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G7 expert group on automated and connected driving

Autonomous vehicle acceptance : overview of recent studies and research

Foreword

Under the G7 french presidency in 2019, a technical workshop was held on april 4-5 in Paris, to exchange national policy updates, with a focus on safety validation, responsibility, and acceptance.

Acceptance is a key challenge for the development of autonomous (or driveless, or automated) driving and mobility. Assessing acceptance levels and factors is still a challenge to research, considering the early phase of development in G7 countries. In this early phase, acceptance can only be assessed with stated preferences on concepts or future usages that are not fully clear to citizens and drivers.

France has proposed, in this context, to develop sharing of lessons learned from research and studies among G7+1 partners (e.g. member countries and European Commission, academia, think tanks, stakeholders).

The present document is a first step towards the objective of better knowledge sharing. It provides an overview of recent studies and research on vehicles conducted in G7+1 countries.

This document is a technical report and has no ambition to set recommendations. It doesn’t reflect any official position from any of the G+1 countries.

Synthesis

Autonomous vehicle acceptance has been extensively documented in the last couple of years (2016-2019). More than 60 references (research and corporate articles, studies) have been identified among which around 30 have been selected for the present overview. These references are mainly based on surveys aiming at identifying acceptance factors, as well as acceptance patterns among different populations. Some references provide first insights on acceptance trends.

These references mainly agree on the following interim findings :

- automated driving acceptance is, overall, increasing over the past years
- however, fluctuations and blowbacks are still dependent on serious and visible accidents
- acceptance appears to be higher in the long-term than for present adoption
- trust is key factor influencing public acceptance
- experiencing either an automated or autonomous transport system increases acceptance
- main suitable target in willingness-to-purchase are young men with high income
- less informed people about AVs are the main opponent to it, and vice versa
- adoption is directly linked to a reduction of the AVs price over time

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I- Meta-analysis and meta-synthetis

European research project BRAVE, november 2017 (cf. selected extracts in annex I).

Studies of public opinion on acceptance and attitudes on automated driving indicate that fears related to system failure seem to be present in the public and need to be taken into account.

The literature review shows that the general level of trust in automated or autonomous driving is limited, within the reviewed studies the majority of participants were concerned that self-driving vehicles cannot drive as well as human drivers. Worries regarding system failure can also be related to trust problems. The comfort that passengers of highly / fully automated vehicles expect or what secondary task they engage in might depend on their tendency to trust machines.

Research findings clearly illustrate that males and females have distinct perceptions, expectations and concerns towards automated / autonomous vehicles. The finding of the described surveys suggest that men generally have more positive expectations regarding automated features / driver assistance systems in cars and also seem to be slightly more willing to buy such systems than females and that the attitude of females towards automated / autonomous vehicles is rather reserved. Research findings also clearly illustrate that males and females have distinct perceptions, expectations and concerns towards automated / autonomous vehicles. Men generally have more positive expectations regarding automated driving and also seem to be slightly more willing to purchase such systems than females and have other ideas regarding how to spend their time within self-driving vehicles. The attitude of females towards automated / autonomous vehicles is rather reserved, females also state to know less about and to be less interested in these types of technical innovations and they express more doubts about the safety of self-driving systems and a higher tendency to mistrust in such systems driving.

Other important implications can be related to worries about data privacy and liability. As it is not clear yet who will be liable in what situation and who will have the right to access the data gathered with the introduction of automated driving on European roads, the uncertainty was found to be a concern to European citizens.

NB : report based on the findings of ten recent studies on public opinion of automated driving. Three of them are based on attitudes and opinions of German samples (ACV, 2015; Bock, German & Sippl, 2017; Gladbach & Richter, 2016), two others conducted among French samples (Payre, Cestac, & Delhomme, 2014; Piao et al. 2016), whilst the others investigate the attitudes of U.S.-citizens (Schoettle & Sivak, 2014, 2015, 2016), UK-citizens (Schoettle & Sivak, 2014) and Australian citizens (Schoettle & Sivak, 2014). Also the findings of a Slovenian survey (Šinko , 2016) were included. Further findings included within this report are those of the multinational survey of Kyriakidis, Happee and de Winter (2015) and those of a survey conducted by the Observatorio Cetelem Auto of Spain (2016). Details about locations, distribution methods, number of respondents and methodology of each study can be viewed in annex 1.

A multi-level model on automated vehicle acceptance : a review-based study
Nordhoff, Kyriakidis, Van Arem, Happe, September 2019

On the basis of a systematic literature review of 124 empirical studies, the study proposes, a multi-level model to predict automated vehicle acceptance. It incorporates a process-oriented view, considering acceptance as the result of a four-stage decision-making process that ranges from the exposure of the individual to automated vehicles (Avs).

In Stage 1, the formation of favourable or unfavourable attitudes towards Avs in stage 2, making the decision to adopt or rejet Avs in stage 3, to the implementation of Avs into practice in stage 4.

The model incorporates 28 acceptance factors that represent seven main acceptance classes. The acceptance factors are located at two levels,i.e., micro and meso. Factors at the micro-level constitute individual difference factors(i.e., socio-demographics, personality and travel behaviour). The meso-level captures the exposure of individuals to Avs, instrumental domain-specific, symbolic-affective a,nd moral-normative factors of acceptance. Tyhe literature review revealed that 6% of the studies investigated the exposure of individuals to Avs (i.e., knowledge and experience). 22% of the studies investigated domain-specific factors (i.e., performance and effort expectancy, safety, facilitating conditions and service and vehicle characteristics), 4% symbolic-affective factors (i.e., hedonic motivation and social influence), and 12% moral-normative factor (i.e., perceived benefits and risks). Factors related to a person's socio-demagraphic profile, travel behaviour and personality were investigated by 28%, 15% and 14% of the studies, respectively.

Factor	Factor class	Acceptance factor	Studies
1	**Exposure to Avs**	Experience with and knowledge about AVs: Awareness of AV technologies, interacting with AVs, satisfaction with in-vehicle technology, familitarity / experience with road automation (e;g., Advanced Driver Assistance Systems (ADAS), SAE Level 2-4), type of information about AVs	49
2		Perfomance expectancy: Equivalent to perceived usefulness	31
3		Effort expectancy: Equivalent to perceived ease of use	19
4		Faciliting conditions: Equivalent to perved behavioural contyrol, hepfulness, technical support, self-efficacy,(conceptual) compatibility/fit, lifestyle fit, technology confidence	10
5		Safety: Perceived safety, reliability, security, equipement and system failure, cyber security/fear of terrorism/hacking, system perfomance in poor/various weather and terrain or unexpected conditions (e.g., automated vehicles getting confused by unexpected situations, automated vehicles not driving as well as human drivers)	73
6		Service and vehicles characteristics: Availability, flexibility, travel speed, travel costs, convenience, integration with other modes, comfort, charging time, interoperability, size, quality and design of exterior and interior, brightness,aesthetics,brand, vehicle behaviour and capabilities (e.g.,dynamic object and event detection, overtaking and braking behavior, longitudinal and lateral control)	45
7	**Symbolic-affective system evaluation**	Hedonic motivation: Equivalent to poleasure, enjoyment, fun	13
8		Social influence: Equivalent to subjective norm, prestige, image	18

9	**Moral-normative system evaluation**	Perceived benefits: Higher productivity due to engagement in non-driving related activities, benefits for the environment (e.g., reduction of fuel consumption, emissions and traffic congestion, lower vehicle awnership), increased mobility independence and freedom for the elderly, disabled and others, no need for driver license/ to spend time and cost on learning how to drive, easier, quicker and less expensive parking, lower repair costs (in case of less accidents),increased jobs, lower insurance premiums	55
10		Perceived risks: Legal liability of drivers or owners, date privacy (location and destinatin traking), loss od driving skills and pleasure, interacting with manually controlled cars, pedestrians and bicyslists, lack of assistance for disabled riders/passagers, affordability, traffic delays,ethical/social consequences (job losses, social isaolatiohn, loss of human element)	50
11	**Socio-demagraphics**	Age	65
12		Gendre	58
13		Household structure: Number of people in household, number/presence of children, workers, dependent people in houhold, age of child, marital status	17
14		Education	34
15		Income	29
16		Employment: Employment statuts, jobs per household, socal class, number of workers in household, flexible work schedule (e;g., offered flextime, permit to compress work schedule)	16
17		Residential situation: Place of residence, house type, home locaion, region, ethnicity, nationality, immigration status	28
18	**Travel behavior**	Access to mobility: possessing valid driver license or public transporrt pass, car/Diesel vehicle/electric vehicle ownership, number of vehicles per household, age of oldest vehicles, number of vehicles sold in past years, vehicles type	29
19		Travel purpose: Number and type of trips in past days (e.g., run errands, pick up kids from soccer practice	10
20		Attitude towards using transport mods: Attitudes towards car ownership/use, use of public transport, walking, cycling, supporting car-free environment	17
21		Frequency of travel mode use: Commonly used/preferred mode of transport, rideshare usage/sharing trips, driving habit, access to car-sharing, drive alone (for work trips)	40
22		Medical condition/disability: Having medical condition/disability that prohibits driving, intensity of disability, visual and physical impairment	10
23		Accident involvement: involvement in accidents, citation record	15
24		Driving mileage: number of kilometers/miles driven (in the last 12 months)	14
25	**Personality**	Trust: Trusting automated vehicles, being comfortable with idea of removing steering wheel, being comfortable with travelling in an AV/with sending an AV on its own, believing that AV drives better than human driver, being concerned about riding in Avs, trusting technology companies	49
26		Technology savviness: innovativeness, number and types of technologies used (e.g., owning smartphones) technology interest, technology readiness, curiosity, attitudes to robot approval, enthusiasm for technology, knowledge of mobility-related developments, technological optimism and faith in progress, technological openness, being comfortable with technology	34
27		Control: Internal and external locus of control, preference to have control over things, having the option of manual drive, autonomy preference, desire for control preference for presence and responsibilities of bus operator/steward/supervisor, camera, interactive screen for communication with bus operator and visualisation of what AV sees	36
28		Sharing AV with stranger: Ability to interact with individuals outside immediate social circle, being concerned about sharing an automated vehicle with strangers, comfort with other drivers behind the wheel	10

Literature review on surveys investigating the acceptance of autonomous vehicles
Becker and Axhausen, november 2016

The goal of a number of surveys in recent years was not only to elicit the general acceptance of the technology, but to additionally explore when, how and why respondents were inclined to make us of it. This is the first literature review on survey regarding autonomous vehicles with the intention to investigate the various methods currently being applied and the conclusions they lead to. In addition to comparing the general results in terms of the distributions of the response variables, the surveyed explanatory variables are categorized and analysed according to their influence in different experiments.

