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Public perception of autonomous vehicles: A qualitative study based on interviews after riding an autonomous shuttle

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ABSTRACT

Autonomous vehicles (AVs) can potentially compensate for human error whilst driving. Thus, the number of accidents and the amount of congestion, emissions and fuel consumption could be reduced. For such reduction to occur, insights into public acceptance of AVs must be considered because they are a crucial factor for the successful implementation of AVs in existing traffic systems.

Purpose: This study aims to explore (1) the mobility behaviour of current passengers, (2) the perception of the public of how AVs can be applied, (3) the perceived challenges of AVs in terms of integration into existing traffic systems, (4) the general attitude of the public towards AVs and (5) the perceived safety of passengers after riding an autonomous shuttle with a maximum SAE level of 3 in the setting of mixed traffic.

Method: This qualitative study was conducted in Carinthia (Austria) in September 2018. Interviews were conducted with 19 participants aged between 20 and 75 years. The participants were recruited through purposeful sampling, and data were collected through in-depth, semistructured interviews which were recorded, transcribed, organised and analysed using systematic, qualitative content analysis.

Results: Results show that transport mobility plays an important role in social life. In rural areas, AVs can shift transportation modes from private cars to public transportation. The respondents perceive AVs as an alternative more than as a substitute for existing means of transportation. With the integration of AVs into existing traffic systems, the transportation of goods and people could be improved despite related uncertainties. This study explores different aspects of societal, technical, legal and economic challenges. Overall, the respondents feel positive about AVs. Responses regarding safety show that experience with AVs and speed are key factors.

Originality/Value: This study is one of the first to explain qualitatively public perceptions of AVs after an actual ride in an AV under real-life conditions. The results, which help understand AVs from the public's perspective, may also provide guidelines for the successful integration of AVs in Austria.

1. Introduction

Transport mobility, which refers to motorised vehicular transportation, offers potential for movement and is regarded as the capacity of an individual to overcome physical distance (Sager, 2005) depending on the mobility tools one has access to

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(Spinney, Scott, & Newbold, 2009). A close link to one's independence also exists because fundamental tasks can be performed beyond the home environment (Vella-Brodrick & Stanley, 2013). In addition, transport mobility can play an important role in terms of well-being and quality of life (Sager, 2005; Spinney et al., 2009; Vella-Brodrick & Stanley, 2013). Over the last few decades, technology has transformed the automotive industry. In this context, autonomous vehicles (AV) have become arguably one of the automotive and mobility industries' most important and innovative technologies. New technologies offer the automobile industry the opportunity to generate new business models, which can improve user experience, security and comfort (Attias, 2017; Berrada, Christoforou, & Leurent, 2017). Along with innovative technologies and services, including electrical cars, app-based car-sharing, taxi solutions and micromobility services, AVs will lead the future of transport mobility (Ehlers, 2018; Krasniqi & Hajrizi, 2016; Spillar, 2019). Automated driving technology is assumed to result in a paradigm shift in the transportation system. This shift to give up the active driving role can influence user experience, mode choices and business models (Chan, 2017). In Western countries, private motor vehicle use has been increasing steadily since the 1960s. In Austria, 4.98 million private motor vehicles were registered at the end of 2018; this number is 1.6% more than the that of the previous year in a country of 8.84 million inhabitants (Statistik Austria, 2019b). The increased use of private cars causes more emissions, increased congestion and higher accident rates. AVs offer an opportunity to shift from excessive private vehicle use to public transportation (Salonen and Haavisto, 2019).

Since the 1970s, numerous studies have shown that human error (e.g. failure, impairment, fatigue or distraction) contributes to more than 90% of accidents (e.g. Dingus et al., 2016; NCSA, 2015; Salmon, Regan, & Johnston, 2005; Treat et al., 1979). Fagnant and Kockelman (2015) estimated the broad economic and safety impact AV technology may have on the basis of three penetration rates (10%, 50% and 90%) which include market shares and technological improvements over time. An AV market penetration rate of 10% is estimated to prevent approximately half of all automobile accidents. By eliminating human error, an AV market penetration rate of 90% could prevent 90% of accidents (Fagnant & Kockelman, 2015). AV technologies can also adjust vehicle speed, thereby improving fuel consumption efficiency. In addition, AVs brake more smoothly and can produce fewer traffic jams (Fagnant & Kockelman, 2015). This reduction in congestion and increase in safety can influence people's travel behaviour. According to Lu, Du, Dunham-Jones, Park, and Crittenden (2017), AVs have the potential to change not only the way we live and work but also the way we travel. Furthermore, AVs may improve transport mobility for teenagers, the elderly and the disabled. The need for parking spaces could also decrease because AVs use parking spaces outside the city (Fagnant & Kockelman, 2015). The environmental impact of automobiles is becoming increasingly important; hence, some cities are limiting vehicle emissions (Attias, 2017). The literature notes that implementing AVs will improve the future of transport mobility. Its technology can reduce crashes and congestion, improve fuel efficiency and reduce parking needs (Bansal, Kockelman, & Singh, 2016; Fagnant & Kockelman, 2015; Levin & Boyles, 2015). It also allows people who cannot drive to travel by car (Fagnant & Kockelman, 2015; Levin & Boyles, 2015). Mobility behaviour is complex, and understanding the reasons for choosing one mode of transportation plays an important role in AVs (Zmud & Sener, 2017). Transportation modes influence preferences, that is, car users prefer the most flexible amongst transportation modes (individual, door-to-door service) and avoid fixed routes. However, public transportation users have an opposite opinion (Földes, Csiszar, & Zarkeshev, 2018). This association has also an economic aspect. The more flexible the offered service, the higher the willingness to pay more for it (Földes et al., 2018).

Along with its numerous advantages, the negative effects and uncertainties that surround AVs must also be mentioned. Policymakers are concerned about the negative effects of AVs on public transit ridership (Gibson, 2017; Merlin, 2017). If the unique selling point of public transport is being able to perform tasks, such as reading or using the smartphone during the ride, then the use of AVs which can offer the same opportunity may lead to a decrease in the demand for mass transit (Gibson, 2017). Consequently, an increased usage of private AVs may stimulate congestion, pollution and urban sprawl (Litman, 2020). Furthermore, social equity, increased infrastructure costs and reduced employment concerns may occur (Freemark, Hudson, & Zhao, 2019; Litman, 2020). Another key challenge may be the need for bandwidth digital communication. Real-time data transmission is a basic requirement of AVs (Granig, Hilgarter, & Prutej, 2018). In this context, latency and reliability are essential components for the implementation of AVs (Andrews et al., 2014). However, the estimated reduction in accidents due to AVs (Fagnant and Kockelman (2015)) did not consider that AVs also create new risks. When fully autonomous vehicles find their way into road traffic, road users can no longer rely on informal communication channels, such as gestures, eye contact or facial expressions, due to the lack of feedback from drivers. The resulting uncertainty can increase the risk of accidents with other road users (Rouchitsas & Alm, 2019; Hilgarter & Granig, 2019). Additionally, some business branches are concerned about the negative effects that AVs could have on different industries, sectors and infrastructure (Cohen & Hopkins, 2019). The most common barriers to implementing AVs are security, privacy and legal issues (Fagnant & Kockelman, 2015; Kyriakidis & Happee, 2015; Piao et al., 2016). Lastly, the public's opinion about AV plays a crucial role in its implementation (Penmetsa, Adanu, Wood, Wang, & Jones, 2019).

