed that people who use public transport once a
21 month or more are more willing to use an autonomous shuttle instead of a traditional bus, than
22 people who use public transport less frequently. Another study states that car users and public
23 transport users might be more willing to change their travel habits to using autonomous transport
24 for journeys to work, than pedestrians and bicycle users (Földes et al., 2018). According to a study
25 conducted by Motak et al. (2017), walking, the belief that public transport comes with too many
26 constraints and knowing about autonomous technology all tend to explain intention to use an
27 autonomous shuttle. Kostorz et al. (2019) concluded that bicycle users, public transport users and
28 people using at least three different means of transport per week were more willing to use an
29 autonomous shuttle than drivers. They also showed a positive association between feeling at ease in
30 a car and the intention to use an autonomous shuttle. However, other studies do not reveal any
31 effect of an individual's current use of a car or public transport on their willingness to use APTVs
32 (Pakusch & Bossauer, 2017). Nor has any effect of frequency of public transport use (Wien, 2019), or
33 frequency of bus use been observed on willingness to use APTVs (Dong et al., 2017). In addition, no
34 association has emerged between public transport use and trust in autonomous shuttles (Dekker,
35 2017). Moreover, neither possession of a monthly public transport pass nor access to a car had any
36 effect on preference for autonomous shuttles over manually-operated shuttles (Alessandrini, Delle
37 Site, Gatta, et al., 2016). Finally, people with the most flexible travel habits (for example car drivers)
38 preferred on-demand autonomous vehicles to autonomous public transport with fixed schedules
39 (Földes et al., 2018).

40 The presence or absence of **mobility difficulties** can also have an effect on acceptance. Faced with
41 the choice of an autonomous shuttle, a rented bicycle or walking, the ability to walk unaided and
42 without stopping for a distance of 200 m and to use a bicycle, increases the probability of choosing
43 the most useful means of transport in terms of cost and travel time (Wicki et al., 2019). This study
44 also showed that the presence of mobility difficulties increases the probability of choosing an
45 autonomous shuttle out of the same three means of transport. Temporary disability (Nordhoff, de

1 Winter, et al., 2019), walking problems, the after-effects of surgery and the need to carry luggage
 2 (Monéger, 2018) all increased the use of autonomous shuttles in the context of a hospital campus. In
 3 addition, people with impaired mobility seem to have a greater preference for an on-board
 4 supervisor than people with no disabilities (Földes et al., 2018).

5 3.2.2.3 Personality factors

6 A high level of **trust in autonomous vehicles** has been found to be a factor in the choice of an
 7 autonomous shuttle over a traditional bus (Wien, 2019; K. Winter et al., 2019) or other means of
 8 transport (Dekker, 2017). Herrenkind et al. (2019) also revealed a positive association between trust
 9 in autonomous shuttles and intention to use this type of vehicle. Attitudes towards technology have
 10 been found to be positively associated with the perceived usefulness of APTVs, and perceived
 11 behavioural control. These attitudes have been negatively associated with concerns about using
 12 APTVs (Acheampong & Cugurullo, 2019). However, Chen's study (2019) indicates that trust in
 13 autonomous shuttles positively modifies attitude towards them but does not have a significant direct
 14 effect on intention to use this type of transport. A positive **attitude towards autonomous shuttles** is
 15 associated with intention to use (Chen, 2019; Kostorz et al., 2019).

16 Numerous studies have observed that **interest in technology** is a factor of acceptance. Participants
 17 who are more positive about technology are more willing to try an autonomous vehicle (Földes et al.,
 18 2018), to choose an autonomous shuttle over a traditional bus (Wien, 2019; K. Winter et al., 2019) or
 19 to choose an autonomous shuttle instead of walking or renting a bicycle (Wicki et al., 2019).
 20 However, competence in technology or the feeling of having a high level of control over technology
 21 (i.e. a person's belief in their own ability to use technology) does not seem to have an effect on the
 22 choice between an autonomous shuttle and walking or renting a bicycle (Wicki et al., 2019).
 23 Confidence in technology also influences intention to use autonomous shuttles (Motak et al., 2017).
 24 Finally, a significant association between attraction to innovation and perceived ease of use of
 25 autonomous shuttles has been observed, but this is not the case for perceived utility (Herrenkind et
 26 al., 2019).

27 Perceived **behavioural control**, that is an individual's confidence in his/her own ability to use an
 28 autonomous shuttle, is another personality factor which has been shown to have an effect on
 29 intention to use (Motak et al., 2017). However, a negative association between the **need to control**
 30 and attitudes towards autonomous shuttles has also been observed (Herrenkind et al., 2019).

31 According to one study (Motak et al., 2017), **ecological values** are not a predictor of intention to use
 32 an autonomous shuttle, and they were not significantly associated with perceived usefulness in
 33 another (Herrenkind et al., 2019). They were, however, found to be positively associated with the
 34 perceived usefulness of APTVs and with intention to use APTVs in a third study (Acheampong &
 35 Cugurullo, 2019).

36 *Table 2. Factors of acceptance, acceptability or usage related to the micro-levelors and the number of studies that*
 37 *investigated them (n)*

| Themes | Factors | n |
|--------------------|---------|--|
| Socio-demographics | Age | Acceptability studies: 6 Acceptance studies: 7 Acceptability/acceptance studies: 2 Acceptability/usage studies: 1 |
| | Gender | Acceptability studies: 9 Acceptance studies: 5 Acceptability/acceptance studies: 2 |

| | | |
|-----------------|-----------------------------------|--|
| | Education | Acceptability studies: 6 Acceptance studies: 1 Acceptability/acceptance studies: 1 |
| | Income | Acceptability studies: 3 Acceptance studies: 1 Acceptability/acceptance studies: 1 |
| | Employment | Acceptability studies: 1 Acceptance studies: 1 Acceptability/usage studies: 1 |
| | Place of residence or work place | Acceptability studies: 4 Acceptance studies: 2 Acceptability/acceptance studies: 1 |
| Travel behavior | Travel purpose and weather | Acceptability studies: 2 Acceptance studies: 1 Acceptability/acceptance studies: 1 |
| | Attitude towards public transport | Acceptability studies: 2 |
| | Travel habits | Acceptability studies: 6 Acceptance studies: 1 Acceptability/acceptance studies: 2 |
| | Mobility difficulties | Acceptability studies: 1 Acceptance studies: 2 Acceptability/acceptance studies: 1 |
| Personality | Trust in autonomous vehicles | Acceptability studies: 4 Acceptance studies: 2 Acceptability/acceptance studies: 1 |
| | Technology interest | Acceptability studies: 3 Acceptance studies: 2 Acceptability/acceptance studies: 1 |
| | Control | Acceptance studies: 2 |
| | Ecological values | Acceptability studies: 1 Acceptance studies: 2 |