Results - Response Variables

(SAV = shared autonomous vehicle ; PAV = pooled autonomous vehicle)

Author(s), Reference	Year	General Opinion/ Intention to use	Willingness to pay (WTP)	Ownership vs shared or pooled
Bansal, Kockelman, & Singh (8)	2016	41% would use an SAV once a week at a price of 1 USD per mile	7253 USD	Both analyzed, no direct comparison
Krueger, Rashidi, & Rose (9)	2016			
Kyriakidis, Happee & De Winter (10)	2015	Enjoyable mean 3.49/5	Median Between 3000 and 5000 USD	
Payre, Cestac, & Delhomme (11)	2014	68.1% above 4 (7 Lickert) on custom acceptability scale		
Bansal, & Kockelman (12)	2016	54,4% as useful; 58.4% scared; 40% for everyday trips	5857 USD	
Howard & Dai(13)	2014	40% buying or equipping; 45% would not use an AV-Taxi on a monthly basis		Both analyzed, no direct comparison
Rödel, Stadler, Meschtscherjakov, & Tscheligi (14)	2014	3.04/6 Behavioral intention to use the system		
Brown et al. (Deloitte) (15)	2014	Graph di_erentiating by 6 countries		
Continental (16, 17)	2013	Welcome technology: 79% China, 61% Japan, 53% Germany, 41% US	2900 EUR Freeway Driving (Germany)	
Ipsos Mori (18)	2014	18% regard the technology as important		
J.D. Power (19)	2012	37% would like to buy	20% would buy at a price of 3000 USD	
Schoettle & Sivak (20)	2015	15.6% prefer full automation		
Schoettle & Sivak (21)	2014	Positive impression: 61.9% Australia, 56.3% U.S., 52.2% U.K.	75th percentile 1880 USD	
Seapine Software (22)	2014	88% worried		
Silberg et al. (KPMG) (3)	2013		Median 4500 USD	50% would give up second car
Zmud, Sener, & Wagner (23)	2016	50% of sample intention for everyday use		59% prefer private AV over SAV; 23% want to reduce vehicle ownership

Effects of socio-demographic variables

Predictor	Effect on Opinion	Dependent Variable
Gender	Positive - Male	Intention to use; Concern; WTP for Ownership; Adoption timing; Acceptance, Regard as important
	Positive Female	Intention to use
	Not sign.	Concern; WTP for Ownership; Mode Choice
Age	Positive	Intention to use
	Negative	WTP for Ownership; Concern; Regard as important; being worried ; intention to use.
	Not sign	Intention to use; Adoption timing; Mode Choice
Income	Positive	WTP for Ownership; Adoption timing
	Not sign.	Intention to use
Education	Not sign.	Intention to use
Children	Negative	Intention to use
	Not sign.	WTP for Ownership; Mode Choice

Effects of attitudinal variables

Predictor	Effect on Opinion	Dependent variable
Technology awareness	Positive	Adoption timing; intention to use
Locus of control	Not sign.	Intention to use
Sensation Seeking	Positive	Intention to use
Personality Test	Not sign.	Driving in Avs enjoyable, driving in Avs is easier than manual driving, worries about data transmission, concerns about software hacking
Passion for driving	Negative	Intention to use; Regard as important
Acceptance of advanced driving systems	Positive	Acceptance
Data privacy concerns	Negative	Intention to use

Effects of the current behavior

Predictor	Effect on Opinion	Dependent variable
Mileage	Positive	WTP for Ownership
	Not sign.	Intention to use; WTP for Ownership; Adoption timing
Car Sharing	Not sign.	WTP for Ownership
	Positive	Mode Choice; PAV
Current Vehicle: Autonomy level	Positive	Intention to use; WTP for Ownership
Current Vehicle: Premium	Positive	Intention to use
Car Availability	Not sign.	Mode Choice
Using multiple modes	Positive	Mode Choice
Number of past crash experiences	Positive	WTP dor Ownership; Adoption timing

Effets of the trip characteristics

Predictor	Effect on opinion	Dependent variable
Population density	Positive	Intention to use; Adoption timing
Trip purpose	Mostly Not sign.	Mode Choice
Trip distance	No effect	Intention to use
On highways and in congested traffic	Positive	Intention to use
Special lanes for Avs	Positive	Intention to use

II- Recent corporate and think-tank studies

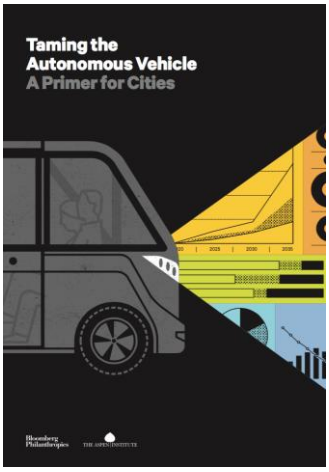
AAA, January 2016

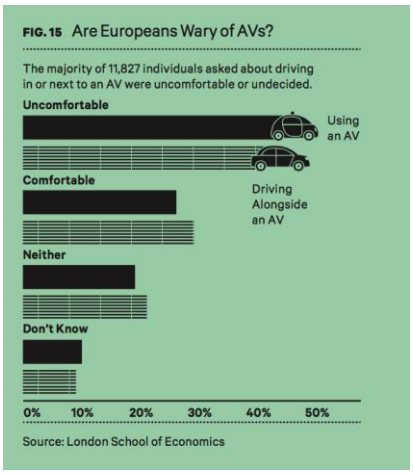
- **Only one-in-five (20%) U.S. drivers would trust an autonomous vehicle** to drive itself with them in it.
- **Three-quarters (75%) of U.S. drivers would be afraid to allow an autonomous vehicle** to drive itself with them in it.
- **Women (81%) are more likely than men (67%) to be afraid** to allow an autonomous vehicle to drive itself with them in it.
- **Baby Boomers (82%) are more likely to be afraid** to allow an autonomous vehicle to drive itself with them in it than younger generations (69%)
- **U.S. drivers are most likely to trust lane departure warning/lane keep assist (52%),** followed by adaptive cruise control (47%), automatic emergency braking (44%) and self-parking technology (36%).
- **Men are more likely than women to trust semi-autonomous vehicle technology*,** specifically self-parking (42% vs. 31%), automatic emergency braking (49% vs. 40%) and adaptive cruise control (50% vs. 43%)
- **Drivers that have semi-autonomous technology* in their vehicle are more likely to trust it** than those that do not, specifically lane-departure warnings/lane keep assist (84% vs. 50%), adaptive cruise control (73% vs. 47%) and automatic emergency braking (71% vs. 44%).

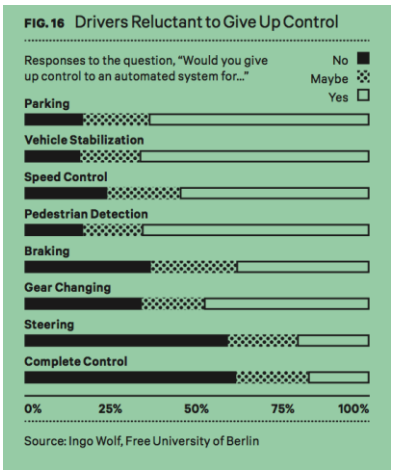
http://publicaffairsresources.aaa.biz/wp-content/uploads/2016/02/Automotive-Engineering-ADAS-Survey-Fact-Sheet-FINAL-3.pdf
http://www.thedrive.com/news/2423/75-of-americans-are-scared-of-self-driving-cars