Recent studies have investigated the public's opinion about AVs. Most focused on demographic variables, such as age and gender (Bansal et al., 2016; Kyriakidis & Happee, 2015; Pettigrew, Worrall, Talati, Fritschi, & Norman, 2019; Rödel, Stadler, Meschtscherjakov, & Tscheligi, 2014; Schoettle & Sivak, 2014; Zmud & Sener, 2017). Kyriakidis and Happee (2015) linked public opinion to personality traits. Most studies reported positive or conditionally positive attitudes towards AV between 42.9% and 79.7% (Hulse, Xie, & Galea, 2018; Pakusch & Bossauer, 2017; Payre, Cestac, & Delhomme, 2014; Schoettle & Sivak, 2014). In Pakusch and Bossauer's (2017) study, majority of the respondents (77.6%) imagined using autonomous public transportation regularly in the future. Schoettle and Sivak (2014) showed that positive or conditionally positive opinions about AVs differ between countries. China had the highest score (87.2%), whereas Japan had the lowest (42.9%). To under-

stand public opinions about AV, most published studies followed a quantitative approach with a questionnaire (Bansal et al., 2016; Kyriakidis & Happee, 2015; Penmetsa et al., 2019; Piao et al., 2016; Schoettle & Sivak, 2014). Frequently, AV acceptance is explained using the technology acceptance model of Davis (1989) or the advanced unified theory of acceptance and use of technology of Venkatesh (2003). Based on these theoretical frameworks, studies have shown that perceived usefulness has the strongest effect on behavioural intentions to use AVs. Perceived ease of use, perceived trust and social influence also are useful predictors of behavioural intentions (Koul & Eydgahi, 2018; Madigan et al., 2016; Nordhoff et al., 2017; Panagiotopoulos & Dimitrakopoulos, 2018). Only a few studies qualitatively dealt with passengers' perceptions of AVs after experiencing the technology (Nordhoff, de Winter, Payre, van Arem, & Happee, 2019; Salonen and Haavisto, 2019). The present study mimics an actual public transportation experience, including traditional stops, a route plan, other passengers on board the shuttle and the movement in mixed traffic. Furthermore, it focuses on the link between the general attitude towards AVs and the areas where people live.

In-depth knowledge about this topic is not yet available, but the successful integration of AVs into existing traffic systems essentially depends on how AVs are perceived by potential users and how AVs respond to their needs. This study aims to reveal in-depth insights into AV integration, exploring public perceptions of AVs through qualitative designs. Specifically, the study explores (1) the mobility behaviour of current passengers, (2) the public's perception of how AVs can be applied, (3) the ability of AVs to integrate into existing traffic systems, (4) the general attitude of the public towards AV and (5) the perceived safety of passengers who have experienced riding AVs.

2. Method

A qualitative approach was chosen to gain insights into the complex field of public perceptions. The intention was to understand subject-oriented perspectives using a structured procedure.

2.1. Participants

A total of 19 German-speaking participants aged 20–75 (M = 47.4 years; SD 20.7 years) took part in the study. The sample size in qualitative studies may vary, but within semistructured interviews, a small sample is sufficient (Qu & Dumay, 2011). The vast majority of interviews in Europe ranges from 11 to 20 interviews per study (Marshall, Cardon, Poddar, & Fontenot, 2013). In general meaning, saturation is achieved after 12–24 interviews (Guest, Bunce, & Johnson, 2006; Hennink, Kaiser, & Marconi, 2017). Therefore, data collection was discontinued after 19 interviews. The recruiting process started with a first screening directly in the test field, that is, a researcher recruited the participants actively with regard to certain characteristics (age, gender, residence) and informed them about the research study. This approach was beneficial because the recruiting individual had an overview of the participants. The sample was stratified to ensure a similar number of males and females and a diversity of ages. In addition, the participants had to be living in different geographical locations because transportation norms differ depending on the place of residence. The participants had to have a minimum B2 German language level (according to the Common European Framework of Reference for Languages) and a willingness to participate.

As shown in Table 1, the sample was 52.6% male and 47.4% female. All participants claimed to own a driver's licence, and 79.0% had their own car; 52.6% of the participants lived in large cities or near a metropolitan area, whereas 47.4% lived in a rural area.

2.2. Data collection

Data were collected through face-to-face interviews in Klagenfurt, City of Carinthia in Southern Austria on 17–20 September 2018. Participants were selected in a public place called 'Alter Platz', where the field operational test of the study was conducted. Klagenfurt, the capital of Carinthia, was selected as a targeted awareness-raising measure, thus addressing the widest possible range of people in Carinthia. The 640 m track consists of three stops and is operational from Monday to Friday between 10 a.m. and 6 p.m. every 10 min. With respect to public roads with mixed traffic, the classification of the Navya

Table 1
Sociodemographic characteristics of participants.

	Male	Female	Total
Total, N (%)	10 (52.6)	9 (47.4)	19 (1 0 0)
Age in years, Mean ± SD	40.4 ± 22.1	53.6 ± 18.3	47.4 ± 20.7
Residence, N (%)			
Urban area	5 (55.6)	4 (44.4)	9 (47.4)
Rural area	5 (50.0)	5 (50.0)	10 (52.6)
Driver's licence, N (%)	10 (52.6)	9 (47.4)	19 (1 0 0)
Own car, N, (%)			
Yes	8 (53.3)	7 (46,7)	15 (79.0)
No	2 (50.0)	2 (50.0)	4 (21.0)

Arma DL4 shuttle in this setting is at maximum level 3 'conditional automation'. In this context, the automated system largely controls the speed, steering and monitoring of the environment under limited conditions (SAE, 2019). The shuttle consists of 11 seats, but for legal reasons, only eight seats were used. The shuttle drove at an average speed of 10 km/h on a predefined track. The mapping of the track was performed 48 h before the experiment started. Localisation and obstacle detection were conducted using lidars (two 360° multilayer lidars and six 180° monolayer lidars), cameras (front/rear cameras), odometry (wheels encoder + inertial unit) and GNSS real-time kinematics. The road had considerable traffic; many pedestrians cross the way of the shuttle. Other road users were made aware of the AVs via traffic signs. The shuttle is fully electric and charged during the night. For legal reasons, an operator who could intervene during an emergency was always on board. The passengers were instructed that the AV was operating autonomously. After physically experiencing an AV ride under real-life conditions, participants were approached by an identified research assistant through purposive sampling. In this context, real-life conditions mean that the ride included traditional stops, a route plan, other passengers on the shuttle and movement in mixed traffic to mimic a real public transportation experience. Before signing up the participants, the research assistant explained the purpose of the study. After some initial questions, each person was asked to participate in the study and agree to a recorded interview, which was held in a quiet cafe.

2.3. Interview procedures

The interviews (N = 19) were semistructured, based on a predefined interview guide (provided in Appendix C), had open-ended questions and took 13 min on average. Interviews began after introducing the study and obtaining participants' informed consent. Participants were asked to

(1) describe their current methods of mobility behaviour and the means of transportation they use for different routes;
(2) imagine how AVs could be used;
(3) describe their general attitude towards AVs, their impressions and their first associations when thinking about AVs;
(4) express their concerns about AVs and identify challenges that must be tackled to integrate AVs into existing traffic systems; and
(5) describe how they assess AV safety issues and the reasons for such method of assessment.

The first interview was the pilot interview, which uncovered a few small deficiencies that were later corrected. No examples that could have affected the interviewees' responses were given in the questions.

2.4. Data analysis

The interviews were digitally recorded and then transcribed verbatim by a research assistant. The MAXQDA 10 programme was used to organise, manage and code the qualitative data efficiently. This software was chosen because it has numerous tools for advanced coding, outputting of coded data, transcription and visualisation and has proven itself in other qualitative studies on AVs (e.g. Nordhoff et al., 2019; Selinka & Kuhn, 2019). The transcriptions were analysed via inductive, qualitative content analysis because of the focused but exploratory character of the study. To avoid free interpretation, we used Mayring (2015) systematic approach, which made the study comprehensible and verifiable. An open coding process occurred whilst the transcript was being viewed and read. On the basis of this process, texts were unified, concepts were highlighted or removed, and elements were identified. The manifest content easily identified some categories, whereas others were difficult to identify because they were based in part on latent content in certain text passages. To analyse the data further, both authors performed the coding, and the categorisation system was adjusted by discussing the coding process. In case of disagreements, the results were further discussed until a consensus was reached. For example, a disagreement about the allocation of the statement *'I have to point out that with the loss of jobs (..)'* ensued. One author classified this as a societal challenge, whereas the other one considered it an economic challenge. In this case, information was obtained, and both variants were discussed with arguments. In particularly difficult cases, another uninvolved expert was consulted until both authors agreed on the classification.

Each category and subcategory had numerous quotes. Only a limited number of was selected to maintain the clarity of the study. The number of quotes formed each category, depending on the number of respondents. In general, one quote represented 1–6 respondents, two quotes represented 7–13 respondents and three quotes represented 14–19 respondents. In the 'Current Mobility Behaviour' section, respondents were categorised in accordance with the area where they lived. Nine participants lived in rural areas, whereas 10 lived in urban areas. The category mentioned by 1–5 respondents was represented by one quote, whereas that mentioned by 6–10 respondents was represented by two quotes.

