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Exploring the acceptance of connected and automated vehicles: Focus group discussions with experts and non-experts in transport

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ABSTRACT

The successful deployment of connected and automated vehicles (CAVs) will largely depend on public opinion. Expectations and concerns are essential components driving the speed of market uptake and final adoption of these technologies. We have studied user expectations and concerns, as well as their provenance, by conducting a series of Focus Group (FG) discussions with transport area experts and non-expert participants, in Italy, Germany, and Spain. Together with user acceptance, potential advantages and disadvantages that CAVs may bring at a societal level were explored. Results show that benefits like increased safety and accessibility and improved travel experience for both driver and passengers could support CAVs' deployment. Nevertheless, a variety of concerns were raised during the discussions, related to privacy, responsibility in case of an accident, and increase in maintenance and repair costs. These aspects could significantly hamper or delay CAVs acceptability and need to be carefully considered by stakeholders. The reported insights from the FG discussions and the fact that some participants noted positive changes of their initial idea of CAVs due to their participation in the discussion, exemplify the importance of citizen engagement activities to address mobility challenges.

1. Introduction

Connected automated vehicles (CAVs) are seen as one of the most disruptive innovations for the current operation of road transport and urban systems. The potential changes that can be triggered and reinforced by this innovation range from direct impacts on congestion, trip costs or modal splits, to second-order impacts on land use or car ownership rates and even third-order repercussions in employment, energy consumption and public health (Milakis et al., 2017). Thus, CAVs can have a significant influence on the transport system which will also depend on their capacity to gain a high share in individual motorized transport. From a societal perspective, they could potentially improve the mobility of people who have difficulties to access other mobility options (e.g., people with impairment, aging people and younger people), and the overall accessibility of cities (Sharma & Zheng, 2021). For such improvement,

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the perception and acceptance of this technology by citizens will be a key mediating factor. However, it could also be one of the main barriers to the deployment of CAVs, If potential users perceive this new technology as a threat to their safety (Riedmaier et al., 2020), their privacy (Kyriakidis et al., 2015) or due to other concerns, including the variety of uncertainties associated with its overarching effects (Fagnant & Kockelman, 2015).

In 2018, road transport in Europe represented 51% of freight and 81.5% of passenger modal split (European Commission, 2020b). The countries investigated in this study - Italy, Germany and Spain - are among the European countries with highest motorisation rates. In 2018, there were 646 vehicles per 1000 inhabitants in Italy, 567 in Germany and 513 in Spain. The share of passenger-kilometres (% of pkm/year) on land travelled by car in 2018 followed a similar pattern: 81.4% pkm/year in Italy, 83.8% in Germany and 83.1% in Spain. These figures illustrate the high dependence of citizens of targeted countries on cars which implies that they would experience potential significant changes if CAVs become wide-spread in Europe.

This study aims to deepen knowledge on potential userś perceptions and expectations towards CAVs and how individual evaluation towards CAVs are formed using Focus Group (FG) discussions. The research has been designed after the publication of the Eurobarometer Survey 496 "Expectations and Concerns from a Connected and Automated Mobility" in April 2020, which provided a general picture of European citizens views and opinions on the topic. The Eurobarometer survey has shown, among other results, that about half of the European citizens are not ready to use CAVs (53%) and are not in favour of their deployment (47%). In addition, 43% of the participants do not believe that automated vehicles options suit their personal mobility needs. The objective of the present work is to provide further insights complementing and deepening the results of the Eurobarometer 496 as well as of other existing studies on user acceptance of CAVs using an explorative qualitative approach. The aim is to identify main concerns behind skepticism found in the Eurobarometer, and potential ways to overcome those. This is done by looking at participants' experience with driving assistance functions, exploring CAVs acceptance, willingness to use, advantages and disadvantages of CAVs at individual and societal level and investigating ideas/visions of vulnerable road users, among other aspects.

The data collection of this research has been based on 15 FG discussions considering transport experts' and non-experts' views about CAVs. These FG discussions have been organised by three partners: the European Commission's Joint Research Centre (JRC), the German Aerospace Center (DLR) and the University of Cantabria (Unican).

The paper is organised as follows: the next section reviews the literature on the potential impacts of CAVs, as well as on the perception of CAVs by users, their willingness to use them and the existence of potential barriers to their adoption. Based on the summary of the state of knowledge, we refine in this section our research questions. Section 3 explains the methodology used. Section 4 describes and reflects the results of the FG discussions analysis. Finally, in Section 5 conclusions and implications for policy and practice are drawn from the results.

2. Literature review

The following literature review briefly discusses the potential drivers for and implications of the introduction of CAVs both on an individual, i.e., user, level and on societal level. On the user level, different potential influencing factors on willingness to use CAVs are identified, including socio-demographics, previous experience with similar technologies, psychological factors, and privately owned vs. shared CAVs. On societal and transport system level, CAVs could have potential effects on travel time, the accessibility of transport options for new user groups and the well-being of vehicle users.

First, previous empirical studies indicated that socio-demographic characteristics of potential users, such as *age and gender* might have an effect on persons acceptance of CAVs. Although these empirical studies showed contradictory results, a tendency was found that men and younger people are more willing to use AVs compared to other genders and age groups (Becker & Axhausen, 2017; Cunningham et al., 2019). In line with these results, woman and greater conscientiousness is associated with greater concerns about AVs (Charness et al., 2018). Moreover, men are showing a more positive emotional response to CAVs compared to women (Hohenberger et al., 2016). Older people are less willing to use CAVs or have a more negative view towards them (Abraham et al., 2017; Acheampong & Cugurullo, 2019; Schoettle & Sivak, 2014) compared to younger people.

Second, *previous experience with Advanced Driver Assistance Systems* (ADAS) correlates positively with the trust in new technologies (Rödel et al., 2014), and prior knowledge about AVs is associated with less concerns towards them (Charness et al., 2018). Furthermore, the technological awareness or acceptance of ADAS also influence the willingness to use CAVs (Becker & Axhausen, 2017; Gkartzonikas & Gkritza, 2019).

Third, *various psychological factors* influence the willingness to buy a specific car, e.g., an AV (e.g., Tsouros & Polydoropoulou, 2020; Wang et al., 2020). Several studies analyse the impact of psychological factors on the willingness to use AVs using various theoretical frameworks, such as the Technology Acceptance Model and its further development UTAUT2 (public acceptance studies, e.g., Nordhoff et al., 2020, field studies, e.g., Xu et al., 2018, or literature review studies, e.g., Gkartzonikas & Gkritza, 2019). These studies reveal that acceptance is influenced by hedonic motivation, social influence and performance expectancy (Nordhoff et al., 2020). Experience with Level 3 of automation increases trust, perceived usefulness, and perceived ease of use (Xu et al., 2018). Further studies on psychological factors that affect willingness to use an AV reveal that people who are more open towards new technologies, enjoy driving and support strict traffic rules, are more likely to have a more positive attitude towards AVs and perceive them as safer as human driver. In contrast, people who avoid risky behaviour are more likely to have a more negative attitude towards AVs and perceive them as more dangerous. Furthermore, conscientiousness is a negative predictor for the eagerness to adopt AVs, whereas emotional stability and openness to experience are positive predictors (Charness et al., 2018). The authors of this study revealed that prior knowledge and openness to experience new technologies were positively associated with the readiness to relinquish driving control, whereas extraversion had a negative association with that factor (see also Xu et al., 2018). Whether people imagine to *privately*

own or to share CAVs affects the preferences for using them (Krueger et al., 2016). It has been shown that during a commute users are less sensitive to the presence of strangers, compared to a leisure-activity trip (Lavieri & Bhat, 2019). The authors also indicated that travel time required to bring other passengers to their destination is a greater barrier to use shared services, than the presence of strangers. In another study (Piao et al., 2016), security was identified as a major concern, especially at night, when considering sharing an AV with strangers.

The potential impacts of CAVs on a societal and transport system level have been reviewed by different authors (Milakis et al., 2017; Soteropoulos et al., 2019; Sousa et al., 2018), using both participatory methods, e.g., collaborative planning through scenario building or back-casting processes (Milakis et al., 2017; Nogués et al., 2020; Vitale Brovarone et al., 2021), and quantitative simulation-based methods (Fagnant & Kockelman, 2014). Simulation studies demonstrate, for instance, the effect that CAVs might have on vehicle miles travelled when assuming a *reduction of the value of travel time (VOT)* for CAV users, which in most of the studies is assumed to range between 25% and 50% higher than today (Auld et al., 2017; Childress et al., 2015; de Almeida Correia et al., 2019; Gucwa, 2014; Kockelman et al., 2017; Molin et al., 2020). Further research showed that potential reduction of VOT bears the risk for an increase in travelling in general as well as an increase in traffic volume (Bahamonde-Birke et al., 2018; Wadud et al., 2016). Second, CAVs may also lead to the *generation of new user groups* of individual motorized modes of transport: people with mobility impairment, aging people with fading driving skills, or people without a driving license become able to use cars. This may result in longer travel distances and a shift to motorized modes of transport (Bahamonde-Birke et al., 2018; Wadud et al., 2016). This would in turn lead to an over-proportional increase of negative transport externalities, such as increased air pollution. Third, CAVs may have an impact on *users themselves*. Previous research has shown that driving by car goes along with the highest stress level for commuters, compared to any other mode of transport (Legrain et al., 2015). AVs may increase the subjective well-being through higher comfort and stress-relief while travelling. It is suggested that the increase of subjective well-being will play a more important role than higher productivity during travelling in an AV (Singleton, 2019). This may be especially true for heavy traffic situations, as AVs provide the opportunity to switch the attention to other activities and reduce the negative effects of travelling by car (Trommer et al., 2016). In terms of *privacy and individual routes*, AVs will exhibit substantial advantages over e.g., taxis or public transport (PT). Lastly, CAVs may impact decision-making during driving, as choices are based on algorithms. This development comes with new safety issues and can perpetuate discrimination, for example because of (discriminatory) biases, ethical decisions, control algorithms and limitations of existing AVs (Lim & Taeihagh, 2019).