Table 3. Overview of the studies selected in the present literature review

| Reference | Vehicle | Methods | Participants | Exposure to autonomous vehicle | Factors studied |
|---|------------------------------------|---|---|--|--|
| Acheampong & Cugurullo, 2019 | Autonomous vehicles including APTV | Online survey (54 items; Likert scales) | 507 adults living in the Greater Dublin Area of the Republic of Ireland | Unspecified | Perceived expectancy Effort expectancy Concerns Subjective Norm Age Gender Education Attitude towards public transport Interest in technology Ecological values |
| Alessandrini, Delle Site, Stam, et al., 2016; Alessandrini et al., 2015; Alessandrini, Delle Site, Gatta, et al., 2016; Alessandrini et al., 2014 | Autonomous shuttle | Stated preference questionnaire (face-to-face, online, or telephone) | 3326 potential users of autonomous shuttles in 12 European cities (167-742/city) For the study of Alessandrini, Delle Site, Stam, et al. (2016): sub-sample of 1714 potential users of autonomous shuttles in 4 cities | No exposure (study conducted before implementation of autonomous shuttles) | Waiting time Travel time Location context Fares Age Gender Education Income Employment Travel habits |
| Anania et al., 2018 | Autonomous school bus | Online questionnaire (7 items; Likert scales + an emotion scale in study 2) | Study 1: 50 participants (25 females) living in the United States (within-subjects design); Study 2: 610 participants (274 females) living in the United States or in India (between-subjects) | Unspecified (probably no exposure) | Gender Place of residence |

| | | | | | |
|-------------------|--------------------|---|---|--|--|
| | | | design). Convenience sampling using Amazon's® Mechanical Turk® | | |
| Chen, 2019 | Autonomous shuttle | Self-administered questionnaire on paper (21 items in Likert scale + questions about respondent's characteristics) | Random selection of 700 questionnaires /1498 correctly completed / 1658 completed by passengers of an autonomous shuttle. Convenience sampling | Data collection after a trial on an autonomous shuttle in a scooter-dominant urban context | Performance perceived Effort perceived Perceived pleasure Age Gender Trust in autonomous vehicles Attitude towards autonomous shuttles |
| Dekker, 2017 | Autonomous shuttle | Online questionnaire (12 Likert scales items + 6 state preference questions + 9 questions about respondent's characteristics; 5-10 min) | 195 correctly completed questionnaires/198 questionnaires completed by participants working in three business areas (including one area served by an autonomous shuttle). Sample quite representative of the Dutch labour force, but with a greater proportion of men and a higher income and educational level | Exposure measured: 13.8% of participants used the autonomous shuttle weekly, 21.5% used it once or several times, 44.6% had seen or read something about it, 20% had no experience of it | Previous experience of autonomous vehicle Waiting time Travel time Fares Location context Flexibility Supervision Age Gender Education Place of residence Income Travel habits Trust in autonomous vehicles |
| Dong et al., 2017 | Autonomous bus | Online state preference questionnaire (Likert scales items + questions explaining | 891 correctly completed questionnaires/930 respondents/3350 University of Pennsylvania employees | Effect of prior knowledge of autonomous vehicles measured (sample proportion not indicated) | Prior knowledge of autonomous vehicle Concerns: road-safety, incivilities, absence of driver Supervision |

| | | | | | |
|----------------------------------|--------------------|--|---|---|---|
| | | previous responses + questions about respondent's characteristics) | who participated in a pre-tax transit commuter program contacted. Compared to transit users: under-representation of 18-24-olds and users 65 years and above; and higher income | | Age Gender Income Travel habits |
| Eden et al., 2017 | Autonomous shuttle | Collective semi-structured interviews | 17 autonomous shuttle passengers in the old town of Sion (Switzerland). Sample characteristics and recruitment methods unspecified | Data collection before and after a trial on an autonomous shuttle | Previous exposure to other APTVs Knowledge of an accident caused by an autonomous vehicle Schedules Location context Seat belt Feeling of safety Vehicle speed Braking behaviour Windows Seat Noise Vehicle size |
| Fernández Medina & Jenkins, 2017 | Autonomous shuttle | Two individual semi-structured interviews (2x60 min) | 33 participants recruited from people interested in trying an autonomous shuttle but who had no professional interest in autonomous technology, mainly living, working or commuting through | Data collection before and after a trial on an autonomous shuttle | Concerns: technology failure, absence of driver Vehicle speed Braking behaviour Road-facing seats Noise Supervision |

| | | | | | |
|-------------------------|---|--|--|---|---|
| | | | Greenwich, London. Various ages, genders and driving status | | |
| Földes et al., 2018 | Autonomous taxis and shuttles with on-demand and fixed services | Online questionnaire with multiple choice and Likert-scale questions (respondent's characteristics, mobility habits and expectations about autonomous vehicles) | 510 Hungarian participants. Sample not representative of the population | Usage cases not available in the region studied; 1/3 of the respondents had heard about autonomous vehicles | Waiting time Fares Travel information Internet access Travel purpose Travel habits Mobility difficulties Interest in technology |
| Fröhlich et al., 2019 | Autonomous shuttle | Study 1: paper questionnaire (illustration of different designs of dynamic information displays, 2 open questions, 2 Likert-scale questions; 10 min). Study 2: questionnaire after a simulated shuttle ride (2 Likert-scale questions; 10 min) | Study 1: 56 participants, without prior experience of a shuttle, aged 15-55. Study 2: 77 participants, aged 17-90. Participants in the 2 studies recruited during a shuttle demonstration on the site of a transport research conference | Study 1: data collection after a shuttle trial Study 2: data collection after simulated shuttle trial | Information about autonomous functioning |
| Herrenkind et al., 2019 | Autonomous shuttle | Study 1: phone individual semi-directed interviews (35 min) Study 2: online and paper survey | Study 1: 15 automotive industry experts (snowball sampling) Study 2: 268 participants recruited in a German city, sample varied in terms of gender, age, income, place of | Study 1: participants with professional experience of at least 3 years in future mobility. Study 2: participants recruited after a shuttle trial | Performance expectancy Effort expectancy Fares Concerns: personal data protection Trust in autonomous vehicle Capacity for personal innovation |