3. Results

When asked to report their first associations or impressions about AVs, majority noted positive aspects, such as innovation, technological progress, environmental protection through the electrification of mobility and a positive future for transport mobility.

'I immediately think of less emissions and environmental protection through electromobility and a better quality of life'. [Participant 4, male]
'I associate it with important technological advances'. [Participant 9, female]
'Good and important innovation that contributes to the future of mobility'. [Participant 7, male]

3.1. Current mobility behaviour

Mobility plays a central role in the social life of all the respondents. All the respondents used cars to go to work or to go shopping. However, our results show differences in mobility behaviour, depending on whether the participants lived in a rural or an urban area. Table 2 presents an overview of these results

3.1.1. Private car

The results show that cars are needed in rural areas because they are the primary means of transportation to work and stores.

'In rural areas, a car is needed to get from A to B. Especially for shopping and getting to work'. [Participant 1, female]
'Mobility without a car is not possible in rural areas'. [Participant 10, male]

People rely on private cars in rural areas because of comfort and flexibility. By contrast, the public transportation infrastructure is underdeveloped in these areas (e.g. late or missed connections and a lack of alternative public transportation options).

'In general, the car is used because public transportation is insufficiently developed'. [Participant 15, female]
'The car is better because it is more comfortable'. [Participant 18, male]

The interviewees from the urban areas use cars during urgent situations when time is a factor and for long-distance travel.

'If it should be comfortable the car is used'. [Participant 17, female]
'The car is used more for long-distances'. [Participant 8, male]

3.1.2. Public transportation

Public transportation is used by participants from rural areas mainly during holidays or when travelling to large cities.

'Public transportation is used on vacation'. [Participant 6, female]
'In principle I travel to and in Vienna by public transportation mode because traffic is no problem out there'. [Participant 14, male]

Public transportation is preferred for long-distance travel or getting around large cities because of the following reasons: lack of directional knowledge in big cities, excellent public transportation, unavailable parking spaces and cost.

'There is no parking at all, and it is cheaper [. . .]'. [Participant 1, female]
'Because I do not want to drive in Vienna because I don't have local knowledge'. [Participant 15, female]

All daily routes are driven by public transportation for interviewees coming from urban areas because parking spaces in urban areas are difficult to find or are expensive.

Table 2
Current mobility behaviour of respondents.

Area	Mode of Transportation	Purpose	Motives
Rural	Private car	All daily travel needs (working, shopping)	Missing travel connections Lack of alternative means of transportation Comfort
	Public transportation	Holidays Travelling in big cities Long-distance travel	Lack of local knowledge Excellent transportation infrastructure in large cities Lack of parking spaces Cost
	Nonmotorised transportation	Free-time activities	Relaxation or recovery
Urban	Private car	Long-distance travel More urgent travel	When travel must be comfortable When travel should be rapid
	Public transportation	All daily travel needs (working, shopping)	Lack of parking spaces Expensive parking spaces
	Nonmotorised transportation	All daily travel needs (working, shopping)	Short-distance travel Cost Simplicity or practicality

'Everything is driven by public transportation, because I'm at home in the big city and I have no car by myself'. [Participant 16, female]
'I use the public transportation i.e. tram, metro and bus, because I live relatively in the city center of Vienna and there is the problem that you never get a parking space where you live and have at least the opportunity to get a private parking space'. [Participant 17, female]

3.1.3. Nonmotorised transportation

The participants from rural areas use bicycles during their free time for relaxation or recovery.

'The bike is mostly used during leisure time [. . .]' [Participant 6, female]

By contrast, interviewees from urban areas either walk or use bicycles for shopping or going to work if distances are relatively short.

'Mainly the bike is used for all ways in the city'. [Participant 7, male]

Urban residents often prefer the use of bicycles because of its simplicity, practicality and low costs.

'To use the bicycling is just more practical and cheaper than other means of transportation'. [Participant 19, female]

3.2. Areas for application of AVs according to public perception

The results clearly show that majority of the respondents perceive AV as an alternative rather than a substitute for existing means of transportation.

'Autonomous vehicles actually mainly as an alternative to other means of transportation in public sector'. [Participant 9, female]
'[. . .] as an alternative, I can imagine that'. [Participant 11, male]

We separate transporting goods from transporting passengers. Although both significantly affect traffic, the respondents perceive more potential for AVs in passenger transportation than in the transportation of goods.

3.2.1. Transportation of goods

Respondents believe that the potential for AV transportation of goods and services, regardless of route, is lower than that of passenger transportation. A few participants, though, reported that AV can be used for goods and services if AVs can use their own designated lane. Respondents also opined that transporting goods and services by rail is difficult because railway lines cannot access many specific locations and building new railway lines is expensive. In the long run, an autonomous truck is cheaper.

'Autonomous driving for trucks on the highway. For example, maybe even a lorry's own lane, which really drives autonomously'. [Participant 1, female]

Another participant reported that AVs can be used for intercompany transportation, specifically for moving goods from factories to warehouses.

'If I imagine a factory where the goods that have just come out of production'. [Participant 18, male]

In airports, AVs can be used to move luggage from one gate to another.

'At airports I could perhaps imagine'. [Participant 18, male]

3.2.2. Transportation of passengers

The interviewees see great potential for AVs in passenger transportation, especially for public transportation and tourism. Only a few respondents envision different sectors, such as healthcare. Most respondents agree that AVs can replace buses, subways or railways.

'Autonomous vehicles can certainly be used in public transportation'. [Participant 10, male]
'AV generally as an alternative on public transportation such as buses, subways or so in general rail traffic or something like that'. [Participant 16, female]
'Most likely in shuttle service'. [Participant 19, female]

Respondents cited the low speed of city traffic as a rationale for AVs. By comparison, they also opined that high-speed freeway or highway driving is much more dangerous.

'So, I could imagine autonomous vehicles on buses in the city centre very well. When driving on freeways or highways, I could not imagine that due to the high speed of over 100 km / h, but in the city centre where the bus often not even 50 km / h drives because I could imagine it well. For me, the potential danger is linked to speed'. [Participant 17, female]

Interviewees also envision AV vehicles being used in cities as shuttles for short-distance sightseeing and city tours.

'Alternative, I can well imagine that it works such a sightseeing shuttle for tourists'. [Participant, 11, male]
'Yes, to the passenger transportation for sightseeing tours for routes where a car does not drive yet'. [Participant, 2, male]

In areas where AV transportation is a novelty, AVs can become a tourist attraction.

'Now it just fascinated for tourists. It's great fun and leaves a lasting impression'. [Participant, 1, female]

AVs also can be used with pickup and delivery services for events and thus can ease traffic.

'For events to bring people from hometown to event location'. [Participant, 11, male]
'Maybe as a traffic solution for events'. [Participant, 7, male]

AVs can be used for airport transportation and as a shuttle to parking spaces (Park and Ride).

'Often there are parking spaces away from the actual place where you want to go, so this is very suitable for AV'. [Participant, 7, male]

AVs can be used in the healthcare sector.

'I can well imagine using the AV in the health care sector'. [Participant, 1, female]

AVs can be used to transport the disabled to a doctor or a pharmacy. Some respondents envision AVs providing transport mobility for all. The technology is as enriching for seniors as it is for people with reduced transport mobility.

'For older people who can't or no longer want to drive or for people with reduced mobility'. [Participant, 1, female]

The overall results of this analysis are shown in Table 3.

3.3. Perceived challenges of AV

AVs have social, technical, legal and economic challenges. Respondents noted that societal challenges, particularly job losses in different professions, are key to the successful implementation of AVs.

'I have to point out that with the loss of jobs, AV is rather critical. Jobs that are lost affect different professions, which of course makes it difficult'. [Participant 17, female]
'With AV, jobs disappear again and whether other jobs are created, no one can yet know'. [Participant 3, male]

Another important societal factor is the acceptance and awareness of AVs by the public. If AVs are not accepted, the public may decline or delay their use.