Results of recently published studies show that most people are not ready to use AVs without a human driver (European Commission, 2020a; Wang et al., 2020). Therefore, particular attention should be drawn to potential barriers. Fagnant & Kockelman (2015) identified six potential barriers to the uptake and use of CAVs: higher costs, legislative uncertainties, public perception and acceptance, security, data privacy and the lack of knowledge. It is crucial to deepen the understanding of these aspects from the user perspective in order to understand the importance of these barriers and to develop strategies to reduce them. In addition, there are some open questions concerning CAVs, e.g., whether vulnerable users such as pedestrians and cyclists will accept to share the public space with CAVs. Also, using qualitative research allows looking deeper into how individual evaluations are formed. Finally, the type and order of magnitude of transport system level impacts depends strongly on the preferred use cases for CAVs (privately owned and individually used CAVs vs. shared vehicles).

Given the uncertainties regarding user preferences of CAVs as well as the complex mechanism behind potential impacts of CAVs on the transport system, qualitative research, especially FG discussions, provide a deep understanding. Widely used in transport research (Davison et al., 2012; Ferrer & Ruiz, 2018; Huth et al., 2014; Jacobsson et al., 2017; Naznin et al., 2017; Nikitas et al., 2019), the FG method was also employed in previous studies to explore individuals' CAVs perceptions, attitudes and knowledge in relation to specific contexts or issues. Those studies captured opinions related to performing activities while the vehicle is driving (Pudāne et al., 2019), drivers behind travel time valuation in an AV compared to manually driven car (Kolarova, 2020), behavioural adaptation of users when confronted with specific driving conditions (Robertson et al., 2017) or trust in AV (Buckley et al., 2018). Different user groups' perspectives were also considered, including older adults (Faber & van Lierop, 2020; Robertson et al., 2017) and impaired people (Brewer & Ellison, 2020; Brinkley et al., 2017; Hwang et al., 2020). The present study explores, on the one hand, the reasons behind the current picture about determinants of user acceptance and impacts of CAVs in the literature and, on the other hand, aims to answer open questions with regard to acceptance towards CAVs.

Summarising the main insights of the studies, we observed an increasing number of researches that focus on determinants of user and public acceptance. Moreover, several review papers emphasise the relevant determinants (e.g., Becker & Axhausen, 2017; Gkartzonikas & Gkritza, 2019). Nevertheless, in the majority of the studies a focus is put on the quantitative methods, with fewer qualitative empirical studies. Therefore, while there has been an increasing number of empirical insights on potential benefits and concerns of users regarding CAVs, the future public acceptance is still highly uncertain. This uncertainty is a result of the unknown technological, sustainability and economic perception of the AVs. By increasing the number of explorative qualitative studies, such as this study, we aim to go deeper into the reasons behind how people currently formed their evaluation of CAVs and what are the reasons behind the stated perceived benefits and concerns related to CAVs. Moreover, current literature mostly addresses individual evaluation of CAVs from the user perspective but does rarely explore how users evaluate potential impacts of CAVs on societal level or transport system level. Especially how people could imagine future transport system will look and work like in the presence of CAVs. Other studies already addressed the preferred forms of transport and the impacts that CAVs might have on individual mobility. Nevertheless, to the best of authors' knowledge, there is a lack of studies that analyse how people envision potential conflict between individual requirements for CAVs and requirements of the city or of transport management authorities. Also, studies mainly focus on potential users and their opinion on CAVs but do not consider the view of experts on the same topics (see an overview in Becker & Axhausen, 2017; Gkartzonikas & Gkritza, 2019). More precisely, individuals are usually asked about their preferences towards CAVs, while

experts are asked about their opinion on the impacts of CAVs on a societal and transport system level (including sometimes expectations about user acceptance). However, there are limited analyses on the perspectives of individuals on the societal impacts of CAVs and of experts on individual preferences towards CAVs. Comparing these views on the same topic might provide insight on the crucial differences between the potential user views and the experts who work on the technology.

Against this background, this study analyses transport expertś and non-expertś experience with driving assistance functions, acceptance of CAVs, and perceived advantages and disadvantages of CAVs at individual and societal level to provide further qualitative insight to the results of the Eurobarometer Survey 496 "Expectations and Concerns from a Connected and Automated Mobility" (European Commission, 2020a). This approach was designed to identify if participants with transport expertise elaborate differently their expectations and concerns towards AVs.

The main goal of the paper is to build upon the knowledge by providing deeper insight on:

a) individual preferences
b) individual evaluation of the social and transport system impacts of AVs including aspects of vehicle connectivity (i.e., CAVs),
c) reasoning behind this evaluation, i.e., how this evaluation is formed on an individual level
d) expert and non-expert views on the topics deriving implications for the further development of CAVs based on potential differences between the views of both groups.

Explorative qualitative research is usually beneficial in early phases of the analyses of the factors influencing the acceptance of a particular technology. Besides, there are various potential use cases of CAVs and there are chances, but also risks related to the introduction of the technology. This makes the development and user perception of CAVs a dynamic field which requires ongoing research to create, introduce and deploy sustainable automated and connected mobility solutions.

3. Methodology

The FG discussions method was employed as it provides the opportunity to elicit views, understandings and different perspectives from the discussion's participants (Stewart & Shamdasani, 2017; van Lierop et al., 2019) and allows flexibility in collecting ideas and new themes during the discussion (Kitzinger, 2005; Morgan, 1996). The design of our FG discussions follow the methodological approach described in Krueger & Casey, (2000); Morgan, (1996); and Onwuegbuzie et al., (2009). In this study, FG discussions were carried out online due to Covid-19 pandemic-related restrictions. This approach has both advantages and disadvantages. On the one hand, it simplifies the presentation of visual information to the participants and the recording of the sessions. On the other hand, occasional technical problems and weak internet connection could slow down the discussions (Schneider et al., 2002; Stewart & Shamdasani, 2017). Online FG discussions allow to obtain a broader geographical coverage, as well as diversity in the participant's groups (Rupert et al., 2017; Schneider et al., 2002; Stewart & Shamdasani, 2017). Under the given circumstances, these FG discussions could have not taken place within the defined timeline without the possibility to run them remotely, delaying or impeding this analysis.

This study consisted of two phases: 1) conceptualization and data collection, and 2) data analysis. During the first phase, the guidelines of the FG discussions were designed, considering the targeted groups and the topics to be explored. Then, the FG discussions with experts and non-experts were carried out. The second phase was exclusively dedicated to the data analysis. It was performed using a combined qualitative and quantitative analysis approach. This content analysis is based on the classification and quantification of the different aspects identified in the answers of the participants to the questions. Fig. 1 gives an overview of the applied analysis procedure.

3.1. Study set up

From June 2020 to January 2021, 15 FG discussions took place with experts and non-experts in transport, organised by JRC, DLR and Unican. Transport experts were identified within the Wise-Act COST Action[1] and among JRC and SUM + LAB researchers[2] dealing with future mobility trends and transport topics. Expert participants, were international transport experts on different matters, such as institutional and regulatory, social, business or technical transport challenges. Authors ensured participants' expertise considering their past and current professional experience, relevant publications, participation in field-related networks and based on their online professional profiles. Participants were asked to join the FG discussions on a voluntary basis. Direct contacts were taken to investigate possible availabilities and positive responses were considered for inclusion into the discussions.

All FG discussions were performed virtually using different online meeting platforms (Webex, Zoom and Teams) and lasted approximately 2h each. Three trial FG discussions were organised to eliminate weaknesses of the script, adjust the time needed for discussion and get familiar with the platforms. Results from these trial FG discussions were not included in the analysis but were used to refine the script.

[1] WISE-ACT (Wider Impacts and Scenario Evaluation of Autonomous and Connected Transport) is a research network of more than 150 experts in 41 countries: https://wise-act.eu/.

[2] The Research Group on Sustainable Mobility and Railway Engineering SUM+LAB was established in 2019 and is a Recognized Research Group of the University of Cantabria, for more information: https://sumlab.unican.es/en/inicio-english/.