| | | | | | |
|-----------------------|--------------------|---|--|---|--|
| | | | residence, familiarity with public transport (57% used this at least a few times a month) | | Control Ecological values Social influence Perceived pleasure |
| Hinderer et al., 2018 | APTV | Paper questionnaire (17 questions): age group (pupil/students, employees, retired people), distance to the nearest bus stop, satisfaction with available mobility service (6 Likert-scale questions), attitudes towards APTV (8 Likert-scale questions), APTV requirements (6 questions) and additional comment sections) | 178 participants living in the village of Buechenbronn (suburban area) recruited outside the polling station during a parliamentary election. Sample composed of 2.87% of the village population | Unspecified | Performance expectancy Waiting time Fares Location context Access to the vehicle with a bicycle or a dog Age |
| Kostorz et al., 2019 | Autonomous shuttle | Online questionnaire including Likert-scale questions (15 minutes): respondent's characteristics, mobility habits and attitudes, introduction to autonomous shuttles, attitudes towards autonomous shuttle, usage and attitudes towards | 900 correctly completed questionnaires out of 1078 adult Germans surveyed. Representative sample of the German population (age, gender, rural-urban distributions) | Prior knowledge of autonomous vehicles measured. No experience of autonomous shuttles, however, the majority of participants knew of them | Prior knowledge of APTVs Effort expectancy Age Place of residence Income Travel purpose Attitude towards public transport Travel habits Attitude towards autonomous shuttles Interest in technology |

| | | | | | |
|-----------------------------|---|--|---|--|--|
| | | technology | | | |
| López-Lambas & Alonso, 2019 | Autonomous vehicles in general and autonomous bus in particular | Two focus groups (1h30-2h) | 8 participants per focus group, recruited in Madrid and Malaga. Age and gender diversity | Unspecified | Concerns: incivilities, technology failures, absence of driver supervision |
| Madigan et al., 2016 | Autonomous shuttle | Questionnaire on tablet (8-10 min), self-administered on site: respondent's characteristics, mobility habits, exposure to autonomous shuttle, attitude towards technology and attitudes towards autonomous shuttles | 349 participants residents or visitors of La Rochelle (France) and Lausanne (Switzerland), 61.6% of males | Participants had already interacted with the shuttle | Previous experience Performance expectancy Effort expectancy Social influence Age Gender Place of residence |
| Madigan et al., 2017 | Autonomous shuttle | Questionnaire on tablet (8-10 min), self-administered on site: respondent's characteristics and 20 Likert-scale questions performance expectancy, effort expectancy, social influence, facilitating condition, hedonic motivation and intention to use the | 315 participants aged 9-65, recruited in Trikala (Greece), 54.6% of males | Participants who had used a shuttle at least once | Previous experience Performance expectancy Effort expectancy Social influence Pleasure Integration into the public transport offer Age Gender |

| | | | | | |
|-----------------------------------|--------------------|---|--|---|---|
| | | autonomous shuttle. | | | |
| Motak et al., 2017; Monéger, 2018 | Autonomous shuttle | <p>Pilot study: 4 focus groups for the creation of the study questionnaire (1h45).</p> <p>Study 1: questionnaire (25-30 min, around 200 items): personal values, sociodemographic characteristics and mobility habits, introduction to autonomous shuttle, and perception and attitudes towards autonomous shuttle</p> <p>Study 2: on-site questionnaire, abbreviated version from the previous one</p> <p>Additional study from Monéger, 2018: experiment on shuttle: measure of acceptance in different conditions (with and without a manual horn; with or without a humanoid voice)</p> | <p>Pilot study: 23 occasional visitors to a hospital campus aged 19-67.</p> <p>Study 1: 370 students aged 18-25.</p> <p>Study 2: occasional visitors to the hospital campus (108 autonomous shuttle non-users of aged 16-87, and 54 first-time users aged 28-76)</p> | <p>Pilot study and study 1: conducted before the implementation of the autonomous shuttle</p> <p>Study 2: data gathering prior to implementation of the autonomous shuttle for 108 respondents, and after a trial on autonomous shuttle for 54 respondents</p> <p>Additional study: data collection after a trial on autonomous shuttle</p> | <p>Previous experience</p> <p>Performance expectancy</p> <p>Effort expectancy</p> <p>Social influence</p> <p>Perceived pleasure</p> <p>Concerns: road-safety</p> <p>Manual control means</p> <p>Supervision</p> <p>Humanoid voice</p> <p>Age</p> <p>Travel habits</p> <p>Mobility difficulties</p> <p>Technology interest</p> <p>Control</p> <p>Ecological values</p> |
| Nordhoff et al., 2018 | Autonomous shuttle | Online questionnaire (68 items): respondent | 384 participants recruited online, 274 | Participants had used an autonomous shuttle | <p>Effort expectancy</p> <p>Vehicle speed</p> |

| | | | | | |
|-----------------------------------|--------------------|---|--|--|--|
| | | characteristics and impressions about the autonomous shuttle and the services, attitudinal questions and acceptance questions | included in the analyses | | Supervision Vehicle size Age Gender Work location |
| Nordhoff, de Winter, et al., 2019 | Autonomous shuttle | Face-to-face or phone (2/30) semi-directed interview (50 min) about acceptance factors of the autonomous shuttle | 30 participants recruited from among former participants in previous studies, students or campus employees and people who expressed interest in participating in the study | Participants used the autonomous shuttle just before data collection | Previous experience Vehicle exposure Media coverage Performance expectancy Location context Travel information Flexibility Reliability Vehicle speed Braking behaviour Stop button Supervision Manual control means Automation level Large windows Free internet access Comfortable seats Internal appearance Air conditioning Vehicle size Obstacle-free access Weather Mobility difficulties |
| Nordhoff et al., 2017 | Autonomous shuttle | Self-administered questionnaire on tablet (37 items): | 326 participants recruited on an autonomous shuttle | Data collection after a trial on the autonomous shuttle; first ever trial for 95.7% of | Performance expectancy Effort expectancy Social influence |