From : Consumer trust in AVs, a selection of studies, European Commission, 2019

Bloomberg Philantropies, March 2017



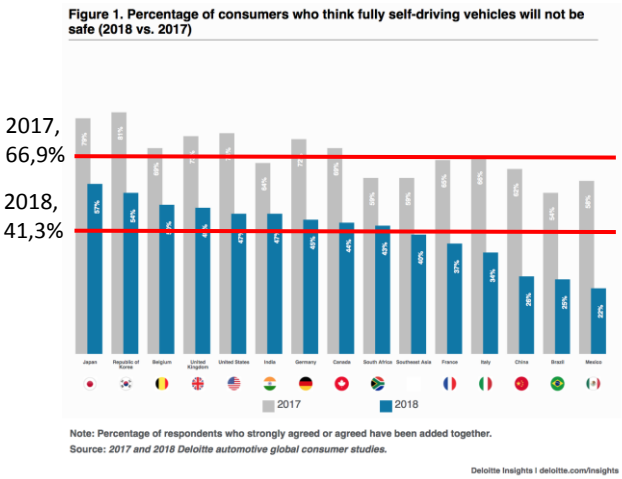


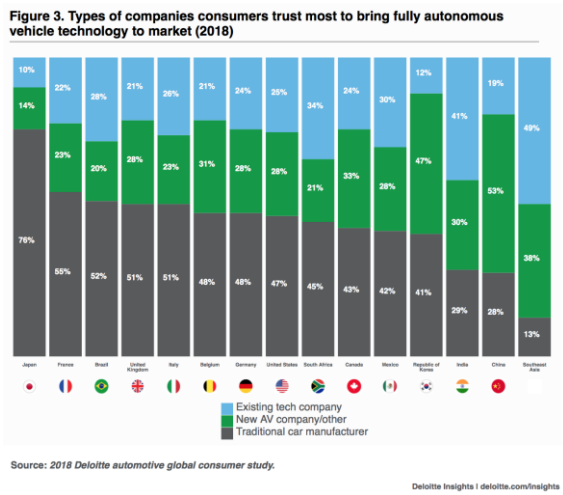


https://www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDF.pdf

From : Consumer trust in AVs, a selection of studies, European Commission, 2019

Deloite, January 2018

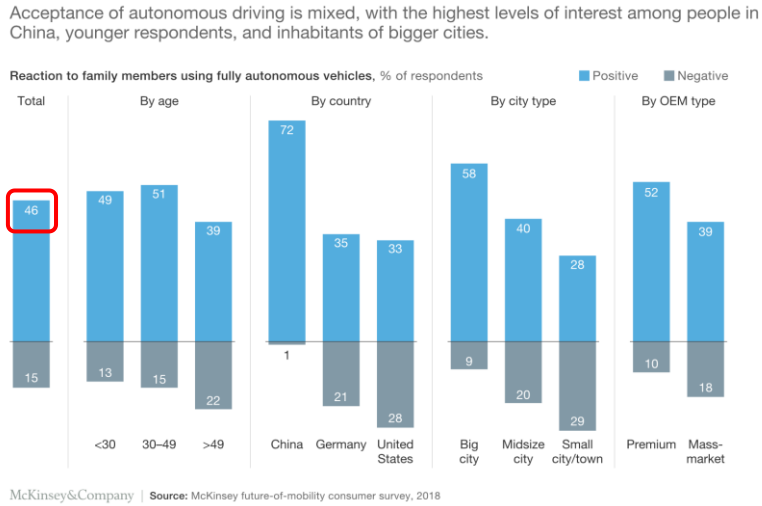




https://www2.deloitte.com/insights/us/en/industry/automotive/advanced-vehicle-technologies-autonomous-electric-vehicles.html

From : Consumer trust in AVs, a selection of studies, European Commission, 2019

McKinsey, December 2018



https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/profiling-tomorrows-trendsetting-car-buyers

From : Consumer trust in AVs, a selection of studies, European Commission, 2019

The Autonomous car, A consumer perspective
Capgemini, may 2019

Survey of over 5,500 consumers from around the world. Key findings :

- Consumers are ready for self-driving cars and optimistic about the future of this technology
    - They are positive about autonomous cars and a majority (59%) are awaiting their arrival with "anticipation
    - Consumers trust automotive OEMs over new startups when it comes to these vehicles and are more optimistic than auto executives when it comes to overcoming the challenges of self-driving
    - Millennials (aged under 35) as well as urban/suburban consumers tend to be more positive compared to those areas and small towns
    - Half of consumers (55%) trust self-driving cars to make sound decisions during unexpected situations.

- Consumer acceptance of self-driving cars will increase over time
    - Acceptance is growing: within five years 52% would prefer to be driven in a self-driving car than a normal one
    - Consumer preference of riding in self-driving car over traditional cars is set to double in five years. While only 25% of consumers would prefer to ride in a self-driving car over a normal one in 12 months'time, over half of the surveyed consumers (52%) would prefer self-driving cars five years from now. This uptake in preference can be attributed to the consumer expectation thatself-driving vehicles will become a mass market product over the years and potential maturity of the market, thereby easing adoption.

- Consumers expect driverless cars to have higher fuel efficiency and be more environmentally sustainable
    - Consumers find greater fuel efficiency (73%) to be a compelling use factor, closely followed by a reduced environmental hazard and carbon footprint (71%) as key factors to encourage purchase/use of self-driving cars.

- Consumers see self-driving cars are more than just a means of transport
    - They see an expanded remit for these vehicles: over half (54%) are comfortable with the self-driving car picking up or dropping off family members and friends, and close to half (49%) see these vehicles running errands
    - They see these vehicles making their lives better: half (50%) expect self-driving cars to save them time, expecting to save as much as 6.5 hours a week

- The in-car experience will be critical, with consumers' wants having implications for many other industries, such as media and entertainment, retail, and healthcare
    - 63% want to spend the time that self-driving cars save them in "socializing"
    - 58% want to disconnect from digital tools and enjoy the road
    - Nearly one in four consumers want to spend the time saved engaging in physical activities that will help them stay fit

Four priorities for organizations looking to accelerate the journey towards a self-driving future :
- Keep the consumer informed and listen to customer needs
- Understand and reassure the consumer: safety and security are key
- Build an ecosystem of services: partner with technology and content provide
- Develop software competencies: accelerate the change inside the company

Global Autonomous Vehicles report
ANSYS, October 2019

ANSYS commissioned Atomik Research to measure global perceptions of autonomous vehicles.

More than 22.000 people from Benelux, China, France, Germany, India, Italy, Japan, Spain, Sweden, the United Kingdom and United States were surveyed.

77% of respondents feel comfortable riding in autonomous cars during their lifetime.
50% said they would be ready to ride within the next five years, while 14% are ready to ride today.

Younger respondents were more interested in autonomous cars than older generations. 87% of 18-to 24-year-olds and 88% of 25-to 34-years-olds said they were ready to ride in autonomous cars in their lifetime. 43% of those over the age of 65 said they would never ride in an autonomous car.

When asked to select from a list of concerns for riding in an autonomous car, 59% of participants chose technology failure leading to a car crash as their top apprehension. Third parties hacking into autonomous cars proved to be respondents second biggest concern at 42%. The third primary concern shared by 35% of respondents was the possibility of other drivers on the road crashing into an autonomous car.

Observatory CETELEM on self-driving cars
2018

On the eve of the 2018 Consumer Electronic Show in Las Vegas, The Cetelem Observatory published the results of a quantitative survey on the autonomous car and the connected car carried out among 10,600 motorists worldwide (15 countries). The main results are the following :

71% of motorists believe that the 100% autonomous car will become a reality within 10 years. If 55% say they are interested in using an autonomous car (61% of those under 30), 71% think that it will become a reality in 10 years. In China, 92% believe it, 69% in France against only 49% in Germany. It should be noted that if motorists mainly think that this autonomous car will become a reality, they are only 35% to be ready to pay more to own one (22% of the French against 78% in China).

48% of motorists declare themselves ready to buy a “Google Car” or an “Apple Car” with Chinese motorists in mind (92%) declaring themselves ready. They are only 39% in the United States while France and Germany close the march (33% and 32%). If this 48% figure remains significant, it is down compared to 2016 when 55% of those questioned declared themselves ready to take the plunge (source: L’Observatoire Cetelem de l'Automobile 2016).

However, classic car manufacturers retain the greatest legitimacy for a transition to these new vehicles (60% of motorists think they are the most legitimate).

The connected car worries motorists. 82% think that it will be expensive, 78% that it will be reserved for technophiles and 55% of those questioned are worried about the use that can be made of the data collected. Respect for privacy is an important concern, much more than the loss of driving pleasure (38% of respondents are concerned). In addition, 83% of motorists expect priority from the connected car to improve personal safety, ahead of financial savings (62%) and driving comfort (37%).

But the autonomous car will be a connected car…

Consumer acceptance of autonomous vehicles
Here 2019

The research conducted in june 2019 featured two phases. A qualitative phase involved 48 consumers with different car usage and preferences across six varied locations (dense cities, sprawl, rural) in an online community. A quantitative phase involved further 2.000 nationally-representative consumers in USA and Germany in an online survey.

The study proposed a special focus on acceptance of, respectively :

- autonomous driving services
- autonomous car ownership

Who would OWN an autonomous car?	*Who would use an autonomous car SERVICE?*
68% with ADAS experience	65% with ADAS experience
42% without ADAS experience	22%without ADAS experience