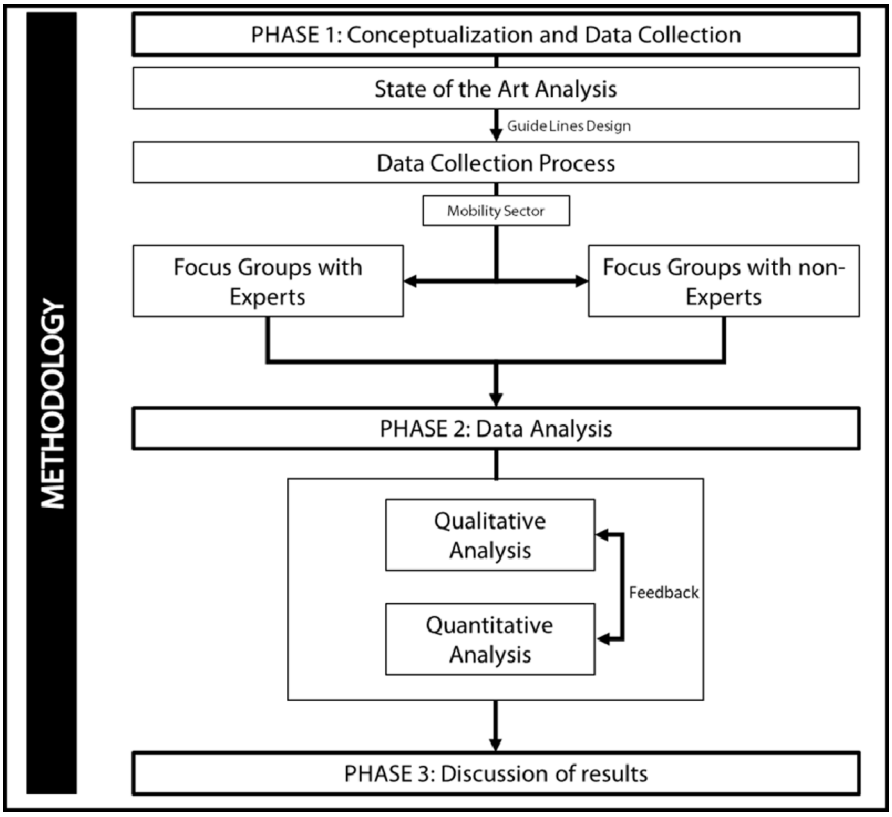

Fig. 1. Structure of the analysis.

Before the FG discussions a short questionnaire (Annex A) was distributed to the participants to collect socio-demographic information and to obtain complete participants' profiles. Participants were provided with a privacy statement and gave their consent for audio–video recording. At the beginning of each FG discussion, a brief introduction to the topic of the discussion was made and a short discussion guideline was given, followed by an ice breaker exercise (asking about usual travel modes for the most frequent daily trips). Then, the participants were presented with a definition of CAVs and afterwards the discussion started. After the end of the FG discussions, recordings were transcribed verbatim by a professional transcriptionist and/or automated speech recognition tools followed by manual revision.

3.2. Sample characteristics and recruitment methods

In 15 FG discussions (see Table 1), 72 people from 15 EU and 8 non-EU countries participated (see Fig. 2 for a geographical distribution of participants). 40 participants had expertise in transport, 32 did not. They were 41.2 years on average, with a range between 23 and 62 years. Out of 72 participants, 41 were women, 30 men and one preferred not to answer. All the participants held a driving license, and no one mentioned reduced mobility or any disability that could constrain their mobility. Further details of the sample are shown in Annex B.

3.2.1. Focus group discussions organised by JRC

JRC organized 10 FG discussions in English language with 46 participants in total. Participants without expertise in the transport field were recruited through a European Commission internal collaborative platform, gathering a total of 10 participants (5 women and 5 men) that were divided into two FG discussions. The average age was 39.1 years (29 to 51 years) with 9 of them living in Italy and one in Belgium (Annex B). Participants with expertise in transport were recruited in the two following ways: (a) through the European-wide network Wise-Act Cost action and the Enlargement & Integration JRC program, and (b) through a European Commission internal collaborative platform. 36 people (22 men, 13 women and 1 did not reply) participated to 8 FG discussions, with an average age of 43 years (27 to 62 years), living in 22 different countries (Annex B). An external contractor supported this round of FG discussions providing a Zoom based meeting platform.

3.2.2. Focus group discussions organised by DLR

18 participants without expertise in transport were recruited to participate in 3 FG discussions organized by DLR, men and women were equally represented. The average age was 41.4 years (29 to 59 years), and all the participants were living in Germany. The

Table 1
Focus Group discussions synopsis.

	JRC	DLR	Unican	Total
Participants				
Experts	36	0	4	**40**
Non-experts	10	18	4	**32**
Total	**46**	**18**	**8**	**72**
Number of FG discussions	10	3	2	**15**
Recruitment	Open Call E&I JRC Workshop[3] Wise-Act network	Contractor	SUM + LAB Personal contacts	
Meeting platform	Webex Zoom	Zoom	Teams	
Analysis software	MAXQDA 2020	MAXQDA 2020	NVivo 11	

[3] https://ec.europa.eu/jrc/en/event/workshop/expectations-and-concerns-about-connected-and-automated-vehicl.

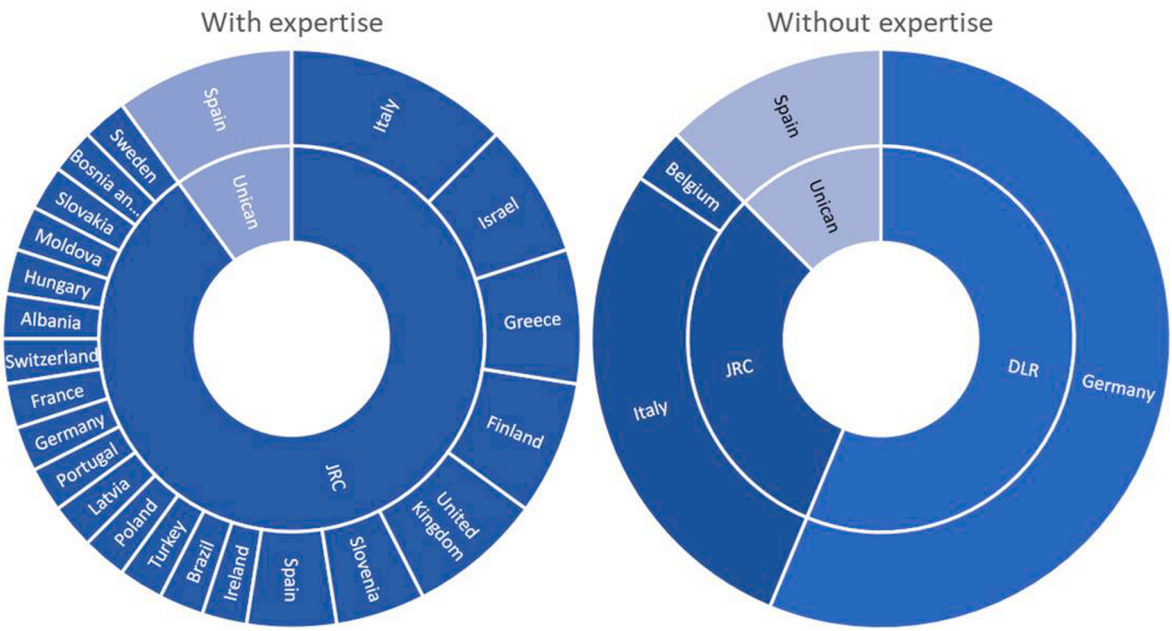

Fig. 2. Geographical distribution of participants.

participants were recruited by an external contractor, who also took care of the technical support during the FG discussions, and the followed transcriptions. Zoom was used as meeting platform. The FG discussions were conducted in the mother tongue of participants, German, and then results translated to English.

3.2.3. Focus group discussions organised by Unican

2 FG discussions, with 4 people each, were carried out by Unican with experts and non-experts in transport. Participants with expertise (1 woman and 3 men) were recruited using the professional network of the SUM + LAB research group, and had an average age of 34 years (27 to 45 years). Participants without expertise (2 women and 2 men) had an average age of 37 years (23 to 48 years) and were recruited through personal contacts. The FG discussions were conducted in Spanish, transcribed with automated speech recognition tools and manual revision and then translated to English.

3.3. Focus group discussions structure

FG discussions were semi-structured, allowing participants to deepen major issues raised in the Eurobarometer 496 survey and included in the developed script (Annex C), which was divided in three main parts:

I. Prior knowledge and experiences with ADAS and autonomous driving;
II. Acceptance of connected and automated driving, especially looking at threats and benefits at individual and societal level, adequacy with current mobility needs, willingness to intervene while driving an AV, and activities to do while the vehicle is driving. Driving styles and parking preferences. At the end of this part specific questions aimed to reveal expectations and concerns from vulnerable road users (VRU) towards sharing public space with CAVs;
III. Overall idea/vision about CAVs and potential change of opinion after the FG discussion.

The FG discussions mainly focused on connected and fully automated vehicles according to the technical specification of level 5 of automation as defined by SAE International (2016). However, some sections investigated attitudes regardless of technical specifications, considering their potential impact on the acceptance of CAVs (e.g., to see how the experience with ADAS or the willingness to intervene can influence CAVs acceptance). The concept of connectivity was linked to automation, through the whole discussion, with exception made for one question on the idea of AVs and its association to provided pictures. To avoid any misunderstanding, the difference between AVs and CAVs was explicitly pointed out, with a given definition (Annex C).