| | | | | | |
|--------------------------|--------------------|---|---|--|--|
| | | intention to use an autonomous shuttle, perceived usefulness, ease of use, social influence, trust, ecological norms, pleasure; respondent's characteristics | demonstration site, on a campus (31.9% male, 77.1% campus employees) | participants | Integration into public transport system Age Gender |
| Pakusch & Bossauer, 2017 | APTV | Online questionnaire: presentation of APTV, mobility habits, experience of autonomous vehicles and attitude towards APTV (Likert scales and open questions), respondent's characteristics | 201 participants (18-81 years, 49.3% female) recruited online, mainly students) | 91% of participants already knew about autonomous vehicles, 37.1% had already tried an autonomous vehicle (train, tram, metro, car or shuttle) | Previous experience Age Gender Travel habits |
| Papadima et al., 2020 | Autonomous shuttle | Study 1: online questionnaire (21 items): respondents characteristics, exposure to autonomous shuttle, impressions of the pilot implantation of autonomous shuttle Study 2: online conjoint analysis; attributes: information provision mode, frequency of service, stop facilities, walking | Trikala citizens recruited online Study 1: 158 participants (48.7% female, 70.3% permanent Trikala citizens) Study 2: 43 participants | Study 1: 78% of participants had never tried an autonomous shuttle; 12% had tried one; 9.5% used one daily. | Frequency Fares Travel information Supervision Access and characteristics of stops |

| | | | | | |
|-----------------------|---|--|---|---|---|
| | | distance from bus stop, supervision, fares | | | |
| Piao et al., 2016 | Autonomous vehicles, including autonomous shuttle | Questionnaire administered online and by phone (28 items): knowledge of autonomous vehicles, attractiveness and concerns about autonomous shuttles, taxis and cars, and attitude towards owning and sharing autonomous cars | Online questionnaire: 148 participants living near an autonomous shuttle demonstration. Phone questionnaire: 352 participants living in the La Rochelle area. After resampling to correspond to local demography in terms of age, gender and education: 425 participants (53.6% female) | Participants living, working or studying in a city with an autonomous shuttle demonstration, 87% of them had heard about autonomous vehicles, and a minority (rate unclear) had already tried an autonomous shuttle | Fares Concerns: incivilities, night service Supervision |
| Portouli et al., 2017 | Autonomous shuttle | Study 1: face-to-face questionnaire: respondent's characteristics, previous exposure to the autonomous shuttle, satisfaction with it, usefulness, safety perceived, and willingness to use it and pay for it Study 2: paper questionnaire: attitude towards autonomous vehicles, attractiveness, concerns and | Study 1: 200 autonomous shuttle passengers (105 females) Study 2: 519 Trikala citizens (urban and suburban areas) | Study 1: participants were autonomous users; 40% had used once, 42.5% twice, 17% 3-5 times and 1 person more than 5 times Study 2: participants were aware of an autonomous shuttle demonstration in Trikala; 318 participants had never used the autonomous shuttle, 105 were regular users | Previous experience Fares Supervision Age Education Employment |

| | | | | | |
|-----------------------|--|--|---|---|---|
| | | preferences | | | |
| Ramseyer et al., 2018 | Autonomous shuttle | Individual interviews. Before an autonomous ride: concerns, anticipated advantages, and advance description of the ride After the ride: description of the ride, positive and negative impressions, things to be changed, changes in previous concerns and intention to use autonomous vehicles | 21 students in risk management from a university in Switzerland | Data collection before and after a trial on an autonomous shuttle (1 st exposure to an autonomous vehicle) | Waiting time Vehicle speed Braking behaviour Supervision Manual control means Windows Seating configuration |
| Roche-Cerasi, 2019 | Autonomous shuttle (+ 1 question about autonomous bus) | Online questionnaire (27 questions): mobility habits, transport priorities, autonomous shuttle experience and their usefulness, concerns and trust and respondents' characteristics | 1479 members of the car federation of Norway (19-98 years, 80.7% male). Sample unrepresentative of the Norwegian population (in terms of age, gender, income, travel habits). | 91.8% of respondents had heard of autonomous shuttles; 1.4% had tried one | Location context Concerns Automation level Age Gender Education Place of residence |
| Salonen, 2018 | Autonomous shuttle | Face-to-face questionnaire: perceptions of traffic safety, on-vehicle security and emergency | 197 autonomous shuttle passengers during an important design exhibition in Finland (61.9% female; discretionary sampling) | Data collection after a trial on an autonomous shuttle | Age Gender Education Income Employment |

| | | | | | |
|--------------------------|---|---|---|---|--|
| | | management on an autonomous shuttle compared to a bus travelling in the same conditions, and respondent's characteristics | | | |
| Salonen & Haavisto, 2019 | Autonomous shuttle | Semi-structured individual interview (10-15 min): reaction to the autonomous shuttle, attitudes towards it, social factors and passenger's feelings | 44 autonomous shuttle passengers on a route between a metro station and a university in Helsinki (45.5% females, 15-64 years, 50% students) | Data collection after a trial in autonomous shuttle | <ul style="list-style-type: none"> Previous experience Knowledge of an accident Media coverage Frequency and schedules Location context Flexibility Concerns: algorithm of decision-making Vehicle speed Supervision |
| Stark et al., 2019 | Three use cases, including autonomous vehicle on a traditional bus route, and first and last mile service | Workshops including 3 focus groups and individual interviews about the needs, requirements and challenges of APTV | 13-16 workshop participants recruited online: public transport users, local authorities and transport operators | Unspecified | <ul style="list-style-type: none"> Waiting time Fares Integration with other transport means and intramodality Location context Travel information Reliability Flexibility Concerns: personal data protection, night service Vehicle speed Countermeasures: child safety seats, registration of passengers, video and audio surveillance, respect of |