Opinion on vehicle substitution potential by autonomous cars or services

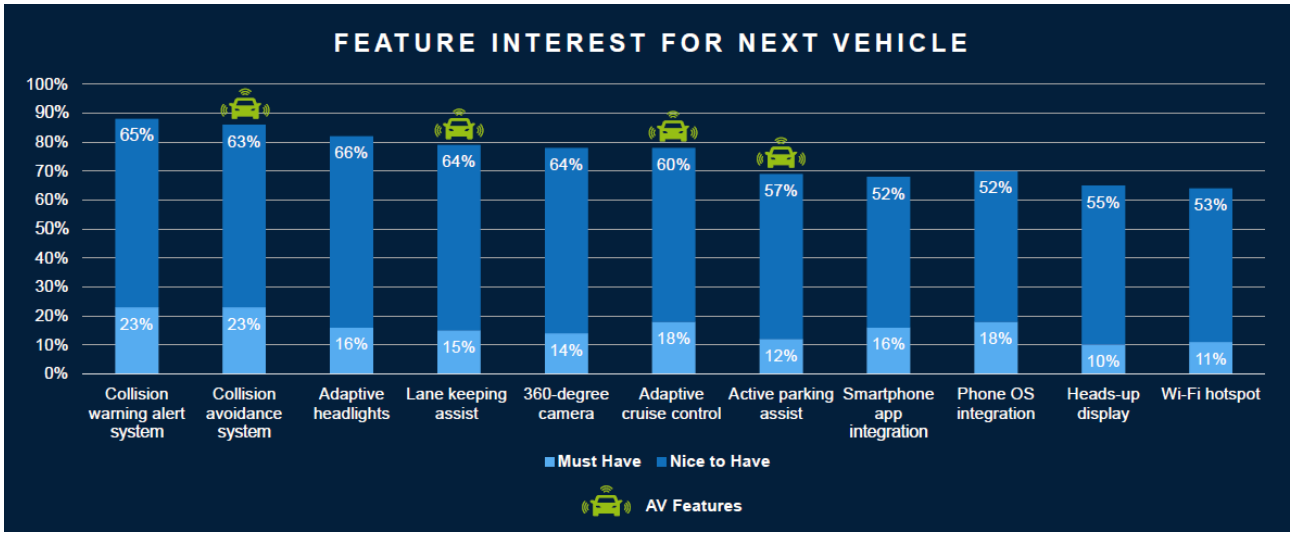
	Autonomous Ownership	Autonomous Service
Private vehicles	58%	47%
Taxi Cab	28%	35%
Company Car	28%	25%
Public Transportation	23%	27%
Ride Sharing	21%	26%

Opinion on travel substitution potential by autonomous cars or services

	Autonomous Ownership	Autonomous Service
Commute : Work/School	44%	35%
Visiting Friends/Family	38%	29%
Evenings Out	32%	31%
Shopping: Grocery	37%	29%
Vacation: Holiday /Long Weekend	37%	29%

Evolution of mobility : autonomous vehicles
Cox Automotive, 2018

Survey on ~1250 people. Main results :



Question	*2018*	*2016*
Agree that new technology makes better drivers	Yes : 54 %	
Would feel uncomfortable riding an autonomous vehicle fully driven by a computer	Yes : 68 %	
Think people should always have the option to drive themselves even in an autonomous vehicle	Yes : 84 %	
Is aware of level 3 = partial autonomy	Yes : 78 %	Yes : 58 %
Is aware of level 4 = full autonomy + human	Yes : 78 %	Yes : 56 %
Is aware of level 5 = full autonomy, no human	Yes : 64 %	Yes : 40 %
Agree with “safe” for level 3	Yes : 59 %	Yes : 73 %
Agree with “safe” for level 4	Yes : 45 %	Yes : 64 %
Agree with “safe” for level 5	Yes : 28 %	Yes : 47 %
Agree that roads would be safer with all fully autonomous vehicles	Yes : 63 %	Yes : 45 %
Agree that autonomous vehicles need real world testing in order to be perfected	Yes : 75 %	
Prefer testing to take place in a different city	Yes : 54 %	
Would not feel comfortable walking near roads where tests take place	Yes : 54 %	
Would not feel comfortable driving on the same roads where tests take place	Yes : 54 %	

Autonomous mobility and vehicles: what are citizens’ expectations for tomorrow?
Missions Publiques, 2018-2019

With a team of partners, Missions Publiques ran the first of two phases of an international and local citizens’ dialogue process. In 2018, an exploratory phase took place in five French cities and two US cities. In 2019, seventeen territories in nine countries in Europe, North America, and Asia hosted a second round of deliberations focused on scenario building, trust, and policy.

Main results :

- The question of governance of the future of mobility is a key-question raised by participants: who will decide what will future mobility look like? Who will manage future transitions? Citizens’ expressions of hopes and recommendations show that they have a strong desire for inclusive governance, that will include them in the decision-making process.
- When asked about their preferred scenarios of deployment of autonomous and automated mobility, participants from all countries prefer the public transportation model and ride share model. Whether in Singapore, USA, Canada and Europe, results are comparable. 78% of North-American participants rated the ride-share model as their preferred deployment scenario, as well as 77% Europeans and 68% of participants from Singapore.
- Participants stated that the importance about controlling the use of personal data : 90% participants think that individual citizens should have control over selling their data or forbidding its use.
- Before safety and security, participants are worried about the cost and the affordability of autonomous and automated. Participants from all around the world stated that autonomous mobility should be accessible to everyone, including disadvantaged people. Safety and technology failures come in second and third places.

III- Public studies and surveys

European barometer
(2015-2017, European Commission)

- Past Eurobarometer surveys have showed that a significant portion of the population still has a negative attitude towards driverless vehicles.
    - Between 52 % and 63 % of users would feel uncomfortable being driven in a full AV (2017 Eurobarometer survey).
- The trend shows increased confidence in the AVconcept
    - 70 % of respondents said they would have been uncomfortable in a self-driving car or truck (2015 Eurobarometer survey).
- Other studies have presented a downward trend in the intention to use an AV, especially as a result of the first accidents involving AVs

NB : New Eurobarometer's results expected by the end of 2019
"Expectations and Concerns from a Connected and Automated Mobility", considering, inter alia :
- *Knowledge and experience about AVs*
- *General perception of future AVs*
- *AVs and shared mobility*
- *Expectations and concerns for AVs*

European barometer 2015-2017 : in-depth analysis
Fortunati, Lugano, Manganelli, 2019

This paper contributes to increasing knowledge in attitudes, perceptions, views and emotions toward car automation and robotization by investigating Europeans' emotions and perceptions toward autonomous vehicles as indicated in two Eurobarmeter surveys.

The two Special Eurobarometer surveys taken into account represent the scaffold of any European date on autonomous systems (Eurobarometer, 2015) and on attitudes toward the impact of digitalization and automation on daily life (Eurobarometer, 2017).

This survey has the merit of investigating autonomous vehicles with respect to transportation of both passengers and goods: In this respect, 35% of Europeans stated that they would feel totally or fairly comfortable traveling in driverless cars. By disagregating the data by country, the situation that emerged in 2014 was quite varie: The percentage of respondents who would feel comfortable traveling in driverless car ranged from 35% in Poland (highest percentage) to 12%m in Cyprus and Greece (lowest percentage). Two regressions were run to understand the main predictors of feeling comfortable traveling or transporting goods in a driverless car (Table 1).

Table 1. OLS Regression Analysis (Beta Coefficients) Related to the 2014 Survey.

	Feeling comfortable traveling in a driverless car		Feeling comfortable with goods being transported in a driverless car	
	β	*p* <	β	*p* <
Age	−.078	.0001	−.053	.0001
Gender[a]	−.109	.0001	−.106	.0001
Education[b]				
Low	−.085	.0001	−.122	.0001
Medium	−.049	.0001	−.069	.0001
High	.039	.0001	.015	.0001
Community[c]				
Large	.015	.0001	.027	.0001
Medium	−.012	.0001	−.020	.0001
Attitude toward robots	.278	.0001	.302	.0001
Use of robots[d]	.028	.0001	.014	.0001
Constant	1.817	.0001	2.005	.0001
R^2 (adjusted)	.149		.164	

[a] Gender: 0 = *male*; 1 = *female*.
[b] Reference group: still studying.
[c] Reference group: small community.
[d] Use of robots: 0 = *no*; 1 = *yes*.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 2. Comparison Between Europeans' Feelings Toward Driverless Cars in 2014 and 2017.

	2014 (Base = 27,801), %	2017 (Base = 27,901), %
Feeling totally or fairly comfortable traveling in a driverless vehicle (scores 5–10)	35	39
Gender		
Men	27	28
Women	16	17
Age		
15–24	27	29
25–39	25	28
40–54	22	25
55+	16	15
Education		
15 years	11	11
16–19 years	20	20
20+ years	28	29
Still studying	28	32
Socio-professional categories		
Self-employed	27	31
Managers	31	31
Other white-collar workers	25	27
Manual workers	20	21
Stay-at-home moms or dads	15	16
Unemployed	20	21
Retired	15	14
Students	28	32

Source: Eurobarometer surveys 427 (Eurobarometer, 2015) and 460 (Eurobarometer, 2017).

French annual survey on autonomous driving
2018 and 2019

Online survey, representative sample of 1002 people over 18. Main results :

Question	2019	2018
Overall acceptance		
Ready to delegate total responsibility of driving to an autonomous vehicle	Yes : 38% No : 62%	Yes : 28% No : 72%
Main reasons (#1 and #2) for using an autonomous vehicle		
Less fatigue in traffic jam	47%	56%
Enhanced safety	38%	39%
Increased free time	33%	37%
Cost savings	23%	25%
Reduces environmental impact	21%	15%
Improved parking facilities	20%	15%
Better routing	18%	
*Main reasons (#1 and #2) for **not** using an autonomous vehicle*		
Mistrust in decision making	54%	55%
Loss of control	44%	50%
Fear of accident	43%	39%
Lack of driving pleasure	36%	41%
Fear of hijacking	20%	16%
Decision making by algorithms and automated systems		
Comfortable with the idea that a decision affecting myself is taken by and algorithm	Yes : 24% No : 59% NR : 17%	
Relevance of automated decision-making for individual cars	Yes : 87% No : 13%	
Relevance of automated decision-making for public transport	Yes : 94% No : 6%	

French qualitative interviews on autonomous driving
september 2019

4 focus groups (~ 15 people) + 26 face-to-face interviews. Main results :

Fuzzy representations :

- Technology perceived as non-mature
- Percieved link with electro-mobility…which development perspectives are also fuzzy
- Low visibility on individual benefits
- Low visibility on collective impacts
- No clear or strong expectations at this stage
- No clear opinion on “raison d’être” (if any)
- Unclear messages from public authorities
- Fears from lack of control
- Overwhelming concerns on safety and security
- Concerns about job losses or skills transitions

But a willingness to be convinced based on usages and experiences

IV- Research

Vehicle Owners' Experiences with and reactions to advanced driver assistance systems
The University of Iowa, September 2018

The purpose of this study was to examine knowledge, understanding, opinions dand experiences of drivers who own and regulary drive a vehicle equipped with selected technologies including forward collission warning, automatic emergency braking, lane departure warning, lane keeping assist, blind spot monitoring, rear cross-traffic alert or adaptive cruise control. Registered owners of selected model year 2016 and 2017 vehicles that included at least three of these technologies as standard equipment were made invitations to participate in an online survey. After confirming eligibility and reporting what technologies they actually had available on their vehicles, respondents were asked a series of in-depth questions about up to three of the technologies on their vehicle. A total of 1,212 eligible respondents completed the survey; in-depth date about experience with specific technologies was obtained from approximately 500 respondents for each respective technology.