3.4. Analysis

The FG discussions were video-recorded and word-to-word transcribed. All the transcriptions were anonymised by replacing the names of participants with fictive pseudonyms. A content analysis method was used to analyse the transcripts (Neuendorf, 2019) supported by MAXQDA 2020 (VERBI Software, 2019) and NVivo 11 (NVivo Qualitative Data Analysis Software, 2015) software for the results analysis. Both software packages are designed for computer-assisted qualitative and mixed methods data and all partners had agreed and developed a common understanding on the analysis approach already before the analysis. The results of the analysis from DLR and Unican were translated into English, allowing for their comparison. A combination of deductive and inductive category construction (Lune & Berg, 2017) was used. In the first step of the analysis a deductive approach was followed by identifying key concepts that arose in the Eurobarometer survey 496 (European Commission, 2020a) and integrating them in the script used during the discussions. Afterwards categories were created putting together similar codes segments. These codes segments were grouped together because of content or context similarities. In parallel, new categories were inductively derived from the transcriptions. Whenever a segment of text represented more than one category, the quote was assigned to each of these categories. At the end, a higher-level grouping into themes brought together similar categories.

In addition, particular attention was given to specific topics where participants were asked to provide an opinion, or to enumerate different views on the same subject. Thus, when the question requested a general opinion (e.g., the question on CAVs' fitting on participants' needs), from each participant, only the opinion was counted, and not the number of times it was mentioned by that same respondent. However, when the addressed topic allowed multiple answers from each participant (e.g., the question on benefits and threats of what CAVs could bring), the frequency of each opinion expressed was counted. In a third step, the collected data from all partners was translated to English and combined in a comprehensive matrix table where the distinct categories and themes were compared, aligned, and merged. Finally, relevant and illustrative quotes of each topic addressed were retained from the transcriptions, out of which the most meaningful ones were selected and presented in this paper.

4. Results and Discussion

This section presents the main results gathered from the content analysis and discusses them within the context of the present analyses. The proportion of participants responding in each question, can be found in Annex D. The outcomes presented below are divided into the different topics addressed during the FG discussions.

4.1. Experiences and feelings about ADAS

At the beginning of the discussions the participants were asked to share their experiences with ADAS - electronic systems assisting drivers while driving or parking. In total, 56 out of the 72 participants mentioned having had experience with ADAS, 11 never used them, and 5 did not answer. Among the ones who already used ADAS, most of them mentioned cruise control systems, lane keeping and parking assistance systems. No detailed specifications were asked about the systems developed by different manufacturers to which the participants were referring in their explanations. Nevertheless, the authors are aware that the different characteristics of ADAS developed by the various manufacturers could influence the perception of the user. Only few participants (5 out of 72) made an explicit reference to specific brands without elaborating further on them.

Some participants used negative adjectives to describe their experiences with ADAS: they described the usage as "annoying" due to problems while using them and their preference to use ADAS only under certain conditions (e.g., low-traffic situations). The words "discomfort", "unsafe", "lack of trust", "fear" and "lack of safety" were related to reliability concerns of these systems and the difficulty to switch from ADAS to manual driving. As some participants explained, these concerns would disappear after familiarisation.

> *"The first time you try it [*i.e.*, lane keeping system], it's intimidating. I mean, we're not familiar with this, so the initial feeling is just fear. But after a while, you just get used to it, and you can trust it, I would say". Luigi, non-expert.*

Some other participants referred to ADAS as "useful", "safe" and "comfortable", finding them supportive while driving, and were interested in their future development. However, they pointed out that the feeling of safety could turn into dangerous behaviours

because of over trust in ADAS that could lead to less attentive driving or to parallel activities.

> *"I know exactly that I'm not supposed to but I catch myself several times taking the phone in this situation and start browsing a little bit because we are moving slow, I don't feel that there is any danger in that moment". Ernesto, expert.*

These statements indicate that the trust in those systems is either a pre-requisite to start using them, or can develop during using them. At the same time, an excess of trust was seen as risky, as the person in the vehicle could become completely inattentive to the driving functions, busy to perform other activities. Concerning the amount of experience with ADAS the Eurobarometer 496 showed similar results: 47% of the surveyed people declared to have used cruise control and 46% automated transmission. The outcome of these FG discussions goes beyond the quantitative information and provides insights on the feelings associated with ADAS technologies, which could be, to some extent, resembling the ones associated to full automation in future scenarios. Taken together, even though many people already used ADAS, what we saw in the FG discussions as well as in the Eurobarometer 496, is that those experiences were not only positive. Many of the concerns about ADAS range around a lack of trust and safety concerns which could be possibly the case also in CAVs. Comparing these results with previous we found that ADAS experience is an important factor influencing the willingness to use CAVs (Becker & Axhausen, 2017; Gkartzonikas & Gkritza, 2019). On the contrary to those studies, we found that experience itself can vary and its evaluation can be either positive or negative, despite the performance of the system, and that experts and non-experts perceive their experiences differently. Experts tend to trust too much the system and see potential danger in this. Non-expertś views vary ranging from feeling of discomfort and unease through disappointment and annoyance with the system to comfort and perceived usefulness of the system. These results suggest that more attention should be given to the way in which people experience ADAS or early stages of CAVs functions rather than on increasing number of early experiences with the system to a broader group of users.

4.2. Idea of AVs, based on three different pictures

In the next part of the FG discussions, participants were shown three pictures and asked if these corresponded with their idea of AVs (Fig. 3).

The first picture ("*the car*") was mainly not associated with an AV, but a modern or even traditional vehicle. Also, this vehicle was associated to be an expensive one that only few could afford. Concerning the second picture ("*the truck*"), participants' opinions diverged. The ones without expertise had in general more difficulties to associate it with an AV, while participants with expertise easily recognized it. Especially, participants without expertise described it as "peculiar" and "scary" because of the lack of windows. They mentioned that a time of adaptation would be needed to get familiar with such an AV. In general, picture three ("*the shuttle*") was associated with an AV, because participants had already seen it in media or used one. Moreover, experts named the shuttle as the first step towards the deployment of AVs since there are already trials ongoing (e.g., airports), compared to the private car and truck for which "both technology and infrastructure need to be improved". The shuttle, in contrast, could be firstly deployed in restricted areas or fixed routes.

> *"The shuttle is my preference because I think it is the first which can be realised in the next future. So, some public transportation in a limited way with a very fixed route that can be realised like that". Daniello, expert.*

People participating in the FG discussions, with or without expertise, link more easily the idea of AVs to the image of a shuttle, again, confirming the views of the majority of European citizens taking part in the Eurobarometer survey. It is interesting to observe that such a choice, made by some transport experts, was justified by the knowledge and experience with trials or prototypes, which was hence associated to the idea of the "most ready" type of CAV. In general, participants without expertise had more difficulties to associate all three vehicles with use cases, compared to experts. This may mean that people might not have, a clear idea of how CAVs look like, and this lack could also lead to mistrust or safety concerns. While also in the Eurobarometer 496, respondents were asked a similar closed question, the FG discussions allowed to analyse deeper the reasons behind the choices of respondents. This study indicates that people not always make a choice by evaluating the most promising and desirable concept of CAVs. Rather, the decision can be formed based on previous experiences or knowledge about certain use cases, their perception of market readiness of the technology in a given use case (e.g., private car vs. shuttle). Moreover, the decision could be highly influenced by the pictures that represent the

Fig. 3. Pictures shown during the FG discussions.

concepts. This suggests that study results on acceptance of certain use cases have to be carefully analysed considering background and knowledge of respondents, as well as how the concept is presented. Questions on which features people consider in their evaluation (e.g., perceived market readiness, vehicle size and design) might be beneficial complementing questions about general evaluation of the usefulness and willingness to use.

4.3. Willingness to use CAVs

Next, the aim was to explore whether and to which extent the participants were generally willing to use CAVs. 41 of the 72 participants mentioned that they would be willing to use CAVs, while 6 would not, 6 were unsure, and 19 did not answer. Among the ones willing to use CAVs, additional details about different circumstances or contexts were provided spontaneously.

Among the ones willing to use CAVs, 16 stated their preference for a PT option in order to achieve a decrease in traffic, reduce travel costs and achieve a positive environmental impact. At the same time, some participants admitted that they would not feel comfortable using CAVs in PT outside dedicated areas (like campuses or airports) nor in a hybrid transport situation where CAVs and non-CAVs would share streets. In addition, experts mentioned potential discomfort of people towards the shared options, because of intimacy concerns about sharing common space with strangers.

Some expert participants mentioned the fact that a few people are very "attached" to their own vehicle and enjoy driving it. They assume, these people would not accept to lose the "pleasure of driving". Some participants would like to use CAVs only in specific contexts (e.g., daily commuting to work), while others would use them in various situations. Among those not willing to use CAVs, participants mentioned lack of trust, past CAV accidents, their satisfaction with their current mobility, and concerns about price-performance relation as arguments.

> "*It may sound superstitious, but the only thing I've usually heard in the news is that someone has been killed in an autonomous vehicle or something like that*". *Juan, non-expert.*

Concerning their trust towards CAVs, some of the participants stressed their need to first be convinced to use them while others seemed to be less resistant, pointing out the positive impact that CAVs could have on the road safety and accident avoidance due to their interconnectivity. In relation to this, a participant, with expertise, highlighted the fact that the implementation process should be progressive in order to limit the public's reticence.