'What could cause problems is that people without understanding block the project'. [Participant 2, male]

Respondents said that privacy also plays an important role in addressing the challenges of AVs, especially regarding the disposition of data produced in the cars. The implementation of AVs may lead to privacy restrictions.

'The Internet and privacy issues are a big challenge. Since data quantities are produced and no one knows what happens with it. So, in principle I already see it critically'. [Participant 9, female]

Another issue regarding AVs is their anticipated high cost, especially when first introduced. The cost would make it difficult for low-income groups to purchase them.

'If the systems are perhaps too costly and therefore the tickets are more expensive, many seniors may not be able to pay for it'. [Participant 7, male]

Some respondents expressed the idea that transport mobility, as a common property, should be provided for free.

'I am already inwardly prepared that mobility as a future trend must be free anyway. Autonomous driving is an innovative idea so the offer must be innovative for the end user' [Participant 7, male]

Table 3
Public perception of AVs.

Mode of Transportation	Areas of Application
Transportation of goods	Land transportation of goods and services Transportation within a company (fabric, airport)
Transportation of people	Public transportation 'Park and Ride' Tourism (sightseeing, events) Healthcare sector Airports

The current state and reliability of AV technology also pose enormous challenges. Although AV technology ultimately needs to be integrated into existing traffic systems, it has yet to mature.

'The technology is progressing faster than we can keep up. Of course, this is not fully developed yet, which can lead to difficulties, but I am convinced that these difficulties can be solved'. [Participant 18, male]

AV security remains vulnerable to security flaws, and the possibility of hacking bothers participants.

'I still see difficulties that such a vehicle could be hacked' [Participant 15, female]

AVs also face legal challenges. Vehicle liability can affect vehicle owners, manufacturers and insurance companies. Respondents believe that the insufficient resolution of legal issues is an important factor why AVs remain as prototypes and are not yet fully marketed to the public.

'Well, I think it will be difficult to put the whole system in a legal framework. There are many questions that will be a problem in the future'. [Participant 14, male]

Concerns about infrastructure, the associated costs of production and possible tax increase are also expressed.

'I already see a bit of a problem with the costs incurred by AV, since community or city often does not have much budget anyway'. [Participant 17, female]

The overall results of this analysis are shown in Table 4.

3.4. General attitude towards AV

The respondents were classified in accordance with their general attitude towards AVs. The four main 'attitude' categories are as follows: (1) Rejectors are negative about the new technology, totally reject AV or only have negative associations about it; (2) conservatives are sceptical and negative about the new technology but do not totally reject it; (3) pragmatists are mostly open-minded and positive about the new technology and mostly speak positively about AV; and (4) enthusiasts are very open-minded about the new technology and appreciate it.

The classification of participants according to their general attitude towards AVs are presented in Table 5 (exact statements are provided in Appendix A).

In this sample, 36.8% of the participants are enthusiastic about AVs and express positive thoughts.

'Autonomous vehicles will surely be the future and it is a positive thing to see'. [Participant 2, male]
'Technology is the future and I see that very positively'. [Participant 14, male]

Pragmatists (26.3% of the interviewees) are also positive about AVs.

'So, in any case I'm positively but of course with some concerns'. [Participant 18, male]

Conservatives (26.3%) are rather negative and sceptical about AV.

'People are still afraid of it, because it is something new and there is still too little experience. I'm not sure, but I see it rather negatively'. [Participant 5, female]

Rejectors, a small sample (10.5%) of the population, have a negative attitude towards AVs, completely rejecting the technology.

'I cannot win anything from that. I think I could not trust the system'. [Participant 17, female]

Gender analysis clearly shows that men are more positive towards AVs compared with women. As shown in Figs. 1 and 2, this gender effect is especially pronounced for enthusiasts and conservatives. The gender effect is less pronounced for pragmatists. Rejectors are equally distributed between males and females.

When positive (enthusiasts and pragmatists) and negative (rejectors and conservatives) groups are distributed by gender, a similar picture about attitudes emerges. Males (N = 8) are more positive towards AVs compared with females (N = 4),

Table 4
Perceived challenges of AV.

Societal Challenges	Technological Challenges
Fear of job loss Lack of acceptance and awareness Privacy issues Lack of social justice	Reliability
Legal Challenges	**Economic Challenges**
Liability	Infrastructure

Table 5
General attitudes towards AV.

ID	Rejectors	Conservatives	Pragmatists	Enthusiasts	Gender	Age	Residence
1			x		female	72	rural
2				x	male	37	urban
3	x				male	68	rural
4			x		male	75	rural
5		x			female	34	urban
6			x		female	73	rural
7				x	male	28	urban
8		x			male	23	urban
9				x	female	39	rural
10				x	male	56	rural
11				x	male	52	urban
12		x			female	60	urban
13			x		male	62	urban
14				x	male	68	rural
15				x	female	23	rural
16		x			female	21	urban
17	x				female	20	urban
18			x		male	67	rural
19		x			female	22	urban
	10.5%	26.3%	26.3%	36.8%			

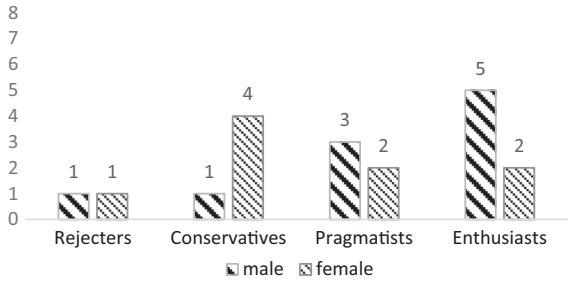

Fig. 1. Gender distribution of the classification of attitudes towards AVs (in absolute values).

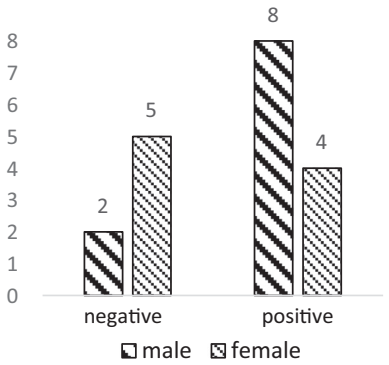

Fig. 2. Positive versus Negative Attitudes towards AVs on the Basis of Gender (in absolute values).

whereas females (N = 5) are more critical about AV compared with males (N = 2). The respondents' positive attitudes towards AVs totalled 63.2%.

Figs. 3 and 4 show the effect of age. Older adults are pragmatists, whereas the younger individuals are conservatives and enthusiasts. Rejectors contain a balanced mix of the young and the old.

When positive (enthusiasts and pragmatists) and negative (rejectors and conservatives) groups are distributed by age, older adults (N = 8) are more positive than younger ones (N = 4) and younger adults (N = 5) are more critical than older ones (N = 2).

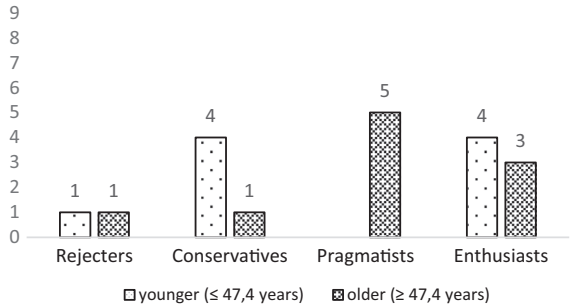

Fig. 3. Age distribution of the classification of attitude towards AVs (in absolute values).

Fig. 4. Positive versus Negative Attitudes towards AVs on the Basis of Age (in absolute values).

As shown in Fig. 5, this effect is more pronounced for enthusiasts (rural areas N = 4 versus urban areas N = 3) and pragmatists (rural areas N = 4 versus urban areas N = 1). The conservative group in urban areas (N = 5) is more sceptical than that in rural areas (N = 0). The rejector group is balanced between rural (N = 1) and urban areas (N = 1).

Fig. 6 shows that the respondents living in rural areas (N = 8) are generally more positive about AVs compared with their urban counterparts (N = 4). More negative statements came from people located in urban areas (N = 6) than from those living in rural areas (N = 1).

3.5. Perceived safety and AV

Overall, 84.2% of the respondents feel safe in the AV, 10.5% notes a lack of confidence in technology and 5.3% has no opinion about AV safety. These conclusions are based on respondents' statements (see Appendix B).