Results indicated that the majority of drivers generally have favorable impressions of the technologies on their vehicles, trsut them helpful, would want to have them in the newest vehicle that they buy and would recommend the technologies to others. However many respondents and in some cases the majority_ demonstrated misperceptions or lack of awareness about what the technologies can and cannot do. Uncertainty and confusion may impact a driver's usage of, comfort with and reliance on the technology. Additionally, the prevalence of drivers' willingness to engage in other activities, look away from the roadway or appreciation of the fact that these technologies are designed to assist the driver but that the driver is still required to be attentive at all times to ensure safety.

Finally, few respondents reported seeking information about technologies from any sources beyond the dealership, owner's manual and their own experience via trial and error ; only about 1 driver 10 reported seeking information on the internet and hardly any reported having sought information about technologies on government websites. More research is needed to determine how best to convey important information to drivers about the function, capabilities and limitations of technologies in their vehicles.

Investigation of older drivers' requirement of the human-machine interaction in highly automated vehicles ; Li, Blythe, Guo, Namdeo 2019

The population of older drivers is increasing in size and age-related functional decline potentially reduce safe driving ability. In order to inform the design of an age-friendly human-machine interaction in highly automated vehicles (HAVs), several semi-structured interviews were conducted with 24 older drivers (71.50 years old mean) to explore their opinions of and requirements towards HAV after they had hands-on experience with a HAV on a driving simulator. Results showed that older drivers were positive towards HAVs and welcomed the hands-on experience with HAVs. In addition, they wanted to retain physical and potential control over the HAVs, and would like to perform a range of non-driving related tasks in HAVs. Meanwhile, they required an information system and a monitoring system to support their interactions with HAVs. Moreover, they required the takeover request of HAVs to be adjustable, explanatory and hierarchical, and they would like the driving styles of HAVs to be imitative and corrective.

Perceptions and expectations of autonomous vehicles – A snapshot of vulnerable road user opinion Penmetsaa, Adanua, Wooda, Wangb, Jonesc 2019

Public perceptions play a crucial role in wider adoption of autonomous vehicles (AVs). This paper aims to present two contributions to the understanding of public attitudes toward AVs.

The first one explores opinions regarding the perceived benefits and challenges of AVs among vulnerable road users – in particular, pedestrians and bicyclists. Second, the paper evaluated whether interaction experiences with AVs influence perceptions among vulnerable road users. The research was done through a survey data collected by Bike PGH, a Pittsburgh based organization involved in programs to promote safe mobility options for road users.

Analysis of the data revealed that respondents with direct experience interacting with AVs reported significantly higher expectations of the safety benefits of the transition to AVs than respondents with no AV interaction experience. This finding did not differ across pedestrian and bicyclist respondents.

The results of this study indicate that as the public increasingly interacts with AVs, their attitudes toward the technology are more likely to be positive.

Thus, this study recommends that policy makers should provide the opportunities for the public to have interaction experience with AVs. The opportunities can be provided through legislation that allows auto manufacturers and technology industries to operate and test AVs on public roads. This interactive experience will positively affect people's perceptions and help in wider adoption of AV technology.

Who will be the early adopters of automated vehicles ? Insights from a survey of electric vehicle owners in the United States ; Hardmann, Berliner, Tal 2018

In 2019, the adoption of automated vehicle is still barely understood and may be the same as plug-in electric vehicles (PEVs) early adopters. The survey, addressed to 2715 consumers in 36 states of USA based on the ownership of PEV (two third of the respondents), aimed at comparing automated vehicles (with human control) and driverless vehicles (without human control) with non-automated vehicles over 12 criteria (safety, comfort, driver fatigue, performance, energy consumption, environmental impacts, travel times, vehicle purchase price, insurance premiums, number of vehicle collisions, ability to complete other tasks). Socioeconomic and attitudinal variables were also part of the survey. Then they were asked how likely they were to purchase an automated vehicle or a driverless vehicle.

The results show that driverless vehicles are perceived as being better for driver fatigue, the environment, and for multi-tasking compared to automated vehicles, though they are perceived as being worse for safety. On average, respondents are more likely to purchase an automated vehicle than a driverless vehicle. Particularly, the more technophobes have the less interest for both vehicles and vice versa. Contrary to previous studies, both types of automated vehicles are generally perceived as being safer than vehicles with no automation though. Finally, the market introduction may follow a similar path as all the new technologies and the ownership of a PEV alone is not the only identifying factor in understanding automated vehicle adopters. Instead, perceptions of the vehicles along with socioeconomic (high household incomes) and attitudinal (technology minded) variables best describe the types of future consumers.

Consumer demand for fully automated driving technology ; Shin, Tada, Managi 2018

This paper evaluates current consumer demand in terms of purchase intention (PI) and willingness to pay (WTP) for fully automated vehicles (FAV) in Japan in 2019. This study was based on online interview addressed to 246 642 participants.

The results were separated whether they are linked to a merit or demerit brought by the FAV. The results suggest that the following merit options positively affect consumer demand for FADS: supporting the elderly, reducing traffic accidents, and reducing the burden of driving. On the other hand, demerit options such as an increase in initial and maintenance costs, information leakage to third parties, and possible malfunctions were found to negatively affect consumer demand. In particular, the merit of FAV in improving elders' driving has a positive and relatively large impact on WTP.

On average, consumers expect FAV to be available for purchase in approximately 13 years, and 47% of respondents report positive PI. Average WTP was approximately 0.19 million yen (1,650 USD) and 0.29 million yen (2,520 USD) for respondents with positive PI.

An international crowdsourcing study into people's statement on fully automated driving Bazilinskyy, Kyriakidis, de Winter, 2015

In 2015, Delft University of Technology conducted a large scale analysis on multiple interviews addressed online. This study investigated anonymous textual comments regarding fully automated driving, based on data extracted from three online surveys with 8,862 respondents from 112 countries. The filtering of comments resulted in 1,952 comments. The sample consisted primarily of males (74%) and had a mean age of 32.6 years.

Then, a crowdsourcing job was launched and 69 workers were asked to assign each of the 1,952 comments to at least one of 12 predefined categories, which included positive and negative attitude to automated driving, enjoyment in manual driving, concerns about trust, reliability of software, and readiness of road infrastructure. After a second filtering, leaving 792 comments for further analysis, 39% of the comments were classified as 'positive attitude towards automated driving' and 23% were classified as 'negative attitude towards automated driving'.

In conclusion, the public opinion appears to be split, with a substantial number of respondents being positive and a significant number of respondents being negative towards fully automated driving. The comments were also analyzed at the national level, where they were grouped by GDP per capita of the respondents' country. The results revealed an association between income level and the number of comments per category. People from high-income countries were more likely to express a negative comment and less likely to express a positive comment about automated driving.

Assessing Public perception of self-driving cars : the autonomous vehicle acceptance model Hewitt, Amanatidis, Politis, Sarkar, 2019

The Autonomous Vehicle Acceptance Model (AVAM) is a model defined in 2019 at the University of Cambridge. It is a model a user acceptance for autonomous vehicles (adapted from existing models of user acceptance for generic technologies) for measuring acceptance in AV in a standardised manner.

It consists in a 26-item questionnaire developed in accordance with the model and a survey to evaluate 6 autonomy scenarios. In a pilot survey (n = 54) and follow-up survey (n = 187), the AVAM presented good internal consistency and replicated patterns from previous surveys.

Results showed that users were less accepting of high autonomy levels and displayed significantly lower intention to use highly autonomous vehicles. The expected driving engagement of hands, feet and eyes was also assessed and showed to be lower for full autonomy compared with all other autonomy levels.

This highlighted that partial autonomy, regardless of level, is perceived to require uniformly higher driver engagement than full autonomy. These results can inform experts regarding public perception of autonomy across SAE levels. The AVAM and associated questionnaire enable standardised evaluation of AVs across studies, allowing for meaningful assessment of changes in perception over time and between different technologies.

Calibrating trust through knowledge: Introducing the concept of informed safety for automation in vehicles ; Khastgir, Birrell, Dhadyalla, Jennings 2018

One of the key factors influencing public acceptance of automated vehicle technologies is their level of trust. Development of trust is a dynamic process and needs to be calibrated to the correct levels for safe deployment to ensure appropriate use of such systems. One of the factors influencing trust is the knowledge provided to the driver about the system’s true capabilities and limitations.
In 2018, in the UK, 56 participants experienced two different types of automated systems: low capability automated system and high capability automated system. Interestingly, with the introduction of knowledge, the average trust levels for both low and high capability automated systems were similar.

After the participants experienced the driving simulator, the authors found that with the introduction of knowledge about the true capabilities and limitations of the automated system, trust in the automated system increased as compared to when no knowledge was provided about the system.