> *"I also see it as a way that you can avoid a lot of accidents if cars are connected to other cars. Because if you have information about what another car is going to do, you can avoid that, you know, so I would use it". Marta, expert.*

The findings of these FG discussions provide a somewhat different picture compared to the outcome of the Eurobarometer survey, in which 56% of the participants declared not to be ready to use CAVs. Instead in the FG discussions, more than half of the participants seemed to be ready to use them. Through the FG discussions it was possible to explore some of the reasons that could explain such orientation, namely safety concerns, satisfaction with current mobility habits or pleasure to drive. On the other hand, participants with expertise provided further information in addition to their intention to use CAVs, and shared some barriers that could affect the adoption of CAVs by people in general (i.e., privacy concerns, attachment to the private owned vehicle and pleasure of driving). The mentioned reasons behind the willingness to use AVs, e.g., safety concerns or driving pleasure, were also found in other studies (see, for instance, the literature reviews conducted by Becker & Axhausen, 2017; Gkartzonikas & Gkritza, 2019). However, opposed to the results of previous quantitative studies, the FG discussions allowed us, to a certain extent, to understand the construction of individual evaluation (see also the discussion in Section 4.5). Among others, the analysis indicates that while some of the potential users went through a rational process by evaluating the pros and cons of the technology, others built their opinion based on spontaneous affective response. In particular, negative articles in the press, anticipated loss of driving pleasure or an unspecified fear related to potential malfunctions of the technology form a general skepticism about CAVs. Interestingly, rational evaluation was not the only found when analyzing statements of experts. In fact, few experts who are informed about the technology capabilities and limits still expressed affective acceptance barriers.

4.4. Willingness to intervene

Next, we explored participants' willingness to intervene while a CAV is driving. In their statements, participants mentioned different reasons, from safety- to pleasure of driving. Those who indicated that safety reasons would make them to take back the control of the vehicle specified that "bad weather conditions", "emergencies", "hacking incidents", and "routes or situations with a higher level of complexity" like traffic jams or mountains, would be the main reasons to take back control of the vehicle. The lack of trust towards CAVs was also mentioned as a reason to intervene.

> "*I would obviously like to intervene especially in areas that are a bit more complex, such as urban areas, because I have a lot more interactions with other vehicles or with conventional vehicles that are not yet at that stage*". *Esther, expert.*

In some other cases the willingness to intervene was related to the pleasure that driving offers to drivers, allowing to stop on the way to enjoy the view or to take preferred routes.

> "*I would guess that it's a huge convenience to be able to be driven in some ways, but I guess that sometimes I would like to drive by myself*". *Fabio, expert.*

On the other hand, participants unwilling to intervene based their opinions on the trust of the technology mentioning that CAVs will be "more reliable in terms of errors than a human driver".

Finally, some participants also underlined that the benefit of performing other activities while driving might be lost due to the attention that passengers need to give to the vehicle's behaviour, assuming that it might be difficult to intervene if needed since they might not be ready.

> *"[…] we may lose some potential benefit of autonomous cars, I'm afraid that if the intervention of the human driver is required, […] then we cannot assume that the driver can just rest or fall asleep or just focus on work while driving". Michele, expert.*

Participants of the FG discussions declared to be ready to take back control of the vehicle for safety reasons and in defined contexts, confirming the lack of complete trust in vehicle behaviour, in line with the Eurobarometer 469, showing the first activity European citizens would do in a CAV would be to check the vehicle behaviour (European Commission, 2020a). Interestingly, also the driving pleasure would make some participants resume the non-autonomous driving functionalities of the CAV. This indicates the lack of trust of CAVs, and emphasizes the necessity to find a solution for the loss of driving pleasure through CAVs.

4.5. Threats and benefits at societal and individual level

In the next part of the FG discussions we explored the participants views on threats and benefits of CAVs on individual and societal level, separately for participants with expertise and without expertise (see Table 2 and Table 3). Aspects that the participants mentioned either as benefits or threats, according to their view, are marked in bold in the two tables below. In contrary, the aspects not in bold were directly classified by the participants only in one category; either benefit or threat. Participants without expertise were more inclined to share their views on an individual perspective, while participants with expertise focused more on the societal level. In addition, some topics were mentioned by both experts and non-experts whereas in half of the cases, topics were brought into focus only by one group (either experts or non-experts). In the case of participants with expertise, the presentation of ideas was more elaborated, with plenty of technical insights compared to the ones of non-experts.

Among the **benefits** on societal and individual level the participants perceived the deployment of CAVs as an opportunity to travel more efficiently due to *decreasing travel time* and to *ease job-commuting*. Furthermore, participants expected an *improved travel experience* reducing stress and increasing relaxation due to the absence of the driving task. Instead, the time usually dedicated to driving tasks could be used to work or practice other activities.

> "*I can use the time to work while driving, well, travelling I can do some work in the vehicle which […] could be a very, very significant change for me, in my personal life". Aida, expert*

Also, the participants linked the deployment of CAVs to a *higher transport efficiency*. Especially because of connectivity, a safer and better traffic system management would be possible, by controlling the speed and movement of the whole fleet. It was also mentioned that a connected and automated PT would provide more flexible services with higher frequencies, and that transport on demand will be facilitated.

> "*So, for example the traffic management system can collect information of the position, speed and then anticipate or plan routes of vehicles. Then we can just manage traffic safer". Michele, expert.*

At the same time, CAVs were also mentioned as comfortable alternative to PT, by *enhancing privacy* and allowing travellers to perform other activities without the discomfort of being surrounded by "strangers".

> "*I could do something like that in the car like reading, but without having 100 of strangers around me I am sharing the train with". Angelika, non-expert.*

Finally, some participants saw the deployment of CAVs as an opportunity to *renew the vehicle fleet* that starts to be old in some

Table 2
CAVs - benefits at societal and individual level.

CAVs – benefits at societal and individual level	Experts	Non-Experts
Decrease in congestion	**X**	**X**
Positive environmental effects	**X**	**X**
Decrease in travel costs	**X**	**X**
Increase of accessibility	**X**	**X**
Increase in safety	**X**	**X**
Increase in security	**X**	**X**
Increase of privacy		**X**
Urban transport planning	**X**	
Decrease of travel time		X
Facilitate job-commuting	X	
Improved travel experience	X	X
Increase in transport efficiency	X	
Personal space and privacy		X
Vehicle fleet renewal	X	

Table 3
CAVs-threats at societal and individual level.

CAVs – threats at societal and individual level	Experts	Non-Experts
Increase in congestion	**X**	
Negative environmental effects	**X**	**X**
Increase in travel costs	**X**	**X**
Barriers to accessibility	**X**	
Decrease of safety	**X**	**X**
Decrease of security	**X**	**X**
Decrease of privacy	**X**	
Urban transport planning	**X**	**X**
Additional infrastructure planning and financial resources	X	X
Decrease in market competition	X	
Decrease in modal share active modes of PT	X	
Decrease in travel flexibility		X
Health issues due to reduced active mobility		X
Increase in maintenance and repair costs of shared CAVs	X	X
Job losses		X
Lack of traditional driving skills	X	
Legal responsibility		X
Transport system dependency on IT features	X	

countries (e.g., Spain).

As a **threat**, participants mentioned some aspects linked to *infrastructure deployment*. This was perceived as "challenging" in terms of the studies and planning required, the number of new functionalities that need to be installed and integrated, and the financial resources required, since this new infrastructure could be different to the current one.

> *"If every single traffic light needs to be connected [to the system], then we have damn many of them. If every street should be included […] then every street in Germany needs to be prepared". Gregor, non-expert.*

Some participants were worried about *market competition*. Especially about companies monopolizing the entire fleet of CAVs and controlling supply and prices. Thinking about shared CAVs, participants mentioned concerns about losing *travel flexibility*, compared to privately owned vehicles. And one participant identified the threat of *reduced active mobility* due to door-to-door transport by CAVs. The *difficulty to come back to the conventional system* due to the loss of driving skills of the new generation of travellers was also mentioned by one participant.

> *"[…] because fewer people make a driving license and at some point, many people will not have the ability to drive a car, so if at some point we'll need to switch again to conventional task then that might be a threat again". Michele, expert.*

Furthermore, the responsibility in case of accidents was also mentioned. While this is clear for conventional cars, the participants were not able to identify the entity which would be responsible when CAVs are involved in an accident (e.g., the industry?). A participant used rhetorical questions to express uncertainty.

> *"And also, if there is an accident, at least I can blame, or the person can take responsibility. If there is an accident, who takes responsibility? The manufacturer of the car? I don't know". Simona, non-expert.*

Privacy of personal data was also highlighted by the participants. They expressed worries about sharing their data with private companies or other users and mentioned the need of an entity, controlling the safety of personal information or creating laws to be followed by the stakeholders. Threats related to the potentially high *dependence of the transport system* (fleet and infrastructure) on IT features insuring safety (e.g., sensors) could make the system more prone to failure if one of the components fails.

Some points were mentioned as **benefit and threat** at the same time. Those different aspects are related to traffic congestion, the environment, accessibility, travel cost, safety, security, and urban planning.