| | | | | | |
|-----------------------|---|--|--|---|---|
| | | | | | <ul style="list-style-type: none"> security standards Vehicle size Obstacle-free access Gender |
| Vöge & McDonald, 2003 | APTV and personal autonomous automobile | 23 focus groups and individual interviews | Total N unspecified (>257). Potential users, non-users, public decision makers, public and private operators in seven countries (such as France, Israel). 10-12 participants /focus group; 27 participants for individual interviews | Unspecified | <ul style="list-style-type: none"> Waiting time Fares Integration with other transport means Location context Travel information Flexibility Vehicle speed Countermeasures: seat belts, prohibition of standing, communication means, autonomous medical emergency management Manual control means Information about autonomous functioning Free internet access Vehicle appearance Cleanliness Vehicle size Obstacle-free access Overloading prevented |
| Wicki et al., 2019 | Autonomous shuttle | Online state preference questionnaire (13 min) with 3 alternatives: autonomous shuttle, walking and rented bike and respondent's | 879 respondents out of 1080 adult residents of the Canton of Schaffhausen invited to participate. Analysis on data of the 761 respondents who knew | Respondents already knew about an autonomous shuttle test | <ul style="list-style-type: none"> Previous experience Waiting time Travel time Fares Occupancy rate Weather Mobility difficulties |

| | | characteristics | about an autonomous shuttle test in the Canton | | Interest in technology |
|------------------------------------|--------------------|--|--|---|--|
| Wien, 2019; K. Winter et al., 2019 | Autonomous shuttle | Online state preference questionnaire with 3 alternatives: autonomous shuttle and regular bus and an opt-out alternative, respondent's characteristics | 282 questionnaires completed out of 305 citizens and employees surveyed in two municipalities (Vaals, Netherlands, and Aachen, Germany) where autonomous shuttles were to be implemented. Respondents used public transport at least yearly (48.9% female). Sample representative of public transport users in the Netherlands | No previous exposure (data collection before implementation of an autonomous shuttle trial) | Waiting time Travel time Fares Flexibility Supervision Age Gender Travel habits Trust in autonomous vehicles Interest in technology |
| S. R. Winter et al., 2018 | Autonomous bus | Online questionnaire with two scenarios: autonomous bus or regular bus and a willingness to ride scale (study 1: within-participants design; study 2: mixed-participants design) | Study 1: 510 American participants (226 females) Study 2: 571 American participants (276 females). Convenience sampling on Amazon Mechanical Turk | Unspecified | Gender Vehicle user (self or family member) Place of residence |
| Wintersberger et al., 2018 | Autonomous shuttle | Face-to-face questionnaire about respondent's characteristics and expectations and | 12 participants, aged under 35, recruited on the autonomous shuttle pilot site in a Bavarian city | Participants had no exposure prior to the study; data gathered before and after an autonomous shuttle trip and a trip in a regular taxi | Previous experience Travel duration Vehicle speed |

| | | | | | |
|--|--|---|--|--|--|
| | | individual semi-directed interview about opinions | | | |
|--|--|---|--|--|--|

4 Discussion

The deployment of APTVs is relatively recent, and they exist mainly in the form of autonomous shuttles as part of pilot experiments (The Aspen Institute Center for Urban Innovation, n.d.). The literature review presented in this paper, which aims to contribute to the design and implantation of this new mode of transport, so that it meets the needs of the greatest possible number of potential users, provides a fairly exhaustive review of the factors of acceptability, acceptance and use of APTVs. This literature review offers ways of alleviating concerns and of encouraging the future use of APTVs. It could serve as a guideline for designers, manufacturers and policy makers, and help them to provide autonomous mobility services which correspond to the needs of users and potential users.

As suggested by the MAVIA model (Nordoff et al., 2019), the process of acceptance starts with the exposure of the individual to the autonomous vehicle in a first stage. The exposure can consist of a real usage or simply to some knowledge about the autonomous vehicle. This first stage is crucial because it moves to the formation of either a favorable or unfavorable attitude towards autonomous vehicles (stage 2) which can influence the decision to adopt it (stage 3) and to use it (stage 4). In accordance with the MAVIA model, a negative experience with an autonomous vehicle may affect the future usage of APTVs. As shown in the present literature review, individuals who have experienced negative exposure related to vehicle safety, to on-board security or abrupt braking experience on an autonomous shuttle may have an unfavorable attitude towards this type of vehicle in the future, limiting their intention to use it

At the opposite, many factors may lead to the formation of a favorable attitude increasing willingness to use APTVs. These factors relate mainly to the ways in which APTVs could improve mobility services and were also found by Nordoff et al. (2019) and presented at the domain-specific system evaluation level. Potential users estimate that they would save time and money, be more comfortable on-board and have good visibility from the vehicle. Free internet access, comfortable and well oriented seats are also factors contributing to a positive attitude towards the APTV. Most of the personal factors which are consistently found to be positively associated with willingness to use APTVs can be influenced by the vehicle's characteristics or by the level of mobility service offered. Trust in autonomous vehicles, users' performance expectancy and effort expectancy, social influence and perceived pleasure might therefore be greater when users or potential users interact with APTVs which are secure, reliable, useful, efficient, comfortable, accessible, easy and pleasant to use. In this perspective, positive exposure to an autonomous vehicle (through experience, word-of-mouth or the media) can increase the likelihood of using an APTV.