The respondents indicated that they feel safe in an AV because of its slow speed of 10 km/h.

'For me, safety in autonomous vehicles is associated with the speed level'. [Participant 16, female]

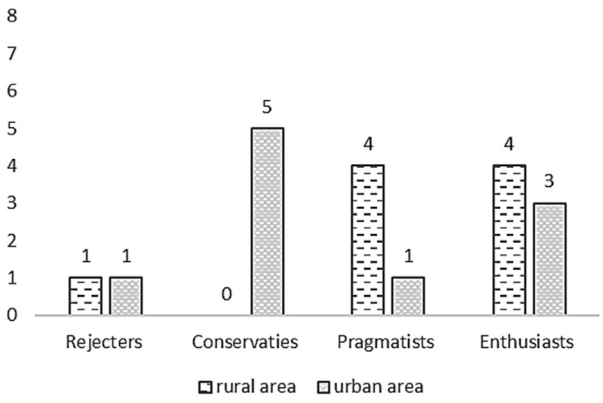

Fig. 5. Residence Distribution of the Classification of Attitudes towards AVs (in absolute values).

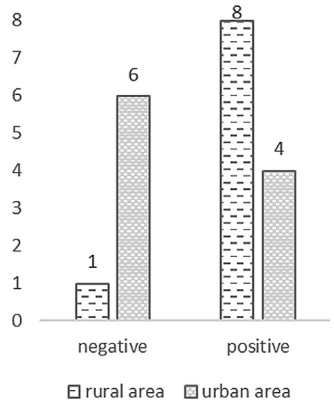

Fig. 6. Residence Differences and Positive versus Negative Attitudes about AV, towards AVs on the Basis of Residence Area (in absolute values).

'I can imagine that I would be a little bit more afraid if the shuttle drove faster'. [Participant 2, male]

The respondents said that experiencing an AV ride can improve one's opinion. They also said that experiencing autopilot in an aircraft can help one feel safer in an AV.

'I think it's definitely safe. Of course, it is something completely new and it is a bit strange that there is no driver in it. But you trust that fairly quickly because you realize that it brakes immediately if anyone or something is in the way'. [Participant 8, male]

Another aspect of safety is a law in Austria requiring an operator to regain control of an AV in case of an emergency.

'So, I feel safe, because the operator was in the shuttle. He certainly helped for the perceived safety level'. [Participant 4, male]

AVs in Austria must meet safety standards; thus, passengers feel safe riding in them. They trust that AV technology is only used if it has been classified as relatively safe. The interviewees rely on the fact that the legislation in Austria allows only safe vehicles to drive on the road. If a vehicle is registered in Austria, then it must have already met very high safety standards.

'No concerning about autonomous shuttles because I know how high the safety requirements are and that they work better than humans. A machine does not have a bad day or whatever. The machine is working all the time in the same condition'. [Participant 14, male]

4. Discussion

Public perception plays a crucial role on how quickly new technology is accepted and adopted. This study investigates the public perception of 19 participants towards AV to generate in-depth knowledge about (1) the mobility behaviour of current passengers, (2) the public perception of AVs, (3) the perceived challenges of integrating AV into existing traffic systems, (4) the general attitude of the public towards AVs and (5) the perceived safety of passengers who have experienced an AV ride.

The results show that opinions about transport mobility depend on whether respondents live in rural or urban areas. In rural areas, a car is used for travelling to work and for shopping and is essential for transport mobility. These findings are consistent with those of Pucher and Renne (2005), who showed that regardless of age, income and race, a private car, the most used mode of transportation, plays a more vital role in rural areas compared with urban ones, where a car is used mainly to travel long distances or to move quickly and comfortably. In our study, missing or inappropriate traffic connections and a lack of other means of transportation are the primary reasons for using a car. Similar to our study, previous ones have demonstrated that using a car relates to its benefits, such as speed, cost, flexibility, safety, convenience, freedom, independence and availability (Beirão & Sarsfield Cabral, 2007; Fraedrich, Heinrichs, Bahamonde-Birke, & Cyganski, 2019). By contrast, the respondents largely use public transportation for holidays, long-distance travel or for travelling to big cities from rural areas. The participants from urban areas use public transportation or nonmotorised modes of transportation daily. A lack of local knowledge about big cities, an excellent infrastructure of public transportation, missing parking spaces and cost aspects comprise the arguments on why public transportation is used. This result is in agreement with Beirão and Sarsfield Cabral (2007) findings, which showed that reduced cost, less stress and shortened travel time on bus lines, amongst others, are important advantages of public transportation. In rural areas, nonmotorised vehicles are used primarily for free-time activities largely because daily journeys in rural areas are often too long for bicycle transportation.

Recent evidence suggests that AVs can change mobility behaviour. In this study, the predominantly positive attitude of the respondents from rural areas towards AVs highlights the enormous potential of the technology. However, a widespread

adoption of AVs can reduce the demand for automobiles even in rural areas. These expectations are consistent with studies by Salonen and Haavisto (2019) and Földes et al. (2018). AVs also have a positive effect on the environment.

Using AVs in different areas of transportation has a huge effect on the economy. Existing modes of transportation, such as buses, subways or trains, will likely be supplemented but not replaced by AVs. For instance, AVs can be used for package deliveries or intracompany movement of goods. AVs can also be used for tourism as sightseeing buses, in the healthcare sector, in airports and as a means to transport drivers to and from distant parking facilities. These applications are consistent with the results obtained by Cohen and Hopkins (2019), who concluded that AVs can disrupt the transportation and tourism industries. To support this study, innovative business models must incorporate AVs. Further research should look further into which areas of applications could best benefit the population at large.

Despite the potential of AVs, the perception of the respondents towards AV includes societal, technical, legal and economic challenges. Societal factors include fears about job losses, the population's general lack of acceptance and awareness about AVs, privacy concerns and lack of social justice. The existing literature generally agrees with these conclusions. Sixty percent of the respondents in a study by Pettigrew, Fritschi, and Norman (2018) indicated that they were at least moderately worried about job losses. Fagnant and Kockelman (2015) emphasised that implementing AVs could cause privacy restrictions for users. Respondents are concerned about security aspects, such as hacking. Technical aspects, such as AV's reliability, also play a prominent role. Kyriakidis and Happee (2015) found that most people were concerned about software hacking and misuse, as well as legal and safety issues. Similarly, the respondents in this study also had concerns about legal issues, which affect vehicle owners, manufacturers and insurance companies. At first glance, the result of liability for autonomous public transport is not an issue for the users. Nevertheless, a closer look reveals that it does play a role, if not a priority. This is precisely the case when users take on the role of the opponent in the event of an accident, and uncertainty exists about who takes responsibility for AF in such casesbecause automated systems are predicted to reduce human error and implicate that the system act almost error-free. This indirect result in public transportation shows how important it is for users to create clear legal framework conditions, even if they are only affected at second glance. This result is confirmed by Fagnant and Kockelman (2015), who found that a legal framework has so far been lacking and can lead to uncertainty. This discussion depends not least on the degree of automation of the technology. As Ni and Leung (2015) showed in their report, the levels of automation, particularly SAE Levels 3 and 4, represent a legal challenge for AVs. Economic challenges include the cost of AVs and possible tax increases. With respect to the cost of AVs, the fact that high costs for private AVs are perceived and regarded less often in daily decisions must be considered; by contrast, high costs for public transport or for mobility as a service solution (MaaS) offers a clear vision for every kilometre. Above all, mobility service providers must anticipate these challenges and develop and offer new and innovative pricing models accordingly.

In this study, people who are enthusiastic about AVs outnumber those who reject the technology. A minority of the sample (the rejectors) shows a negative attitude towards AV and completely reject the technology. In between, the pragmatists are predominantly positive about AV and the conservatives are predominantly negative. Overall, the respondents' reactions were balanced. A predominantly positive attitude towards AVs was expressed by 63.16% of the respondents. This result concurs with that of other studies, such as those by Piao et al., 2016; Hulse et al., 2018; Salonen and Haavisto, 2019; Pettigrew et al., 2019; Kyriakidis & Happee, 2015 and Nordhoff et al., 2018.