Eliciting preferences for adoption of fully automated vehicles using best-worst analysis
Shabanpour, Golshani, Shamshiripour, Mohammadian 2018

This study, led in the US in 2018, presents a new approach for modeling the adoption behavior of fully autonomous vehicles (AVs) using the profile-case best-worst scaling model. The study relies on a survey conducted on 1253 individuals in Chicago.

In this approach, an AV profile which is characterized in terms of the main vehicle attributes and their associated levels is presented to the decision maker and he/she is asked to select the most and the least attractive attributes. Further, a binary adoption question at the end of the choice task inquires if the respondent is willing to purchase the described AV. Utilizing this method, one can recognize the difference between the intrinsic impacts of the vehicle attributes and the impact of the attribute levels on the adoption decision.

Results of the analysis indicate that people are much more sensitive to the purchase price and incentive policies such as taking liability away from the "driver" in case of accidents and provision of exclusive lanes for AVs compared to other factors such as fuel efficiency, safety, or environmental friendliness. Further, it is found that millennials with higher income, those who live in the downtown area, and the majority of people who have experienced an accident in the past have greater interests in adopting this technology.

Cognitive underpinnings of beliefs and confidence in beliefs about fully automated vehicles.
Sanbonmatsu, Strayer, Yu, Biondi, Cooper 2018

This study investigated the cognitive underpinnings of consumers' beliefs and confidence in their beliefs about fully automated vehicles. It consisted in a survey addressed to 114 individuals and measured general confidence, beliefs, intentions, perceived knowledge of automated vehicles, measure knowledge of automated vehicles, propensity to trust technology.

Findings indicate that the most unfavorable views of fully automated vehicles are held by the least knowledgeable consumers. Thus, a significant contributor to negativity toward self-driving vehicles appears to be ignorance. The favorableness of beliefs about fully automated vehicles was also related to trust in technology; consumers who do not perceive that technology is helpful and reliable, and who do not believe that positive outcomes result from relying on technology evaluate self-driving cars less positively.

Although consumers were generally confident in their views of self-driving cars, many were uninformed about them. Consumers' confidence in their beliefs was more strongly correlated with perceived knowledge and general confidence than real expertise. Thus, consumers' confidence in their opinions about fully automated vehicles appears to be driven by cognitions that are largely superfluous. Participants' confidence in negative beliefs about fully automated vehicles suggests their opinions will not be easily influenced via persuasion.

Effects of positive and negative information on consumers' willingness to ride a driverless vehicle
Anania, Rice, Pierce, Winter, Milne, 2018

Media portrayal of automated vehicle has the potential to affect consumer perceptions and consequently their success or failure. The study aimed at investigating the effect of different types of information (positive or negative) on consumer perception of driverless vehicles and the differences that may exist between different gender (male, female) or nationalities (US, India) when confronted to a common information.

In 2018, 99 individuals were recruited and given a scenario in which they were passenger of a driverless vehicle with no other option. Then they were either presented a negative or positive piece of information about respectively an accident involving an automated vehicle or its potential to reduce it. With the negative information regarding driverless vehicle comes a tendancy to be less willing to ride one and vice versa. In conclusion, it is mentioned that a safety-based policy that mentions crashes may be perceived as a negative information linked with driverless vehicles.

Understanding trust and acceptance of automated vehicles: An exploratory simulator study of control between automated and manual driving
Molnar, Ryan, Pradhan, Eby, St Louis, Zakrajsek, 2018

Human drivers remain an integral component of the system and their acceptance and use of the automated technology needs to be much better understood. One factor that has emerged as a strong influence on the acceptance and use of automated technology is trust.

Two research questions where addressed : what factors are associated with the extent to which individuals report trust in automated technology after a simulated automated drive experience . The second research question was: How are trust in automated technology, control preferences, and experience with technology associated with objective measures intended to capture acceptance of automated technology.

To address this question, 72 participants were presented different simulated driving environments containing multiple mode transition scenarios between automated and manual driving. Following the drive, each participant completed a structured interview to explore his or her self-perceptions related to the drive, as well as a self-administered questionnaire on background characteristics.

Then, objective data collected during the driving simulation was used as a measure intended to capture acceptance of the automated technology with the following hypothesis: longer response times reflected greater acceptance of the technology, a larger proportion of scenarios in manual mode reflected less acceptance of the automated technology.

Results showed that driving-specific control preferences were significantly related to reported trust, in particular for those who experienced the driving simulator. Plus, some individuals may be more predisposed to accepting automated vehicle technologies based on their comfort with being a passenger rather than the driver. This suggests that trust in automated driving, at least as reported after a simulated experience with the technology, is an important component of acceptance of the technology.

Predicting the adoption of connected autonomous vehicles: A new approach based on the theory of diffusion of innovations ; Talebiana, Mishra, 2018

This paper proposes a new approach to forecast long-term adoption of connected autonomous vehicles (CAVs).

The concept of resistance is employed to explain why individuals typically tend to defer the adoption of an innovation (based on both functional and psychological barriers). It was assumed that there exists a social network among individuals through which they communicate based on certain frequencies. In addition, individuals can be subject to media advertisement based on certain frequencies.

Individual perceptions are dynamic and change over time as the individual is exposed to advertisement and communicates with satisfied and dissatisfied adopters. An individual decides to adopt firstly when there is a need for a new vehicle; then when his/her willingness-to-pay is greater than CAV price; and finally when his/her overall impression about CAVs reaches a cutoff value.

Results show that the automobile fleet will be near homogenous in about 2050 only if CAV prices decrease at an annual rate of 15% or 20%. A 6-month pre-introduction marketing campaign may have no significant impact on adoption trend. Marketing is shown to ignite CAV diffusion but its effect is capped. CAV market share will be close to 100% only if all adopters are satisfied with their purchases; therefore, the probability that an individual becomes a satisfied adopter plays an important role in the trend of adoption. To concludes, autonomous shared riding services are expected to have a significant prospect, and thus their impacts on overall CAV market penetrations should be incorporated into the current approach.

The role of system description for conditionally automated vehicles
Blömacher, Nöcker, Huff 2018

The research aimed at studying whether and how a priori system descriptions influence humans' mental models of conditionally automated systems. The authors presented participants with three different preliminary system descriptions (correct, incomplete, and incorrect) and measured their knowledge of the driving system, confidence in their own answers, as well as trust and acceptance in the system after they had seen a simulated driving situation in which the automated system failed. For participants who received an incorrect description about the system, knowledge about the systems' functioning increased more over time than the other conditions. Thus, participants adapted quite quickly to the new driving situations. Importantly, learning in the incorrect condition was relatively fast.

Data presented in this study offered new insights into the impact of preliminary system descriptions of a conditionally automated driving vehicle. The influence of preliminary system description is critical for the first moment of use. Therefore, accidents may happen in the first moments of driving a conditionally automated driving vehicle because of incorrect mental models developed from incorrect preliminary system information. However, this critical influence of preliminary system description decreases over time. Drivers with an incorrect mental model of system functionality are able to learn how the system works. Moreover, the different mental models developed from preliminary system descriptions are independent of trust and acceptance influences.

To sum up, the verbalized knowledge can be influenced by preliminary system description. However, the knowledge which cannot be verbalized may have a higher impact on driving behavior and should be pursued in further research.

User acceptance of automated shuttles in Berlin-Schöneberg: A questionnaire study
Nordhoff, de Winter, Madigan, Merat, van Arem, Happee 2017

This paper presents the results of a questionnaire study among individuals (n = 384) who physically experienced an automated shuttle on an office campus in Berlin-Schöneberg.

The findings indicate that the respondents were positive towards automated shuttles and could envision their use as feeders to public transport systems, in both urban and rural areas as well as sharing the shuttle with fellow travelers. The respondents were less satisfied with the effectiveness of the shuttle compared to their existing form of travel, the speed of the shuttle, and the space for luggage. Analysis resulted in the retention of three components: first, intention to use, second, shuttle and service characteristics, and third, shuttle effectiveness compared to existing transport. Older respondents expressed higher intention to use, but found the shuttle less effective than their existing travel. The paper concludes that automated shuttles are a valued concept, but speed and efficiency have to improve, in order for automated shuttles to become viable on a wide scale.

Parents' perspectives on using autonomous vehicles to enhance children's mobility
Leea, Mirmanb 2018

The research focus on the impact of Autonomous Vehicles (AVs) on enhancing the mobility of children who are also mobility disadvantaged, as child passengers are likely part of AV ridership scenarios in the perceivable future. To address this question, the study collected perceived benefits and concerns of AVs from a US convenience sample of parents whose children relied on them for mobility.

It was found that parents had reasonable concerns about losing active vehicle control when using AVs to transport their children or when leaving their children alone. However, parents could foresee the benefits of using AVs to transport their children by freeing up themselves from manual driving and spending time with their children. Parents' intentions to travel in AV and their technology readiness as well as parent (sex, residence area) and child (age, restraint system) demographic profiles were important determinants of potential AV acceptance and impact.

The study found that parents varied in their AV acceptance and could be grouped into two distinct categories: (1) The curious parents who would like to try AV and embrace technology innovativeness. These parents rated the perceived benefits relatively high, and their interests might be fueled by general inclination toward technologies; (2) The practical parents who had practical considerations (such as children being younger and using car seats and lower income), but saw the benefits of using AVs to transport children. These parents also had recent accidents. Although hesitant, this group might see AVs as a way to support their family functions by supplementing transportation needs.

Findings related to sex of parents and residence locations also support the literature, i.e., fathers perceived the benefits to be higher, but mothers perceived the concerns to be higher and urban residents perceived the benefits of AVs to be higher than suburban residents.