The literature review of Jing et al. (2020) conducted on any kind of autonomous vehicles also indicated that psychological factors have proven to be predictors of acceptance intention. They reported that the effect of the psychological variables on the acceptance may be direct or indirect. The authors also highlighted that there are complex interactions between variables, the choice to use or not an APTV is thus multifactorial. The presence of interactions between factors may explain that results sometimes appear divergent in the literature. Low vehicle speed, for instance, can be perceived both as a marker of security, and a sign of inefficiency. The presence of supervision, which can be reassuring for some users, can also be perceived as evidence that the vehicle is not entirely reliable by others. Discrepancies surrounding personal factors, in particular socio-demographic characteristics, also exist. Although male and younger users and potential users appear to have a more positive attitude towards APTVs in some studies, not all studies point in the same direction

regarding the effects of gender, age, education level and place of residence. In addition, inconsistencies around ecological values could be related to the fact that autonomous vehicles can be seen as being both ecological (since they are commonly associated with electric vehicles), and as non-ecological (compared to walking or cycling). However, these contradictory results could also be related to differences between studies in terms of methodology (qualitative interview or online survey; involving a shuttle trial or not), nature and size of study samples, usage contexts (campus, city center or rural environment) or vehicle considered (shuttle, buses). In one study, for example, participants indicated that their positive perception of the safety of an autonomous shuttle might change if the vehicle was larger (for example a bus), if there was no supervisor, or if the journey took place on a real road and at normal speed (Eden et al., 2017).

To summarize, the factors of acceptance of APTVs the most cited in the literature relate to the quality of the service on offer, as is the case for every means of public transport. As research has shown, autonomous aspects seem to matter less than the improvement of mobility services (Fernández Medina & Jenkins, 2017; Hinderer et al., 2018). Nevertheless, the autonomous aspect of APTVs and the absence of a driver bring new concerns. These concerns are about the vehicle's total dependency on technology, poor braking behaviour, safety and on-board security. Factors related to comfort and vehicle access appear to be less central, but results on these may be due to the fact that samples studied are not always representative, and do not include the profiles of all potential users. Elderly people and people with disabilities, who are not explicitly included in the studies we reviewed, may have greater needs in terms of accessibility or comfort. In addition, for both safety and acceptability issues, implementation of APTVs which are unreliable and inefficient appears to compromise the future use of these vehicles. While rail-bound autonomous public transport vehicles (subways, trains, trams) are now a full part of the transport supply, and are preferred over non-rail autonomous public transport vehicles (Pakusch & Bossauer, 2017), these new autonomous systems give rise to concerns, and raise questions about their acceptability.

One limitation of the present literature review was that the majority of the studies reviewed here consisted of surveys conducted on respondents who had never used an APTV. Some of the findings are therefore based on the projections of potential users rather than on the actual opinions of real users, limiting their generalization. As it is the case for recent publications (Bernhard et al., 2020; Hilgarter & Granig, 2020), it can be reasonably expected that as more and more APTVs are introduced, future studies will focus more on individuals who have already tried one of these vehicles, or who even use them for day to day travel. Future studies will go on to fine-tune the findings of our present review of the literature.

4.1. Conclusion and recommendations

As highlighted by the present review, it is important not to expose the public to pilot implementations with negative experience, especially those involving bad braking behaviours and which do not meet mobility needs. It is essential to propose secure, useful and comfortable autonomous systems if we wish to encourage more wide-spread adherence to APTVs. To alleviate users' concerns, rules such as the prohibition of standing when the vehicle is in motion could be imposed. Preventive equipment, such as seat belts, child safety seats, video surveillance or a means of dealing with emergencies (for example, a button for emergency stops or to open the doors and a means of communication) could also be made available.

Potential users also require a means of compensating for the absence of a driver - for example, information screens and easy, obstacle-free access to the vehicle. As for the location of APTV implementation, normal urban traffic conditions are seen as less acceptable. Implementation in a more secure context, for example on dedicated routes, on campus, or in areas with no public transport links, such as rural areas, is seen as preferable.

A great deal remains to be done before APTVs, which correspond completely to users' needs can be successfully implemented. Although many pilot experiments with autonomous shuttles have been conducted, they have not yet managed to entirely convince all potential users. The latter continue to express concerns about safety, security, usability, accessibility and comfort. This review of the literature allows us to conclude that in order to improve acceptance of APTVs, users' confidence in them must increase.

Finally, a number of factors cited across studies should be investigated more thoroughly in future research in order to assess their impact on acceptance of APTVs. These factors are the display of information about autonomous functioning, vehicle appearance, air-conditioning, cleanliness, prevention of vehicle overload, vehicle access with a bicycle or a dog, and some stop characteristics. Similarly, relatively little research has been carried out on personal factors, such as attitudes towards public transport, behavioural control and need for control.

Other studies are required to analyze the needs, expectations and concerns of elderly people and people with disabilities in greater detail. Although some of the studies included in the present review evoke the needs and concerns expressed on this subject by respondents, APTV accessibility for people with disabilities and the elderly does not seem to have been studied specifically (Tabattanon et al., 2019).

- Funding

This literature review has been conducted within the framework of the STAR project funded by FUI (Fonds Unique Interministériel) of the French government.

5 References

* References included in the literature review

*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: Traffic Psychology and Behaviour*, 62, 349-375.

*Alessandrini, A., Alfonsi, R., Delle Site, P., & Stam, D. (2014). Users' preferences towards automated road public transport: results from European surveys. *Transportation Research Procedia*, 3, 139-144.

- *Alessandrini, A., Delle Site, P., Gatta, V., Marcucci, E., & Zhang, Q. (2015). *Stated preference logit analysis of users' attitudes towards conventional and automated buses* (No. 0215).
- *Alessandrini, A., Delle Site, P., Gatta, V., Marcucci, E., & Zhang, Q. (2016). Investigating Users' Attitudes Towards Conventional and Automated Buses. *International Journal of Transport Economics*, 43(4), 413-436. <https://doi.org/10.19272/201606704001>
- *Alessandrini, A., Delle Site, P., Stam, D., Gatta, V., Marcucci, E., & Zhang, Q. (2016). Using repeated-measurement stated preference data to investigate users' attitudes towards automated buses within major facilities. *Advances in Intelligent Systems and Computing*, 539, 189-199. https://doi.org/10.1007/978-3-319-48944-5_18
- *Anania, E. C., Rice, S., Winter, S. R., Milner, M. N., Walters, N. W., & Pierce, M. (2018). Why people are not willing to let their children ride in driverless school buses: A gender and nationality comparison. *Social Sciences*, 7(3), 34.
- Azad, M., Hoseinzadeh, N., Brakewood, C., Cherry, C. R., & Han, L. D. (2019). *A Literature Review on Fully Autonomous Buses*. Washington DC: Transportation Research Board.
- Bernhard, C., Oberfeld, D., Hoffmann, C., Weismüller, D., & Hecht, H. (2020). User acceptance of automated public transport: Valence of an autonomous minibus experience. *Transportation Research Part F: Traffic Psychology and Behaviour*, 70, 109-123. <https://doi.org/10.1016/j.trf.2020.02.008>
- *Chen, C.-F. (2019). Factors affecting the decision to use autonomous shuttle services: Evidence from a scooter-dominant urban context. *Transportation research part F: traffic psychology and behaviour*, 67, 195-204. <https://doi.org/10.1016/j.trf.2019.10.016>
- Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, 13(3), 319-340. <https://doi.org/10.2307/249008>
- *Dekker, M. J. (2017). *Riding a self-driving bus to work: Investigating how travellers perceive ADS-DVs on the last mile*.