This study also shows the effect of gender. Males generally have a more positive outlook towards AVs compared with females. This result also matches those from earlier studies, such as those by Hulse et al., 2018; Bansal et al., 2016; Pettigrew et al., 2019 and Rödel et al., 2014.

The effect of age in this study indicates that in the enthusiast group, younger adults were more positive about AVs compared with the older ones. However, when all four groups are combined, older adults have a more positive impression of AVs in comparison with their younger counterparts. Studies by Madigan et al. (2016) showed that AV acceptance in Greece was higher for younger adults, whereas acceptance in France and Switzerland was higher for older adults. Cultural distinctions between these countries or a degree of subjectivity in the studies may explain these differences. Future studies should continue to analyse why older and younger adults differ in their attitudes towards AV.

This study also reveals that respondents from rural areas are more positive about AVs compared with those from urban areas largely because rural areas are more dispersed and therefore less amenable to public or nonmotorised transportation.

Our results indicate that because of slow speed and technology, most respondents feel safe in AVs. Further pilot tests of AVs in different areas and speed levels are necessary to identify where AVs can be suitably used and at what speed passengers feel comfortable. Salonen and Haavisto (2019) showed that riding in an AV can improve passengers' perception of safety. One ride alone may suffice. These authors also noted that subjective factors, e.g. positive attitude during a trip, tend to improve general feelings about safety. Interacting with vulnerable road users can also improve perceived levels of safety (Penmetsa et al., 2019) as can safety standards and an operator's ability to take control of the vehicle in case of an emergency. These results show that despite the often-predicted increase in traffic safety through AVs, people who can intervene in an emergency convey a higher sense of safety compared with autonomic systems. These results are confirmed by Nordhoff et al. (2017), who showed that respondents prefer the monitoring of AVs over unattended full automation. This result may also be due to the rather limited experience with AVs. When AVs become fully autonomous in the future, new maintenance methods must be developed to maintain the population's sense of safety. Therefore, the perception of AV safety without an operator on board must be investigated in future studies to identify possible differences between the users of AVs with and without an operator on board and consequently develop new strategies for safety perception.

Lastly, a few important limitations must be considered. First, qualitative information, which is difficult to verify, can mean that a study's results cannot be generalised. To tackle this limitation, we used a systematic approach and attempted to present the analysis in a detailed manner to reduce subjectivity. Second, the respondents' general attitudes towards AVs were subjectively based on their statements. To manage this limitation, statements were independently assigned to groups by two researchers. Disagreements were discussed until a consensus was reached. Third, we believe that longer interviews might have revealed more detail. Fourth, when interpreting the results, the fact that the shuttle ride was under restricted conditions, such as a speed limit of 10 km/h, predefined route and operator on board, must be considered. These aspects may influence the perception of AVs. For instance, the participants in this study were sceptical about high-speed motorway driving because they were exposed with a low-speed autonomous shuttle.

A strength of this study is that it assessed public perceptions of AVs after the respondents experienced an actual AV shuttle ride. This feature distinguishes the present research from many other studies, where respondents only imagined using the technology. The ride is similar to a daily commute on public transportation, with several other passengers on board. The results of this study can be considered representative for Austria and for other comparable countries because almost half of the Austrian population still reside in rural regions; moreover, evidence of poor public transport mobility exists (Statistik Austria, 2019a).

Other questions in need of further investigation include how AVs influence mobility behaviour, how users determine their transportation preferences in rural and urban areas, how AVs will be integrated into the existing transportation network and how AVs will influence the labour market.

5. Conclusion

This study offers insights into the public perception of AVs and suggests that a new era of AV transport mobility has already begun. Transport mobility plays a crucial role for people in developed countries, influencing participation in social life. We make a distinction between transport mobility preferences in rural and urban areas. Public perception is a key factor for the realisation and successful integration of AVs into the existing traffic network. The predominantly positive public attitude towards AVs highlights the enormous potential of AV use. A pattern in which AVs are positively regarded in rural areas more than in urban areas is observed. This pattern could be an indication that public transport with AVs, especially in rural areas, would be accepted by the population and could be used for coverage. Thus, existing public transport services and road access in rural areas can be improved. The pattern in which older adults perceive potential benefits in AVs more than their younger counterparts supports the idea that AVs can sustain the mobility of elderly people. Versatile areas of application can sustainably change individuals' mobility behaviour, for instance, by shifting from an excessive use of private cars to public transportation for daily travel needs in rural areas. However, this relationship implies that using AVs for public transportation satisfies customers' needs better than before. Flexibility and appropriate transportation connections are key aspects. Local centres need to be connected to public transportation. Integrating AVs into existing traffic systems also plays an important economic role because it opens opportunities for new business models that have yet to be developed and evaluated. For AVs to succeed, the public's perception must be considered. Improved awareness, training and persuasion are needed to make autonomous driving suitable for everyday use. In each challenging area of public perception, tackling prospective customers' needs and obtaining information from the automotive industry, transportation companies and policymakers are important. The automotive industry should provide transparent information about what AVs are capable of. International legal frameworks should also be created by policymakers, and mobility service providers should find new ways to expand and improve the existing offers and generate innovative pricing models that can create an adequate transport system for the population.

CRediT authorship contribution statement

Kathrin Hilgarter: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, and Writing - original draft. **Peter Granig:** Funding acquisition, Formal analysis, Resources, Supervision, and Writing - review & editing.

Declaration of Competing Interest

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

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Appendix A

ID	Rejectors	Conservatives	Pragmatists	Enthusiasts	Gender	Age	Location
1			*'It's a great thing, but, it is now still in the experimental phase.'*		female	72	rural
2				*'Autonomous vehicles will surely be the future, and it is a positive thing to see.'*	male	37	urban
3	*'Autonomous vehicles will certainly not prevail. It is difficult to imagine.'*				male	68	rural
4			*'It will probably take another 10–15 years, but at some point, this will be the future. This is mostly positive to see.'*		male	75	rural
5		*'People are still afraid of it, because it is something new and there is still too little experience. I'm not sure, but I see it rather negatively.'*			female	34	urban
6			*'Basically, a bit sceptical and anxious, but quite willing to get involved. It will be the future, that is undisputed.'*		female	73	rural
7				*'Access for us must be found as soon as possible. I see it very positively and am optimistic about AV.'*	male	28	urban
8		*'Interesting and innovative, but also a great new challenge.'*			male	23	urban
9				*'I'm a supporter of AV and I think that it is very good.'*	female	39	rural
10				*'I think autonomous vehicles are a good idea. You can save time, and traffic would be more fluid.'*	male	56	rural
11				*'I'm convinced that this is our future and that it is important.'*	male	52	urban
12		*'I'm not completely averse, but people are out of the machine and jobs are lost.'*			female	60	urban

(*continued on next page*)

Appendix A (*continued*)

ID	Rejectors	Conservatives	Pragmatists	Enthusiasts	Gender	Age	Location
13			*'I think that it is a good thing, I can imagine that it will prevail over the next years.'*		male	62	urban
14				*'Technology is the future and I see that very positively.'*	male	68	rural
15				*'Well, I'm very positive about that.'*	female	23	rural
16		*'In general, I find it very interesting how far the technology is already, but I see ethical issues as a major challenge.'*			female	21	urban
17	*'I cannot win anything from that. I think I could not trust the system.'*				female	20	urban
18			*'So, in any case I'm positive, with some concerns, of course.'*		male	67	rural
19		*'I do not have enough experience with it so far, and I am not sure if I would trust the system.'*			female	22	urban
	Rejectors 10.5% (2)	Conservatives 26.3% (5)	Pragmatists 26.3% (5)	Enthusiasts 36.8% (7)			

Appendix B

ID	I feel safe	I feel unsafe	Gender	Age	Location
1	*'I was not afraid'*		female	72	rural
2	*'I felt safe'*		male	37	urban
3		*'I do not trust the technique. I am relatively sceptical. The technology is too new'*	male	68	rural
4	*'Well, I feel pretty safe here'*		male	75	rural
5	*'The operator on board made me feel safer'*		female	34	urban
6	*'Yes, I trust that system'*		female	73	rural
7	*'Yes, I felt absolutely safe'*		male	28	urban
8	*'I think it's definitely safe. Of course, it's always something new every time because it's a bit strange that you do not have a driver inside but uh you trust that pretty fast anyway'*		male	23	urban
9	*'I felt very safe and I trusted autonomous vehicles'*		female	39	rural
10	*'I did not care. Aircraft are also on autopilot most of the time'*		male	56	rural
11	*'At the beginning, the first few seconds it is a strange feeling. But then not anymore'*		male	52	urban
12	*'Yes, at the speed I felt safe'*		female	60	urban
13	*'By all means, I felt very safe there'*		male	62	urban