Perceptions of robots and driveless cars : Survey on adolescents in Northeast Italy
Fortunati, Lugano and Manganelli 2019

This survey was administered to 801 adolescents. First, the aim was to explore knowledge and imaginary about robots and their awareness of current robotization technology, including cars (Fortunati, Esposito, Sarrica, & Ferrin, 2015). A question was asked whether different current objects where robots, or not :

Table 5. Are They Robots? (Base = 801 high school students).

Machine	Mean (*SD*)
A computer is a robot	3.02 (.98)
A mobile phone is a robot	2.73 (1.03)
A vending machine is a robot	2.58 (.99)
A PS3/Xbox is a robot	2.57 (1.01)
A vacuum cleaner is a robot	2.49 (1.00)
A washing machine is a robot	2.43 (.98)
A food processor (chopper, blender, grinder) is a robot	2.49 (1.06)
A validation machine in a bus is a robot	2.31 (1.00)
A robot-shaped toy is a robot	2.28 (1.11)
A car is a robot	2.24 (1.02)
An airplane is a robot	2.13 (1.00)
An oven is a robot	2.00 (.93)

Note. Mean values derived from the scores given to this set of statements on a 4-point Likert scale: 1 = *not at all*; 2 = *a little*; 3 = *enough*; 4 = *for sure*.

Then, a specific question about the feeling of confidence in the driveless car was introduced in the questionnaire administered to adolescents. The question was : “Would you trust getting in a car that drives itself” (with a scale from 1 to 5). The average score was barely positive (2,54 , STD = 1,35). Males are slightly more confident tah females. Age (13-15 ; 16-17 ; 18-25) is not related to the answer. Students involved in scientific studies show the highest confidence scores. Trust in driveless car is significantly related to emotions towards robots and the intensity of the desire to have one’s own robot. Under these emotions towards robots, the most correlated to trust in driveless cars are : joy, interest, wonder and fear.

However, there is no significant correlation between the opinion that “the car is a robot” and confidence in driveless cars.

Annex I : European research project BRAVE (november 2017) : selected extracts

Chapters thereafter are based on the findings of ten recent studies on public opinion of automated driving. Three of them are based on attitudes and opinions of German samples (ACV, 2015; Bock, German & Sippl, 2017; Gladbach & Richter, 2016), two others conducted among French samples (Payre, Cestac, & Delhomme, 2014; Piao et al. 2016), whilst the others investigate the attitudes of U.S.-citizens (Schoettle & Sivak, 2014, 2015, 2016), UK-citizens (Schoettle & Sivak, 2014) and Australian citizens (Schoettle & Sivak, 2014). Also the findings of a Slovenian survey (Šinko , 2016) were included. Further findings included within this report are those of the multinational survey of Kyriakidis, Happee and de Winter (2015) and those of a survey conducted by the Observatorio Cetelem Auto of Spain (2016).

Details about locations, distribution methods, number of respondents and methodology of each study can be viewed in table 1.

Table 1: Summary of selected studies on public opinion of highly automated / autonomous vehicles among the general population

Authors	Year	Location	Distribution method	N*	Methodology	Automation level	Behavioral intention
ACV	2015	Germany	Online questionnaire	1.021	Descriptive	Autonomous (not classified)	Purchase intention, Intention to use
Bock, German & Sippl	2017	Germany	Online questionnaire	888	Descriptive	Fully automated	Purchase intention
Gladbach & Richter	2016	Germany	Online questionnaires	663	Descriptive	Autonomous (According to SAE standard, not classified).	Purchase intention, Intention to use
Kyriakidis, Happee, & de Winter	2015	109 countries	Online questionnaire	4.886	Descriptive	BASt	Purchase intention
Observatorio Cetelem	2016	15 countries	Online questionnaire	8.500	Descriptive	Autonomous vehicles	Intention to use,
Payre et al.	2014	France	Interviews, online questionnaire	421	Descriptive, Inferential	Conditionally or highly automated	Purchase intention
Piao et al.	2016	France	online questionnaire, telephone interview	425	Descriptive	Automated vehicles (not classified)	Intention to use
Schoettle & Sivak	2014	US, UK, Australia	Online questionnaire	1.533	Descriptive, Inferential	NHTSA	Purchase intention
Schoettle & Sivak	2016	US	Online questionnaire	618	Descriptive	Partially, highly and fully automated driving	N / A
Šinko	2016	Slovenia	Online questionnaire	549	Descriptive	Autonomous vehicles	Purchase intention

Safety

The safety of automated driving vehicles is an implication that is strongly perceived by the public. In the survey of Observatorio Cetelem (2016) it was rated as main priority for the introduction of "connected vehicles"3 by most of the participants (77 %) followed by cost (73 %) and time savings (50 %) (cf. 3 It was not clear on what basis the Spanish source distinguished connected vehicles and autonomous vehicles or whether the two terms are used synonymously.

Questions on safety aspects were contained by nearly all the reviewed studies. The perception of safety in highly automated vehicles seems to be a rather complicated issue. Within the described surveys safety is either brought up as barrier or enabler of acceptance. Safety benefits of automated vehicles are often referred to the crash reduction potential of highly automated vehicles. As most crashes (90 %) are due to human error, reckless driving or driving under the influence of drugs, alcohol or medicines (cf. Fagnant & Kockelmann, 2015), highly automated vehicles bear the potential of reducing or even eliminating crashes related to human error. Within the described studies safety benefits as enablers of acceptance are mostly related to a supposed crash reduction or the possibility to eliminate human errors.

A question within the survey of ACV (2015) referring to possible advantages of autonomous driving also contains items on safety benefits. In this context 42 % of the participants associate the use of AVs with the reduction of crashes whilst 34 % of the participants believe that self-driving vehicles could increase road safety (ACV, 2015, p. 8).

Also in the survey of Piao et al. (2016) 82 % of the participants indicate that safety benefits (linked to the elimination of human errors) are an attribute they consider moderately / very attractive in vehicle automation technology. So did 77 % of the international survey by Observatorio Cetelem (2016) who moderately / strongly agreed that "connected vehicles are a strong progress in terms of security". In this context, especially the Spanish participants (81 %) displayed positive expectations regarding safety benefits.

Also the participants of the survey by Schoettle and Sivak (2014) were rather optimistic about potential safety benefits of self-driving vehicles. In this context the majority believes that the use of self-driving vehicles could result in fewer crashes (70 %) or reduce the severity of crashes (72 %). Declines in crashes in the context of selfdriving vehicles are also expected by the majority (79 %) of the respondents in the study of Bock, German, and Sippl (2017).

Barriers towards safety are brought up in the context of technical / system failure or the safety and reliability of highly automated vehicles in general. In the survey of Kyriakidis, Happee, and de Winter (2015) the majority (65 %) of the participants indicate to be worried about the safety and reliability of fully automated driving systems. Also the majority of the respondents (81 %) of the survey of Schoettle and Sivak (2014) indicate to be moderately or very concerned about safety consequences related to equipment failure or system failure). Within the survey of ACV (2015) more than half of the participants (58 %) state reservations about the idea of fully automated driving because they were afraid of technical failure.

Data protection

The constant gathering and exchange of data requires special technical and legal measures in order to make sure that the data is not viewed by other parties without the user / driver consenting. Within the survey of Schoettle and Sivak (2014) the majority of the participants (64.5 %) indicate to be moderately / very concerned about the data privacy of self-driving vehicles.

A similar tendency is found within the ACV-study (2015), where only 35 % of the participants are optimistic about data transmission between self-driving and other actors whilst the majority (48 %) refuses to share their data – thereof 28 % as a matter of principle and 20 % because they are afraid of their data being accessed by third parties, such as their employer or insurance companies.

In the survey of Kyriakidis, Happee, and de Winter (2015) it becomes more clear that participants rate data transmission more critical depending on who would be able to access the data. The participants could indicate the degree to which they agree with statements on data transmission on the basis of a 5-point-scale. It is found that participants are rather comfortable with their data being transmitted to surrounding vehicles (Mean = 3.75), vehicle developers (Mean = 3.56) and organisations involved in the maintenance the roadway (Mean = 3.61). They are slightly less comfortable with the scenario of the data being transmitted to insurance companies (Mean = 3.27) or tax authorities (Mean = 2.88).

Cyber-security

Cyber-security is an implication for automated vehicles of which the real impact on individual safety and society is still unclear. However the risk of hacking reportedly is an object of public concern. In this context, 31 % of participants of the ACV-study (2015) state restraints towards the idea of fully automated driving because of the risk of hacking (not further specified) (ACV, 2015, p. 11). Also in the study of Gladbach and Richter (2016) 56 % of the questioned sample indicates that the risk of hacking dissuades them from wanting to use autonomous vehicles. Further 63 % indicate to be afraid that cyber criminals could take control of autonomous vehicles. Cyber-security is also addressed in the survey of Schoettle and Sivak (2014). There the respondents state to be moderately or very concerned about the system (69 %) or the vehicle (68 %) being hacked.

Liability

Liability is addressed within four of the above stated studies.

It is shown that the majority of the participants of the (French) sample of Piao et al. (2016) (84 %) are moderately or very concerned about “legal liability in case of an accident”.

Within the study of Kyriakidis, Happee, and de Winter, 68 % of the respondents indicate to be worried about the introduction of fully automated driving systems because of the question of who will be legally responsible if a crash occurs.

Liability is also an issue of concern in the survey of Schoettle and Sivak (2014) in which the majority of the respondents (74 %) are moderately or very concerned about the legal liability of drivers / owners of self-driving vehicles.

The reportedly high concern about liability seems somehow opposed to the results of the ACV-study (2015), where only 37 % of the participants state concerns about legal issues (such as liability) in the context of autonomous driving.