The deployment of CAVs could have a positive impact on *traffic congestion*. Traffic congestion could decrease as vehicles and infrastructures could be connected. Hence helping regulating road traffic. Moreover, the type of services deployed or preferred (i.e., private ownership in opposition to PT or shared mobility), could play a role in decreasing traffic congestion. According to one participant, the general preference of people for private ownership will increase the consumption of private CAVs and thus decrease their price. As a consequence, the market uptake of those vehicles will increase further, creating more congestion in a long-term perspective. Two participants also emphasized that the impact on congestion might depend on car usage: increased congestion could be a consequence of the increased vehicles activities (i.e., people travelling more for different purposes), and legislation allowing moving fleets, avoiding idle capital and parking expenses.

> *"[…] if vehicles are well connected […] if they can communicate between them then you can prevent some traffic jams in the cities during high [traffic] hours". Luisella, expert.*

Participants highlighted that the *impact on the environment* would mainly depends on the type of vehicles deployed, i.e., if they are electric or not, shared or not. In addition, the possible impact of CAVs on managing traffic flow better and avoiding congestion could also have a knock-on impact on reducing emissions.

> *"[…] then we will not have traffic congestion because you'll know which road has less traffic and where you can park, so we'll have less traffic congestion and decreased levels of pollution". Francesca, expert.*

The increase of *accessibility* for populations presently having lower access to mobility was also mentioned (i.e., people living in rural areas, without connections to PT, people with mobility impairment and younger people). Participants underlined the potential "impact on social inclusion and social equality" of CAVs by improving the whole transport system. However, potential barriers were also named: the lack of infrastructure in rural areas that could limit the access to automated services, and the reluctance of people to allow their children inside CAVs without a human present.

> *"[…] in terms of accessibility, the rural areas are the ones who should benefit the most. But […] from a technical perspective, this is also the most challenging thing, because this will be the last area where this technology will function […]". Ernesto, expert.*

Transport cost could be lowered since drivers of PT will not be needed anymore, but in the case of shared mobility options, the automated features of CAVs (e.g., Lidars) could increase the purchase cost of vehicles. Furthermore, more technology may also lead to more breakdowns or problems related to automated features that could further increase the maintenance and repair costs.

As regards *safety*, a notable part of participants perceived the technology as more reliable because it minimizes human error, extends the human vision thanks to sensors and prevents dangerous behaviour (i.e., drinking and driving). However, they also expressed concerns related to transport system failures, cyber-attacks, and handover situations in which the passenger might need to take back the control of the vehicle unexpectedly. In addition, it was also mentioned that safety will be possible only if conventional vehicles are not present in the roads.

> *"I have seen what computers do, how they fail, how they break, and I am very apprehensive about riding in a vehicle that is going to decide about your life, and that may fail for any little thing". Juan, non-expert.*

Security related issues were also emphasized by participants. The risk of having vehicles hacked was mentioned, as well as that any person or company could access personal data about the location of the car and the previous trips. Others expressed concerns towards possible terrorist attacks. Some participants would not like to share the space with strangers, while a participant noted that individual use of CAVs could increase security of people that presently walk or use PT at night (especially women).

> *"[…] there is a possibility now for the entire fleet to be jeopardized this way, so they are like computer connected to the internet and maybe somebody can actually hack the entire system". Ernesto, expert.*

Lastly, participants mentioned that the deployment of CAVs would affect the *urban planning* of the city. While the deployment of a shared option or the increase of car usage will free space in the cities because parking would not be needed anymore, the decrease of travel time induced by CAVs will increase city sprawl and thus extend cities.

The potential risks and benefits that FG discussions participants associate with CAVs emerged spontaneously and are aligned to the outcome of the Eurobarometer 496. In this case, though, the expertise of some participants supported them in providing additional elements, such as possible improvement of transport planning and systems, effects on travel costs and fleet composition, as well as changes in market dynamics or modal shift. It seems important to raise public awareness about CAVs on societal over individual benefits. The FG discussions showed that individuals mainly mentioned their personal, individual consequences of CAVs, while experts also talked about the societal consequences. There is an exception, in the Eurobarometer 496 as well as in the FG discussions: the consequence of CAVs deployment chosen most frequently was the reduction in professional drivers, which was also voiced during the FG discussion, however only by non-experts. Even though, individuals elaborated about positive personal effects of CAVs, some were scared about potential dependencies. Also, participants have a basic understanding of the impact of human errors compared to machines, but still, they have not enough trust in CAVs to give up their control.

Some of the results are in line with insights from previous studies that explore perceived benefits and concerns related to CAVs (see the literature reviews conducted by Milakis et al., 2017; Gkartzonikas & Gkritza, 2019). For instance, previous studies found that travel time valuation, potential increased safety and improved travel experience are among the most expected benefits of CAVs while safety concerns, data privacy issues and cost increase are among the main concerns of users. However, unlike previous studies, this study considers also potential benefits and threats for the society from individual and expert perspective. These include impact on traffic flow and congestion, environmental impacts as well as impact on the use of active modes of transport (walking, cycling). As expected, experts that participated in the FG discussions tended to discuss societal and travel system impacts and non-experts individual

preferences. Interestingly and novel, however, due to the used guiding questions and introduction of pictures of potential future AV and traffic design, we achieved a change of the perspective of both groups. This allowed capturing individual preferences of experts and views of non-experts on traffic system impacts. Interestingly, experts and non-experts had similar views on individual benefits and concerns, despite their deeper knowledge. Societal and traffic system impacts, were discussed differently, but non-experts who reflected on various impacts of the technology considering not only individual requirements, but also societal ones.

The approach of the FG discussions allowed to develop a group dynamic which gave participants space to reflect on societal issues related to CAVs which quantitative studies cannot achieve. Therefore, on a meta level, important result of the analyses of the FG discussions is that engaging potential users in a discussion on societal impacts of CAVs encourages reflection on the technology impacts, sparks the potential change of views and facilitates adjusting requirements by considering potential downsides of the technology (e.g., increased acceptance of shared options given potential downsides of individual car use).

4.6. How CAVs fit mobility needs

Then, participants were asked to reflect on their current mobility needs, and to discuss if CAVs would be able to fulfil them. In total, 30 out of the 72 participants responded positively, 24 negatively, 16 did not answer and 2 were unsure (i.e., they were not convinced yet that the technology would work reliably).

Most of those who responded positively associated their daily mobility needs with a specific automated mode of transport. The ones preferring automated PT mentioned that, compared to the conventional one, it would increase itineraries' frequency, improve accessibility as well as reliability due to the absence of accident-prone human driving. Some others stated that an improvement of the current PT would sufficiently satisfy their mobility needs. The participants with a preference for privately owned vehicles framed the use of CAVs either for long distance trips or where other transport alternatives are lacking. Others approved the fact that CAVs will enable them to undertake other activities while traveling. Three experts further elaborated on this topic, sharing that automated mobility could significantly impact their lives since their place of living could be placed further from the workplace, with better living conditions.

> "*My choice would be to change my hometown, somewhere closer to the sea". Francesca, expert.*

Participants who do not consider CAVs to fit their mobility needs mainly focused on the high level of satisfaction and efficiency regarding their current mode of transport. Some others linked their preference for non-automated mobility to the possibility to easily cover their travel distance by other modes of transport like walking or biking. In addition, others would rather use CAVs occasionally, on long-distance ttrips, to go to the airport, or for goods' delivery. The use of CAVs for short-distance trips was noted as "useless" by few participants.

> *"I'm currently in Barcelona, which has a very good public transport system, the introduction of autonomous vehicles will not improve my commute. I would use it for intercity travel, but not for urban travel, as the public transport system is very good". Mateo, non-expert.*

CAVs as means of PT were mentioned together with the concept of shared automated mobility: these ideas were brought forward when discussing the willingness to use such vehicles and mobility needs. The Eurobarometer results showed that only a small majority of people found a fit between their mobility needs and CAVs, which could be explained by some arguments gathered during the FG discussions, such as the satisfaction with current mobility options or the use of CAVs in specific situations (e.g., long trips). This would lead us to inform transport users on how CAVs could improve their mobility. These results are in line with previous studies which suggest that current travel behaviour is an important determinant of the willingness to use CAVs (see e.g., the literature review by Becker & Axhausen, 2017). Additionally to previous studies, the results of this study reveal that satisfaction with the current option and currentt coping strategies to deal with shortcomings of available options influence the evaluation of CAVs and their suitability for certain trips.

4.7. Activities performed while driving

This section served to explore the activities that drivers would like to perform in a fully CAV. Expert participants mostly mentioned work-related activities (e.g., "having meetings"); and also "sleeping", "looking at the landscape", "calling", "surfing in the web", "reading", "eating", "listening to music" and "listening to travel information". Few participants would prefer not to perform any activity since they experience motion sickness while driving and some others mentioned that the driving style would influence significantly the possible on-board activities. They also explained that activities are linked to different factors such as: vehicles' ownership status (i.e., private or shared), the purpose of the trip and the travel distance. One participant made a reference to the interior design of the CAV that could either facilitate or discourage some activities on-board (i.e., presence of internet connection and desks for laptops).

Non-expert participants are frequently mentioned activities related to leisure and relaxation. They also added "taking photos", "put make-up" and "play with kids" inside the vehicle. Interestingly, five participants without expertise were unwilling to perform any activity since they would prefer to focus on the way the CAV is driving. They also revealed lack of trust and safety-related concerns

behind this choice making clear that they would "try not to sleep" or "keep their eyes on the road".