Appendix B (*continued*)

ID	I feel safe	I feel unsafe	Gender	Age	Location
14	*'I had no reservations at all'*		male	68	rural
15	*'I think I'm sure I've been watching this for a while and I've seen that the car responds very well to pedestrians and cyclists and it's very safe, I think'*		female	23	rural
16	*'Yes. So, I felt very safe. It's also a low speed'*		female	21	urban
17		*'I have no confidence because the facts are missing'*	female	20	urban
18	*'So, I have to say that I was completely safe. I really trusted the whole thing'*		male	67	rural
19		*'I do not know how to trust that. In principle, I trust people more than machines'*	female	22	urban

Appendix C. Structured interview guide: Public perception towards AVs

Socioeconomic characteristics:	
Place of residence	Please describe your place of residence. • Where do you live? • Where is it located? • How many inhabitants are living in your place of residence? • What facilities can be found there? • Do you like living there? If so, why? If not, why?
Age in years	How old are you?
Driver's licence	Do you have a driver's licence?
Own car	Do you have your own car?
(1) Current mobility behaviour	
Description of the current mobility behaviour and the means of transportation they use for different routes	What means of transportation are you using today? • Why did you choose this means of transport? Which means of transportation do you use the most and why? For what purposes do you use which means of transport and why? • Are there certain purposes for which you only use public transport? If so, which and why? Otherwise, why not? • Are there certain purposes for which you only use the private vehicle? If so, which and why? Otherwise, why not? • Are there certain purposes for which you only use nonmotorised vehicles, e.g. bike? If so, which and why? Otherwise, why not?
(2) Public perception of AVs - Application fields	
Imagination of the population of how AVs can be used in different application fields	For what purposes can you imagine AVs are being used? In which fields of application can you imagine AVs are being used and why? • In which fields of application can you imagine yourself using AVs? On which roads do you think AVs can be used and why?
(3) Perceived challenges of AVs	
Concerns of the population about AVs	What do you personally dislike about AVs? What do you think are the difficulties encountered when using AVs and why? In your opinion, what are the challenges of AVs and why? What problems with AVs can you imagine?

(*continued on next page*)

Appendix C (*continued*)

(4) General attitude towards AVs	
General attitudes, impressions and first associations towards AVs	What are your first impressions when you think about AVs? What do you think about AVs in general and why? How do you personally rate the development of AVs?
5) Safety and AV	
Perceived safety of passengers who have experienced an AV ride	Do you trust the AV technology? Why or why not? Do you feel safe in AVs? Why or why not? What measures are currently giving you the feeling of safety inside AVs? • Is there anything that made you feel safe in the AV? • Is there anything that made you feel unsafe inside the AV?

References

Andrews, J. G., Buzzi, S., Choi, W., Hanly, S. V., Lozano, A., Soong, A. C. K., & Zhang, J. C. (2014). What Will 5G Be?. *IEEE Journal on Selected Areas in Communications, 32*(6), 1065–1082. https://doi.org/10.1109/JSAC.2014.2328098.

Attias, D. (2017). The Autonomous Car, a Disruptive Business Model?. In D. Attias (Ed.), *The Automobile Revolution* (pp. 99–113). Springer International Publishing. https://doi.org/10.1007/978-3-319-45838-0_7.

Bansal, P., Kockelman, K. M., & Singh, A. (2016). Assessing public opinions of and interest in new vehicle technologies: An Austin perspective. *Transportation Research Part C: Emerging Technologies, 67*, 1–14. https://doi.org/10.1016/j.trc.2016.01.019.

Beirão, G., & Sarsfield Cabral, J. A. (2007). Understanding attitudes towards public transport and private car: A qualitative study. *Transport Policy, 14*(6), 478–489. https://doi.org/10.1016/j.tranpol.2007.04.009.

Berrada, J., Christoforou, Z., & Leurent, F. (2017). *Which business models for autonomous vehicles?*. Strasbourg: ITS Europe.

Chan, C.-Y. (2017). Advancements, prospects, and impacts of automated driving systems. *International Journal of Transportation Science and Technology, 6*(3), 208–216. https://doi.org/10.1016/j.ijtst.2017.07.008.

Cohen, S. A., & Hopkins, D. (2019). Autonomous vehicles and the future of urban tourism. *Annals of Tourism Research, 74*, 33–42. https://doi.org/10.1016/j.annals.2018.10.009.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319. https://doi.org/10.2307/249008.

Dingus, T. A., Guo, F., Lee, S., Antin, J. F., Perez, M., Buchanan-King, M., & Hankey, J. (2016). Driver crash risk factors and prevalence evaluation using naturalistic driving data. *Proceedings of the National Academy of Sciences of the United States of America, 113*(10), 2636–2641. https://doi.org/10.1073/pnas.1513271113.

Ehlers, C. (2018). Mobility of the future - connected, autonomous, shared, electric. Engine & Environment. 30th International AVL Conference "Engine & Environment", June 7th - 8th, Graz, Austria.

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: Opportunities, barriers and policy recommendations. *Transportation Research Part a: Policy and Practice, 77*, 167–181. https://doi.org/10.1016/j.tra.2015.04.003.

Földes, D., Csiszar, C., & Zarkeshev, A. (2018). User expectations towards mobility services based on autonomous vehicle. 8th International Scientific Conference, CMDTUR, At Žilina, Slovakia.

Fraedrich, E., Heinrichs, D., Bahamonde-Birke, F. J., & Cyganski, R. (2019). Autonomous driving, the built environment and policy implications. *Transportation Research Part a: Policy and Practice, 122*, 162–172. https://doi.org/10.1016/j.tra.2018.02.018.

Freemark, Y., Hudson, A., & Zhao, J. (2019). Are Cities Prepared for Autonomous Vehicles?. *Journal of the American Planning Association, 85*(2), 133–151. https://doi.org/10.1080/01944363.2019.1603760.

Gibson, B. (2017). Analysis of Autonomous Vehicle Policies. https://doi.org/10.13023/KTC.RR.2016.25

Granig, P., Hilgarter, K., & Prutej, W. (2018). Mit Innovation von 5G zum autonomen Fahren. Tagungsband Des 12. Forschungsforum Der Österreichischen Fachhochschulen (FFH) 2018, Salzburg.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough?. *Field Methods, 18*(1), 59–82. https://doi.org/10.1177/1525822X05279903.

Hennink, M. M., Kaiser, B. N., & Marconi, V. C. (2017). Code saturation versus meaning saturation: How many interviews are enough?. *Qualitative Health Research, 27*(4), 591–608. https://doi.org/10.1177/1049732316665344.

Hulse, L. M., Xie, H., & Galea, E. R. (2018). Perceptions of autonomous vehicles: Relationships with road users, risk, gender and age. *Safety Science, 102*, 1–13. https://doi.org/10.1016/j.ssci.2017.10.001.

Koul, S., & Eydgahi, A. (2018). Utilizing Technology Acceptance Model (TAM) for driverless car technology Adoption. *Journal of Technology Management & Innovation, 13*(4), 37–46. https://doi.org/10.4067/S0718-27242018000400037.

Krasniqi, X., & Hajrizi, E. (2016). Use of IoT technology to drive the automotive industry from connected to full autonomous vehicles. *IFAC-PapersOnLine, 49*(29), 269–274. https://doi.org/10.1016/j.ifacol.2016.11.078.

Kyriakidis, M., Happee, R [R.], & Winter, J.C.F. de [J.C.F.] (2015). Public opinion on automated driving: Results of an international questionnaire among 5000 respondents. Transportation Research Part F: Traffic Psychology and Behaviour, 32, 127–140. https://doi.org/10.1016/j.trf.2015.04.014.

Levin, M. W., & Boyles, S. D. (2015). Effects of autonomous vehicle ownership on trip, mode, and route choice. *Transportation Research Record: Journal of the Transportation Research Board, 2493*(1), 29–38. https://doi.org/10.3141/2493-04.