Joy of driving

The higher the level of vehicle automation the more the driving task is shifted from the driver to the system. Public opinion research shows that this is not always perceived as a benefit. Even though Kelkel (2015) finds no significant effect of driving enjoyment on the intention to purchase within his model of acceptance of driverless vehicle technology, the loss of the joy of driving still seems to be of concern to a relevant share of drivers. At least this is reported by two of the above-stated studies.

In this context the survey of ACV (2015) reveals that almost half of the participants (42 %) indicate reservations against fully automated driving because of the loss of driving enjoyment.

According to the study of Kyriakidis, Happee, and de Winter (2015) 63 % of the participants are worried that due to the introduction of fully automated driving systems drivers might deprive them of driving enjoyment and the feeling of being in control. This can be aligned with their finding that participants on average rate manual driving the most enjoyable mode of driving (Mean = 4.04), followed by partially (Mean = 3.72), highly (Mean = 3.54) and fully automated driving (Mean = 3.49).

Even if the concern of losing the joy of driving is obviously shared by the public, it is suggested by Observatorio Cetelem (2016) that this aspect still might be less important compared to other issues being perceived as barriers to acceptance. In in their survey participants were asked to choose their primary object of concerns related to connected driving. It was found that among six options, the loss of driving enjoyment occupied the fifth place (9 %).

As a consequence it can be retained that the joy of driving seems to be an issue perceived by the public, however its impact on acceptance still requires further research.

Cost reduction

The introduction of automated vehicles bears the potential of reducing cost that also affect the customer. In this context an interview based study of A.T. Kearney (2016) suggests that a reduction of insurance liability and also reduced energy consumption is expected in the course of the introduction of fully automated cars.

Expectations and attitudes towards possible cost benefits are also investigated within two of the eight reviewed studies. The participants of the study of Piao et al. (2016) rate cost benefits related to lower insurance rates (92 %) and reduced fuel consumption (93 %) as a moderately / very attractive feature in automated vehicles. Also the majority of the respondents (72 %) in the survey of Schoettle and Sivak (2014) is quite optimistic about fuel savings associated with the use of self-driving vehicles.

Trust and control

Within the survey of Bock, German, and Sippl (2017) 60 % of the respondents state to have difficulties trusting AVs. Trust is referred to as "the attitude that an agent will help achieve an individual's goal in a situation characterised by uncertainty and vulnerability". The shift from a human to a system-based control of the driving task requires that the system is able to drive at least as good and safe (or better and safer) as a human driver. Trust in the context of highly automated driving can be described as the driver's belief that the system drives at least as good and safe as a human driver (goal) with the uncertainty / vulnerability of the situation due to the risk that drivers or passengers might get involved in crashes due to poor system performance.

Within the survey of ACV (2015) one question investigates the opinions of the participants about the driving performance of self-driving vehicle technology compared to human driving. It is found that the percentage of the participants (34 %) who believe that self-driving vehicle technology drives better and safer than a human driver is slightly smaller than the percentage of those who believe that humans are the better drivers (39 %).

This tendency is confirmed by Schoettle and Sivak (2014) who report that 67 % of their respondents have stated concerns about "self-driving vehicles not driving as well as human drivers" (cf. Schoettle & Sivak, 2014). All in all it can be concluded that the trust in system driving is limited and that at present the general population prefers humans to be in control of the driving task. This is also suggested by Schoettle and Sivak (2016) who find that even in completely self-driving vehicles nearly all of the respondents (94.5 %) prefer to have a steering wheel plus accelerator and brake pedals enabling them to take control of the vehicle if desired.

Fears of losing the control of the vehicle were also reported for the sample of the Observatorio Cetelem study (2016). When asked to choose their primary object of concerns related to connected driving, the participants (24 %) were most frequently found to cite the vehicle not being under complete human control as their primary concern (ranked 1st before five other options).

In the context of trust issues linked to the control switch from human to system control, it was also reported by Šinko (2016) that 46 % of the participants would not purchase autonomous vehicles because they were not ready to give up the control over the car. Further 37 % were convinced that humans "can still react better than computers".

Time savings

In SAE level 3 vehicle automation the driving task is performed by a system with the driver being free to spend his or her time on activities other than driving, however, being able to respond to a request to intervene. Most of the reviewed surveys focus on the question of how drivers would make use of their travelling time. In this context Gladbach and Richter (2016) find that the majority of the participants in their sample (49 %) would browse the Internet while travelling whilst about a third (30 %) would use their travelling time to work (if the travelling time is counted as working time). The least preferred option of spending time within the German sample is sleeping while travelling.

Preferences on secondary tasks whilst driving with autonomous vehicles were also investigated by Šinko (2016). It was shown that most participants of her Slovenian sample intended to read (19 %) whilst others (18 %) indicated they wanted to use their mobile phone, whilst others (16 %) indicated they'd simply watch the environment (not specified). Further 15 % intended to relax or sleep whilst 13 % would make use of their time for working.

The inclination of the participants to engage in secondary tasks was also investigated in the survey of Kyriakidis, Happee, and de Winter (2015).The authors report that a higher level of vehicle automation is associated with an increased likeliness of the participants to engage in secondary tasks (sleeping, listening to music / radio, passengers etc.). Especially within the fully automated driving level a strongly increasing number of participants intend to rest / sleep, to watch movies or to read.

Behavioural intentions

According to the different acceptance models, behavioural intentions result from attitudes that can refer to perceptions of specific product characteristics or expectations on efforts linked to the use of a system, its perceived ease of use, social norms related to such systems as well as facilitating conditions / behavioural control. Depending on the respective acceptance model, behavioural intentions can be apprehended in terms of an intention to use or an intention to purchase a specific. The studies relevant for the acceptance of automated driving often measure the purchase intention together with a willingness of the respondents to pay a specific amount. In this manner, the value participants assign to such technologies became clear.

Purchase intention and willingness to pay

Purchase intention regarding fully automated vehicles is relatively low in the German sample of Gladbach and Richter (2016) who report that only a third of the questioned participants indicate an intention to purchase an AV. Within the sample of Bock, German, and Sippl (2017) a rise in price of no higher than €5.000 is acceptable to 43.5 % of the respondents, whilst 41.5 % are not willing to pay more than €1.000.

In the study of Payre et al. (2014) the majority of the participants (78 %) state to be willing to buy a fully automated car. The average amount the French respondents are willing to pay is €1.624.

A similar finding is reported by Piao et al. (2016) who state that the majority (73 %) of their French sample would like to own automated cars, whilst 27 % indicate to prefer using them through services such as car sharing, or pooling schemes (cf. Piao et al., 2016).

Within the anglophone sample of Schoettle and Sivak (2014) the degree of interest in having a completely self-driving vehicle as “a vehicle they own or lease” is assessed. It is found that 66 % are very / moderately / slightly interested in possessing this technology. However, the most frequent response to this question is “not at all interested” in each sample of the three countries (UK, U.S. and Australia). Furthermore, it is found that the majority of respondents from all countries are not willing to pay extra for self-driving technology that is 54.5 % of the U.S.-respondents, 60 % of the U.K.-respondents and 55.2 % of the respondents from Australia.

Kyriakidis, Happee , and de Winter (2015, p. 133) also dedicate three question to the participant’s willingness to pay for technology related to different levels of vehicle automation. It is shown that the respondents are willing to pay the highest amounts of money for fully automated driving (Mean = 4.56), followed by highly automated driving (Mean = 4.28) and partially automated driving (Mean = 4.11). The indicated mean values represent a price range between US$1.000 and US$5.000 US.

Within the Slovenian sample of Šinko (2016) it was reported that the willingness to buy autonomous vehicles was relatively low. In this context only a quarter (25 %) of the participants was positive about purchasing fully automated vehicles whilst the remaining 75 % indicated they were not willing to buy autonomous vehicles.

Intention to use

The measuring of an intention to use automated cars differs from study to study. Some questions elicit whether the participants could imagine using autonomous vehicles in general or as solely used transport methods. Other questions refer to an “interest in using”. In this context 65 % of the German sample of Bock, German, and Sippl (2017) are positive about the use of fully automated cars. However more than half of the respondents refuse a future with fully automated cars as solely used transport method on roads.

Similarly, in the survey of Gladbach and Richter (2016) more than a half (51 %) of the questioned Germans could imagine using AVs, however a third (33 %) show reserved attitudes regarding the use of AVs.

The intention to use an AV seems slightly higher among the French sample of Payre et al. (2014). The authors report the majority of the participants (71 %) to be interested in using fully automated driving while impaired (e.g., alcohol, drug use, medication).

The multinational survey of Observatorio Cetelem (2016) also investigated the intention to use of their multinational sample (cf. Figure 7, the blue columns). It was shown there that the Italian participants were most interested in using autonomous vehicles (65 %), followed by the Spanish participants (54 %), the French participants (51 %), the Belgian participants (50 %), the German participants (44 %) and the American participants (32 %) (cf. Observatorio Cetelem, 2016, p. 40).

Annex II : list of research references

Title	Authors	Year
Calibrating trust through knowledge: Introducing the concept of informed safety for automation in vehicles	Siddartha Khastgir, Stewart Birrell, Gunwant Dhadyalla, Paul Jennings	2018
A multi-level model on automated vehicle acceptance (MAVA) a review-based study	Sina Nordhoff, Miltos Kyriakidis, Bart van Arem, Riender Happee	2019
Literature review on surveys investigating the acceptance of automated vehicles	F.Becker, K.W. Axhausen	2017
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What impressions do users have after a ride in an automated shuttle ? An interview study	Sina Nordhoff, Joost de Winter, William Payre, Bart van Arem, Riender Happee	2018
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