These findings are aligned with the overall European citizens view on this topic which emerged from the Eurobarometer survey: the most frequently chosen options were indeed related to some kind of leisure activities (e.g., enjoying the scenery (40%), listening to music (34%), phone calls (25%), etc.) together with paying attention to the vehicle behaviour (37%). This may lead to design CAVs according to the activities that individuals want to perform in these vehicles. The results are in line also with previous studies that found a benefit of driving autonomously in having time for relax or leisure rather than being productive en-route (e.g., Cyganski, 2015).

4.8. Driving styles and parking preferences

Next, we wanted to understand which driving style would be preferred for a CAV, and to explore the impact that automation could have on parking preferences.

Participants mentioned a variety of potential driving styles that could be adopted by CAVs like "compliant with traffic rules", "safe", "cost-efficient", "comfortable", "eco-friendly", "relaxed", "smooth", "sporty", "compatible with motion-sickness" or in between "aggressive" and "relaxed". Interestingly, some of the participants preferred the driving mode of the CAV to replicate their own driving style.

The majority explained that they would prefer if CAVs to provide different driving styles and let the passengers choose according to their preferences depending on weather conditions, specific road characteristics (i.e., urban/highways), the presence of children on board, the haste to reach the destination, and motion sickness.

As regards parking preferences, participants would prefer to keep privately owned CAVs within a short distance to have them at their disposal at any time and to monitor them for security reasons to prevent a potential theft. Two participants added that a possible lack of parking spots close to their premises would make them consider other transport options.

> *"[…] I would like to have them maybe five minutes by walking and not 15 min by walking. So, then I would maybe already do something else or change my mobility behaviour". Arturo, expert.*

Participants were divided into those mainly concerned about CAVs' punctuality rather than the parking position and those mainly concerned about parking the vehicles in a secured parking place.

> *"If it can park itself, it can also pick me up from where I am. So, I wouldn't care where it parks itself". Peter, non-expert.*

Parking preferences are also related to parking costs, and some participants would consider sending the vehicle further away to save money. Finally, part of the participants -mainly experts- mentioned the possibility of shared mobility, where parking will become obsolete and unnecessary. These results show, individuals prefer either to have different options of driving styles, or their own driving style to be replicated. This may represent the lack of trust of the participants towards CAVs requiring them to test different driving styles and to get familiar with different functionalities. To our best knowledge, while other aspects of user acceptance of CAVs are addressed in various empirical studies, preferable driving styles, i.e., modes for CAVs, are not yet addressed in the literature.

4.9. Vulnerable road user perspective

Participants were then confronted with the idea of sharing road space with CAVs, asking about their possible level of comfort as vulnerable road users (VRU) (i.e., cyclist or pedestrian). The majority of participants (46 in total) would feel comfortable sharing space with CAVs, while 8 would not and 18 did not answer.

Those participants being comfortable with sharing the road with CAVs linked this to increased safety, compared to human drivers. However, some participants mentioned that they would need some time of adaption to fully trust this technology.

> *"At the beginning you would be with thousand eyes, looking everywhere, not trusting anything, and with time, if nothing happens, you would get used to it and you wouldn't even look". Juan, non-expert.*

According to one expert participant, the fact that CAV fleet would have to drive very slowly to ensure VRUs safety, would make conventional driving more attractive again (faster). Furthermore, the reduced reaction capacity of CAV users (due to potential other activities), would make some participants feel uncomfortable with CAVs in their surroundings.

> *"I don't think I would feel comfortable at all, because I would have to assume that the driver sitting in the vehicle doesn't have his eyes on the road at all, because he's working or doing something else". Annalena, non-expert.*

Different arguments were considered as possible prerequisites to enhance VRU comfort. Experts mentioned an adequate road infrastructure, the introduction of traffic prioritization rules, and the use of sensors or dedicated areas for CAVs, avoiding hybrid contexts. Non-experts expressed the idea of sensors for bikers and pedestrians. It is worth mentioning that a contrasting overall opinion resulted from the Eurobarometer survey, where the majority of pedestrians and cyclists would not be comfortable if surrounded by

CAVs. Most likely some of the concerns which arose during the FG discussions are also behind the results of the Eurobarometer survey.

4.10. Overall opinion about CAVs

Respondents were then asked about their overall opinion about CAVs, namely if they would consider the technology to be good or bad. They indicated mostly positive or neutral positions. In total 30 participants mentioned that CAVs are good, while 4 participants expressed negative views and 32 had a more balanced opinion, providing different arguments that would support their views. Those evaluating CAVs as "good" were referring to the various benefits that the technology could bring, such as increased safety, smoother traffic flow or decrease in the number of vehicles in cities and time savings. When unsure how to evaluate the technology, the respondents provided different arguments indicating that CAVs themselves can be defined as "neither good nor bad", because their impact on the society and for each single citizen depends strongly on how the technology will be implemented.

Participants having negative views regarding the deployment of CAVs explained that the technology itself cannot be considered as a problem-solver, and should rather be seen as a tool among other existing ones.

> *"The solution, really, is not in the technology, but technology is a part, a support, is a functional tool, … and it's not that automated transport will save the world, that's for sure". Marta, expert.*

4.11. Additional elements and change of view

Although not explicitly addressed during the discussion, the topic of children travelling in CAVs was introduced by some participants who expressed their positive attitude towards this idea. In the Eurobarometer, results on the topic showed that the level of comfort would be increased if a supervisor would be present in the vehicle, which was also the case in the FG discussions. It is noteworthy that the presence of a supervisor in the vehicle would be needed to control children's behaviour and to provide guidance on their routes, rather than to check the CAV.

Among the factors that would influence CAVs deployment, the role of different transport stakeholders has been defined as fundamental. Reference was made to public and private stakeholders: while for public institutions the key role was allocated to steer policy measures and initiatives, private stakeholders were mentioned in relation to industry business approaches and models that could be decisive in CAVs' deployment. Although the different stakeholders' roles could affect CAVs deployment a lot, the priority should be to ensure the comprehensive fulfilment of citizens' mobility needs, including especially those of vulnerable persons, such as children, pedestrians, cyclists, etc. This topic prompted the participants to question themselves on the legal responsibility and ethical aspects that could arise in case of accidents, wondering who should be considered liable in such situations.

> *"At the moment it's still like that there's always someone in it (the vehicle). What happens then, who is to blame, […] if the system breaks down or is hacked, who is to blame then, who is to blame if someone dies in a car accident or something, that's really bad". Noah, non-expert.*

The concluding points of discussions touched upon whether the FG discussions had made the participants change their mind in relation to their initial idea or opinion about CAVs. Overall, few participants stated that their initial idea had changed towards a more positive view, because of their participation to the discussion. For the majority of them the response was neutral, indicating that they remained with their initial idea, either positive or negative. In general, no major differences were found between the expert and non-expert participants, showing nonetheless different degrees of knowledge on this topic. Most of the participants were enthusiastic at the end of the discussion, stating how enriching it was for them also because it could stimulate additional thoughts on aspects not previously pondered, on new perspectives or angles related to the topic of CAVs.

5. Conclusions and outlook

Acceptance is paramount for technology uptake, which can occur once a sentiment of trust is developed around such technology (Lee & See, 2004). This applies also to vehicle automation, as already pointed out in previous work on this topic (Bansal & Kockelman, 2018; Esterwood et al., 2021; Gkartzonikas & Gkritza, 2019; Hegner et al., 2019; Zhang et al., 2019). It is confirmed by the outcome of the present analysis, the aim of which was to assess peoples' perceptions, expectations and concerns about CAVs, through qualitative insights from FG discussions, going beyond the Eurobarometer 496 results (European Commission, 2020a). The importance of developing trust around CAVs appeared spontaneously in many instances during the FG discussions touching upon different topics, such as the willingness to use CAVs, the possibility to reassume driving tasks, and the feelings that respondents would experience when surrounded by CAVs in the public space. Furthermore, the current lack of trust, in many cases, can be traced back to a lack of knowledge of participants with no expertise about CAVs. The results of the present paper allow the conclusion that individuals without expertise in transportation are not fully aware of CAVs benefit at both individual and societal level. Enhance public knowledge could support acceptance increase and enhance trust towards CAVs.

As presented earlier, the FG discussions organised for the purpose of this study were held by the three partners with participants

living in 23 countries. Among them there were participants having some expertise in the transport field and others not familiar with the concept of automation, nor with transport related topics. While it was interesting to broaden the scope of the work and get some national/local perspectives, no major differences emerged from the different countries' outcomes. This could be due to the rather international background of a part of the participants, as well as to the consensus on certain issues discussed, which may not find clear differentiations among European citizens, either experts or not.

During the FG discussions special importance was given to explore the ways that CAVs will affect the user and the society in parallel. This was done because societal aspects are often neglected when discussing user acceptance (Bornholt & Heidt, 2019) even though they are intrinsically linked.

When analysing different answers of transport experts and non-experts, a clear agreement was found in relation to the main points discussed, and to overall views and opinions on the specific topics touched upon. Even though it was evident that the supporting elements and the speculations accompanying the opinions of the expert participants were anchored to more elaborated concepts and arguments derived, most likely, from the experts' specific background knowledge, which was not necessarily on CAVs. Furthermore, the transport experts could identify more societal consequences of CAVs, while it was not mostly the case for the non-expert ones.