<https://repository.tudelft.nl/islandora/object/uuid%253Ac9773355-d4a3-4063-9799-11343c625c01?collection=education>

- *Dong, X., DiScenna, M., Guerra, E., & Transportation Research Board. (2017). *Transit User Perception of Driverless Buses*. *Transportation*, 46(1), 35-50.
- *Eden, G., Nanchen, B., Ramseyer, R., & Evequoz, F. (2017). Expectation and Experience: Passenger Acceptance of Autonomous Public Transportation Vehicles. In R. Bernhaupt, G. Dalvi, A. Joshi, D. K. Balkrishan, J. O'Neill, & M. Winckler (Éds.), *Human-Computer Interaction—Interact 2017* (p. 360-363). Springer International Publishing Ag.
- *Fernández Medina, K., & Jenkins, R. (2017). *GATEway: Public Perceptions of a Last-Mile Driverless Shuttle*. https://gateway-project.org.uk/wp-content/uploads/2018/06/D3.7_TRL-Workshop-Findings-Report.pdf.
- Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research. *Contemporary Sociology*, 6(2), 244-245. <https://doi.org/10.2307/2065853>
- *Földes, D., Csiszár, C., & Zarkeshev, A. (2018). User expectations towards mobility services based on autonomous vehicle. In *8th International Scientific Conference CMDTUR 2018* (p. 7-14).
- *Fröhlich, P., Schatz, R., Buchta, M., Schrammel, J., Suetterle, S., & Tscheligi, M. (2019). "What's the Robo-Driver up to?" Requirements for Screen-based Awareness and Intent Communication in Autonomous Buses. *i-com*, 18(2), 151–165.
- Gandia, R. M., Antonialli, F., Cavazza, B. H., Neto, A. M., Lima, D. A. de, Sugano, J. Y., Nicolai, I., & Zambalde, A. L. (2019). Autonomous vehicles: Scientometric and bibliometric review. *Transport Reviews*, 39(1), 9-28. <https://doi.org/10.1080/01441647.2018.1518937>
- Harb, M., Xiao, Y., Circella, G., Mokhtarian, P. L., & Walker, J. L. (2018). Projecting travelers into a world of self-driving vehicles: Estimating travel behavior implications via a naturalistic experiment. *Transportation*, 45(6), 1671-1685. <https://doi.org/10.1007/s11116-018-9937-9>

- *Herrenkind, B., Brendel, A. B., Nastjuk, I., Greve, M., & Kolbe, L. M. (2019). Investigating end-user acceptance of autonomous electric buses to accelerate diffusion. *Transportation Research Part D: Transport and Environment*, 74, 255-276. <https://doi.org/10.1016/j.trd.2019.08.003>
- Hilgarter, K., & Granig, P. (2020). Public perception of autonomous vehicles: A qualitative study based on interviews after riding an autonomous shuttle. *Transportation Research Part F: Traffic Psychology and Behaviour*, 72, 226-243. <https://doi.org/10.1016/j.trf.2020.05.012>
- *Hinderer, H., Stegmüller, J., Schmidt, J., Sommer, J., & Lucke, J. (2018). Acceptance of Autonomous Vehicles in Suburban Public Transport An empirical study on requirements and prerequisites expected by inhabitants. In *Ieee International Conference on Engineering, Technology and Innovation (Ice/Itmc)*. Stuttgart (p. 1-8). doi: 10.1109/ICE.2018.8436261.
- Jing, P., Xu, G., Chen, Y., Shi, Y., & Zhan, F. (2020). The determinants behind the acceptance of autonomous vehicles: a systematic review. *Sustainability*, 12(5), 1719.
- *Kostorz, N., Hilgert, T., Kagerbauer, M., & Vortisch, P. (2019). What do people think about autonomous minibuses in Germany? In *8th Symposium of the European Association for Research in Transportation* (p. 1-12).
- *López-Lambas, M. E., & Alonso, A. (2019). The Driverless Bus: An Analysis of Public Perceptions and Acceptability. *Sustainability*, 11(4986), 1-25.
- *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. <https://doi.org/10.1016/j.trpro.2016.05.237>
- *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. <https://doi.org/10.1016/j.trf.2017.07.007>

- Millonig, A., & Froehlich, P. (2018). *Where Autonomous Buses Might and Might Not Bridge the Gaps in the 4 A's of Public Transport Passenger Needs—A Review*. In *Proceedings of the 10th International ACM Conference on automotive user interfaces and interactive vehicular applications*. (p. 291-297).
- *Monéger, F. (2018). *Conception d'un service de transport par navettes autonomes acceptable et sécurisé : Approche ergonomique par l'analyse des expériences vécues et des valeurs en acte* [PhD Thesis, Université Clermont Auvergne].
- *Motak, L., Neuville, E., Chambres, P., Marmoiton, F., Moneger, F., Coutarel, F., & Izaute, M. (2017). Antecedent variables of intentions to use an autonomous shuttle: Moving beyond TAM and TPB? *European Review of Applied Psychology-Revue Europeenne De Psychologie Appliquee*, 67(5), 269-278. <https://doi.org/10.1016/j.erap.2017.06.001>
- *Nordhoff, S., de Winter, J., Madigan, R., Merat, N., van Arem, B., & Happee, R. (2018). User acceptance of automated shuttles in Berlin-Schoneberg: A questionnaire study. *Transportation Research Part F-Traffic Psychology and Behaviour*, 58, 843-854. <https://doi.org/10.1016/j.trf.2018.06.024>
- *Nordhoff, S., de Winter, J., Payre, W., van Arem, B., & Happee, R. (2019). What impressions do users have after a ride in an automated shuttle? An interview study. *Transportation Research Part F: Traffic Psychology and Behaviour*, 63, 252-269. <https://doi.org/10.1016/j.trf.2019.04.009>
- Nordhoff, S., Kyriakidis, M., Van Arem, B., & Happee, R. (2019). A multi-level model on automated vehicle acceptance (MAVA): A review-based study. *Theoretical Issues in Ergonomics Science*, 20(6), 682–710.
- *Nordhoff, S., van Arem, B., Merat, N., Madigan, R., Ruhrort, L., Knie, A., & Happee, R. (2017). User acceptance of driverless shuttles running in an open and mixed traffic environment. In *Proceedings of the 12th ITS European Congress, Strasbourg, France* (p. 19–22).