Litman, T. (2020). Autonomous Vehicle Implementation Predictions: Implications for Transport Planning.

Lu, Z., Du, R., Dunham-Jones, E., Park, H., & Crittenden, J. (2017). Data-enabled public preferences inform integration of autonomous vehicles with transit-oriented development in Atlanta. *Cities, 63*, 118–127. https://doi.org/10.1016/j.cities.2017.01.004.

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.

Marshall, B., Cardon, P., Poddar, A., & Fontenot, R. (2013). Does sample size matter in qualitative research? A review of qualitative interviews in is research. *Journal of Computer Information Systems, 54*(1), 11–22. https://doi.org/10.1080/08874417.2013.11645667.

Mayring, P. (2015). Qualitative content analysis: Theoretical background and procedures. In A. Bikner-Ahsbahs, C. Knipping, & N. Presmeg (Eds.), Advances in Mathematics Education. Approaches to Qualitative Research in Mathematics Education (Vol. 23, pp. 365–380). Springer Netherlands. https://doi.org/10.1007/978-94-017-9181-6_13.

Merlin, L. (2017). Comparing automated shared taxis and conventional bus transit for a small city. *Journal of Public Transportation, 20*(2), 19–39.

NCSA. (2015). Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115.
Ni, R., & Leung, J. (2015). Safety and Liability of Autonomous Vehicle Technologies. https://groups.csail.mit.edu/mac/classes/6.805/student-papers/fall14-papers/Autonomous_Vehicle_Technologies.pdf.
Nordhoff, S., van Arem, B., Merat, N., Madigan, R., Ruhrort, L., Knieb, A., & Happeea, R. (2017). User Acceptance of Driverless Shuttles Running in an Open and Mixed Traffic Environment. ITS European Congress. 12th ITS European Congress, Strasbourg, France.
Nordhoff, S., Winter, J. de [Joost], Payre, W., van Arem, B., & Happee, R [Riender] (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
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 (pp. 52–60). SCITEPRESS - Science and Technology Publications. https://doi.org/10.5220/0006472900520060
Nordhoff, S., Winter, J. de, Kyriakidis, M., van Arem, B., & Happee, R. (2018). Acceptance of Driverless Vehicles: Results from a Large Cross-National Questionnaire Study. *Journal of Advanced Transportation*, 1–22. https://doi.org/10.1155/2018/5382192.
Panagiotopoulos, I., & Dimitrakopoulos, G. (2018). An empirical investigation on consumers' intentions towards autonomous driving. *Transportation Research Part C: Emerging Technologies, 95*, 773–784. https://doi.org/10.1016/j.trc.2018.08.013.
Payre, W., Cestac, J., & Delhomme, P. (2014). Intention to use a fully automated car: Attitudes and a priori acceptability. *Transportation Research Part F: Traffic Psychology and Behaviour, 27*, 252–263. https://doi.org/10.1016/j.trf.2014.04.009.
Penmetsa, P., Adanu, E. K., Wood, D., Wang, T., & Jones, S. L. (2019). Perceptions and expectations of autonomous vehicles – A snapshot of vulnerable road user opinion. *Technological Forecasting and Social Change, 143*, 9–13. https://doi.org/10.1016/j.techfore.2019.02.010.
Pettigrew, S., Fritschi, L., & Norman, R. (2018). The potential implications of autonomous vehicles in and around the workplace. *International Journal of Environmental Research and Public Health, 15*, (9). https://doi.org/10.3390/ijerph15091876.
Pettigrew, S., Worrall, C., Talati, Z., Fritschi, L., & Norman, R. (2019). Dimensions of attitudes to autonomous vehicles. *Urban, Planning and Transport Research, 7*(1), 19–33. https://doi.org/10.1080/21650020.2019.1604155.
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.
Pucher, J., & Renne, J. L. (2005). Rural mobility and mode choice: Evidence from the 2001 National Household Travel Survey. *Transportation, 32*(2), 165–186. https://doi.org/10.1007/s11116-004-5508-3.
Qu, S. Q., & Dumay, J. (2011). The qualitative research interview. *Qualitative Research in Accounting & Management, 8*(3), 238–264. https://doi.org/10.1108/11766091111162070.
Rödel, C., Stadler, S., Meschtscherjakov, A., & Tscheligi, M. (2014). Towards Autonomous Cars. In L. N. Boyle (Ed.), Proceedings of the 6th International Conference on Automotive User Interfaces and Interactive Vehicular Applications - AutomotiveUI '14 (pp. 1–8). ACM Press. https://doi.org/10.1145/2667317.2667330
SAE. (2019). SAE Standards News: J3016 automated-driving graphic update. https://www.sae.org/news/2019/01/sae-updates-j3016-automated-driving-graphic.
Sager, T. (2005). Footloose and Forecast-free:: Hypermobility and the Planning of Society. European Journal of Spatial Development, 17.
Salmon, P., Regan, M., & Johnston, I. (2005). Human error and road transport: Phase one - Literature review. Accident Research Centre. https://www.monash.edu/__data/assets/pdf_file/0010/216946/Human-Error-and-Road-Transport-Phase-One-A-framework-for-an-error-tolerant-road-transport-system.pdf
Salonen, A., & Haavisto, N. (2019). Towards autonomous transportation. Passengers' experiences, perceptions and feelings in a driverless shuttle bus in Finland. Sustainability, 11 (3), 588. https://doi.org/10.3390/su11030588
Schoettle, B., & Sivak, M. (2014). A survey of public opinion about autonomous and self-driving vehicles in the U.S., the U.K., and Australia. https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108384/103024.pdf?sequence=1&isAllowed=y
Selinka, S., & Kuhn, M. (2019). Influences of User Experience on Consumer Perception: A Study on "Autonomous Driving". In P. Rossi & N. Krey (Eds.), Developments in Marketing Science: Proceedings of the Academy of Marketing Science. Finding New Ways to Engage and Satisfy Global Customers (Vol. 7, pp. 295–306). Springer International Publishing. https://doi.org/10.1007/978-3-030-02568-7_78
Rouchitsas, A., & Alm, H. (2019). External Human-Machine Interfaces for Autonomous Vehicle-to-Pedestrian Communication: A Review of Empirical Work. *Frontiers in psychology, 10*, 1–12. https://doi.org/10.3389/fpsyg.2019.02757.
Spillar, R. (2019). The state of smart mobility in austin. *ITE Journal, 89*(8), 14–15.
Spinney, J. E. L., Scott, D. M., & Newbold, K. B. (2009). Transport mobility benefits and quality of life: A time-use perspective of elderly Canadians. *Transport Policy, 16*(1), 1–11. https://doi.org/10.1016/j.tranpol.2009.01.002.
Statistik Austria. (2019a). Gliederungen nach städtischen und ländlichen Gebieten. http://www.statistik.at/web_de/klassifikationen/regionale_gliederungen/stadt_land/index.html
Statistik Austria. (2019b). Kraftfahrzeuge - Bestand. https://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/verkehr/strasse/kraftfahrzeuge_-_bestand/index.html
Treat, J. R., Tumbas, N. S., McDonald, S. T., Shinar, D., Hume, R. D., Mayer, R. E., ... Castellan, N. J. (1979). *Tri-Level Study of the cause of traffic accidents: final report.*. https://doi.org/10.1037/e488172008-001.
Vella-Brodrick, D. A., & Stanley, J. (2013). The significance of transport mobility in predicting well-being. *Transport Policy, 29*, 236–242. https://doi.org/10.1016/j.tranpol.2013.06.005.
Venkatesh, Morris, & Davis (2003). User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly, 27 (3), 425. https://doi.org/10.2307/30036540
Zmud, J. P., & Sener, I. N. (2017). Towards an Understanding of the Travel Behavior Impact of Autonomous Vehicles. *Transportation Research Procedia, 25*, 2500–2519. https://doi.org/10.1016/j.trpro.2017.05.281.
Hilgarter, K., Granig, P. (2019): Automatisierte Fahrzeuge und die Kommunikation mit anderen VerkehrsteilnehmerInnen. Forschungsforum der österreichischen Fachhochschulen. Wiener Neustadt, 24.04.2019.