- *Pakusch, C., & Bossauer, P. (2017). User acceptance of fully autonomous public transport. In *Proceedings of the 14th International Joint Conference on e-Business and Telecommunications 2* (p. 52-60).
- *Papadima, G., Genitsaris, E., Karagiotas, I., Naniopoulos, A., & Nalmpantis, D. (2020). Investigation of acceptance of driverless buses in the city of Trikala and optimization of the service using Conjoint Analysis. *Utilities Policy*, *62*, 1-9.
- *Piao, J., McDonald, M., Hounsell, N., Graindorge, M., Graindorge, T., & Malhene, N. (2016). Public Views towards Implementation of Automated Vehicles in Urban Areas. *Transportation Research Procedia*, *14*, 2168-2177. <https://doi.org/10.1016/j.trpro.2016.05.232>
- *Portouli, E., Karaseitanidis, G., Lytrivis, P., Amditis, A., Raptis, O., & Karaberi, C. (2017). Public attitudes towards autonomous mini buses operating in real conditions in a Hellenic city. In *28th IEEE Intelligent Vehicles Symposium* (p. 571-576).
- *Ramseyer, R., Cimmino, F., Emery, L., Grezes, S., Grezes, V., Nanchen, B., Simon, E., & Fragniere, E. (2018). *Using Phenomenology to Assess Risk Perception of a New Technology in Public Transportation the Case of the Autonomous Vehicles as Mobility as a Service (MaaS) in Switzerland*. In *2018 3rd International Conference on System Reliability and Safety (ICSRS)* (pp. 289-293). <https://doi.org/10.1109/ICSRS.2018.8688840>
- *Roche-Cerasi, I. (2019). Public acceptance of driverless shuttles in Norway. *Transportation research part F: traffic psychology and behaviour*, *66*, 162-183. <https://doi.org/10.1016/j.trf.2019.09.002>
- SAE International. (2018). *Taxonomy and definitions for terms related to driving automation systems for on-road motor vehicles*. https://saemobilus.sae.org/content/j3016_201806
- *Salonen, A. O. (2018). Passenger's subjective traffic safety, in-vehicle security and emergency management in the driverless shuttle bus in Finland. *Transport Policy*, *61*, 106-110.

- *Salonen, A. O., & Haavisto, N. (2019). Towards Autonomous Transportation. Passengers' Experiences, Perceptions and Feelings in a Driverless Shuttle Bus in Finland. *Sustainability*, 11(3), 1-19. <https://doi.org/10.3390/su11030588>
- Schade, J., & Schlag, B. (2003). Acceptability of urban transport pricing strategies. *Transportation Research Part F: Traffic Psychology and Behaviour*, 6(1), 45-61.
- Schuitema, G., Steg, L., & Forward, S. (2010). Explaining differences in acceptability before and acceptance after the implementation of a congestion charge in Stockholm. *Transportation Research Part A: Policy and Practice*, 44(2), 99-109.
- *Stark, K., Gade, K., & Heinrichs, D. (2019). What Does the Future of Automated Driving Mean for Public Transportation? *Transportation Research Record: Journal of the Transportation Research Board*, 89-93.
- Tabattanon, K., Sandhu, N., & D'Souza, C. (2019). Accessible Design of Low-Speed Automated Shuttles: A Brief Review of Lessons Learned from Public Transit. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 63(1), (p. 526-530).
- The Aspen Institute Center for Urban Innovation. (n.d.). *Bloomberg Aspen Initiative on Cities and Autonomous Vehicles*. Retrieved the 2019, June 24th, from <https://avsincities.bloomberg.org/>
- Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, 27(3), 425-478. <https://doi.org/10.2307/30036540>
- *Vöge, P., & McDonald, M. (2003). User needs analysis for automated urban transport systems – A qualitative approach. In *Proceedings of the 10th world congress on intelligent transport systems and services* (p. 16–20).
- *Wicki, M., Guidon, S., Becker, F., Axhausen, K. W., & Bernauer, T. (2019). How technology commitment affects willingness to use AVs: Results from realistic mode choice experiment for a self-driving shuttle service. In *19th Swiss Transport Research Conference* (p. 1-28).

*Wien, J. (2019). *An assessment of the willingness to choose a self-driving bus for an urban trip: A public transport user's perspective.*

<https://repository.tudelft.nl/islandora/object/uuid%3A8064cc17-dc0e-4c0c-9a9c-6efca8564d94>.

*Winter, K., Wien, J., Molin, E., Cats, O., Morsink, P., & van Arem, B. (2019). Taking the self-driving bus: A passenger choice experiment. In *6th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS)*, 1–8.

*Winter, S. R., Rice, S., Mehta, R., Walters, N. W., Pierce, M. B., Anania, E. C., Milner, M. N., & Rao, N. (2018). Do Americans differ in their willingness to ride in a driverless bus? *Journal of Unmanned Vehicle Systems*, 6(4), 267-278. <https://doi.org/10.1139/juvs-2018-0020>

*Wintersberger, P., Frison, A.-K., & Riener, A. (2018). Man vs. machine: Comparing a fully automated bus shuttle with a manually driven group taxi in a field study. In *Adjunct Proceedings of the 10th International Conference on Automotive User Interfaces and Interactive Vehicular Applications* (p. 215–220).