In line with Sharma & Zheng (2021), our findings show that although the evaluation of CAVs was positive among part of the participants, the road towards the adoption of the technology will be long and will require stakeholders to start preparing the implementation of the CAVs in the transport system, from now on. Individuals should be able to experience CAVs to gain trust and knowledge about them. Also in agreement with literature, besides perceived potential benefits, including safety, accessibility and travel efficiency, participants mentioned concerns regarding safety, legal responsibility, and privacy (Cunningham et al., 2019; Fagnant & Kockelman, 2015; Kyriakidis et al., 2015). Participants also expressed the need to trust the technology and to have the guarantee that it is safe before using it, while others mentioned, as vulnerable road users, that they expect the infrastructure to ensure safety when sharing the space with CAVs. All those concerns - if not carefully considered by stakeholders – will impact negatively the acceptance by citizens and could therefore slow down the market deployment of CAVs and thus the benefits they could bring. On the other hand, despite a high degree of willingness to use CAVs expressed in the discussions, the results of this qualitative analysis suggest that CAVs could not be considered by citizens for their daily mobility, but rather for leisure trips (e.g., long-distance trips), or in case they do not have any other alternatives. The participants expressed the opinion that their current mobility needs are served best by their own mobility pattern. This emphasizes how important it is to let individuals experience the benefits of CAVs in daily mobility.

Although this study offers insights into potential users expectations and concerns regarding CAVs, some limitations have to be acknowledged. The virtual setting of the discussions due to the Covid-19-related restrictions decreases the level of interaction between participants compared to a face-to-face discussion. This poses additional challenges to the moderators and excludes people without or with limited computer skills (Survey Research Center, 2016). It needs to be mentioned that, despite the international character of the study with FG discussions held in Italy, Spain and Germany, the local requirements and sampling prerequisites were quite similar and therefore we assume a high level of comparability. Conclusions from this study are drawn at a theoretical level, based on responses collected from participants who have not actually experienced CAVs that, nonetheless, found the FG discussions to be an enriching experience. This could show a relation between public awareness of self-driving technology and public acceptance and thus the importance of this type of activities to engage citizens in matters that impact their lives.

Although technological innovations could come with benefits, their societal acceptance is paramount for their full deployment, hence it is important to develop policy processes able to enhance public awareness, and public participation in the development of new technologies, possibly leading to CAVs acceptance before their final release.

This needs to be done progressively, starting from the design phase, where both governments and industry could engage people from the beginning in order to increase their knowledge and to motivate them to co-create their future mobility. Additional participatory means could be workshops, trainings, public consultation activities and trials.

Therefore, this FG discussions approach can be considered as the initial phase of a participatory process with citizen where people get more familiar with the concept of CAVs and start reflecting on its implications. It is critical at this point to develop a well-structured communication strategy in order to inform people about the potential benefits and threats of this innovation, building trust with them and achieving a smoother transition towards CAVs. As demonstrated by Piao et al., (2016) in their study, the next step after this theoretical study would be the actual interaction with such vehicles in real-life environments since it may impact positively people's acceptance. For instance, Living Labs could propose a favourable context for trials and public interaction in a co-design perspective. The advantages of such participatory approach include making citizens genuinely engaged in various roles as informant, tester, contributor or even co-creator.

Future work should extend this study to include different users' samples, such as children and women, and additional topics which were not exhaustively covered in this study and emerged spontaneously as relevant issues, such as: legal responsibility, ethical aspects and the role of different stakeholders in CAVs deployment. Moreover, to further investigate this topic, future work could be based on modelling how the interactions among different psychosocial factors influence CAVs' perception. Moreover, to overcome the theoretical limitation of this research, future work will include user's participation in practical demonstration of automated vehicles prototypes aiming at exploring their views and opinions once confronted with such technologies in real-life settings, capturing the feelings associated to such an experience within the framework of a JRC Living lab activity.

CRediT authorship contribution statement

Amandine Duboz: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Writing – review & editing. **Andromachi Mourtzouchou:** Conceptualization, Data curation, Formal analysis, Methodology, Visualization, Writing – review & editing. **Monica Grosso:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Viktoriya Kolarova:** Conceptualization, Data curation, Methodology, Software, Writing – review & editing. **Rubén Cordera:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Visualization, Writing – review & editing. **Sophie Nägele:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Writing – review & editing. **Maria Alonso Raposo:** Conceptualization, Methodology, Writing – review & editing. **Jette Krause:** Conceptualization, Methodology, Writing – review & editing. **Ada Garus:** Conceptualization, Writing – review & editing. **Christine Eisenmann:** Conceptualization, Methodology, Writing – review & editing. **Luigi dell'Olio:** Conceptualization, Writing – review & editing. **Borja Alonso:** Conceptualization, Writing – review & editing. **Biagio Ciuffo:** Conceptualization, Methodology, Supervision, 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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Annex A. -Questionnaire shared before the FG discussions

Q1. Please indicate your name and your surname.
Q2. Gender identity.

- o Woman
- o Man
- o Prefer to self-describe:
- o Prefer not to say

Q3. Age:
Q4. Do you have a driving license?

- o Yes
- o No

Q5. Do you have reduced mobility or any disability that constrains your mobility?

- o Yes
- o No

Q6. Where do you live? Please specify the country:

Annex B. - Participants' characteristics

		Experts JRC-UNICAN								Non-experts JRC-DLR-UNICAN					
	Group 1 (N = 4)	Group 2 (N = 4)	Group 3 (N = 3)	Group 4 (N = 5)	Group 5 (N = 6)	Group 6 (N = 3)	Group 7 (N = 7)	Group 8 (N = 4)	Group 9 (N = 4)	Group 10 (N = 5)	Group 11 (N = 5)	Group 12 (N = 6)	Group 13 (N = 6)	Group 14 (N = 6)	Group 15 (N = 4)
		Total = 40								**Total = 32**					
Average Age	49.7	47.3	36.6	38.4	41.6	42.6	44	42.7	34	40.8	37.4	43.8	40.5	40	37
Gender															
Man	3	2	2	2	4	1	5	3	3	2	3	3	3	3	2
Woman	1	2	1	3	2	1	2	1	1	3	2	3	3	3	2
Don't say/self-description	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Country of residence															
Albania	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Belgium	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Bosnia and Herzegovina	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Brazil	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Finland	0	0	1	0	0	1	1	0	0	0	0	0	0	0	0
France	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Germany	0	0	0	0	1	0	0	0	0	0	0	6	6	6	0
Greece	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Ireland	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Israel	0	0	0	2	0	0	1	0	0	0	0	0	0	0	0
Italy	4	1	0	0	0	0	0	0	0	5	4	0	0	0	0
Latvia	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Moldova	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Poland	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Portugal	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Slovakia	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Slovenia	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Spain	0	0	0	0	0	0	1	1	4	0	0	0	0	0	4
Sweden	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Switzerland	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Turkey	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
United Kingdom	0	1	0	0	0	0	1	1	0	0	0	0	0	0	0

Annex C. - Script for moderators

Opening (5 min.).

- Presentation of the moderator and co-moderator.
- Presentation of the topic of the FG discussion.
- Duration and schedule of the FG discussion.
- Mention to data privacy and guidelines to be followed during the discussion.

Part 0: Current mobility behaviour-ice braking (10 min.).

- Short presentation of the participants.
- Mention of the mode of transport they used for their daily commuting (before Covid-19 pandemic).

Part 1: Advanced Driving Assistance Systems (ADAS)-experience and general attitudes (30 min.).

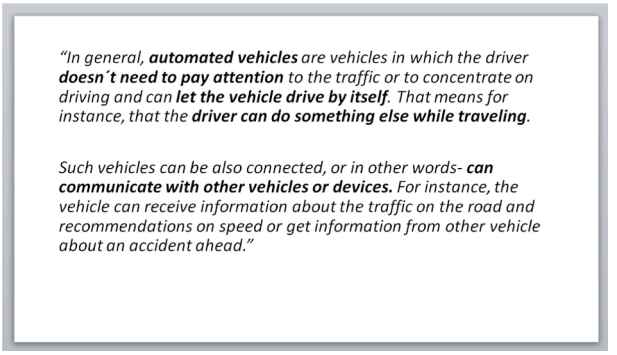
(a) ADAS and AD experience (10 min.).

- Do you have experience with ADAS (short definition provided).
- What type of experience? With which ADAS?
- Have you heard about Automated Vehicles (AVs).

(b) Introduction: AVs (10 min.).

- To what extent does each picture correspond to your idea of AVs? Why/ Why not?

Definition of AVs/CAVs-Level 5 of automation



Part 2: CAVs - Expectations, requirements and concerns (75 min.).
(a) Benefits and threats in both individual and societal level (15 min.).
Willingness to use and reasons behind:

- If you had the opportunity, would you be ready to use CAVs (consider different types of cars, shuttles, etc.)? Why/ Why not?

(b) Everyday life, willingness to intervene, activities and parking preferences.
Everyday life with a CAV:

- Do you think that a CAV suits your mobility needs?
- If yes, for which purposes would you use it?

Willingness to intervene:

- Do you want to drive fully autonomously, or do you want to intervene at some point?

- When would you like to intervene? Why?

Activities performed while the AV is travelling:

- What kind of activities would you like to perform in the vehicle?

Driving style:

- How would you describe your driving style?
- What kind of driving style do you wish it to have while the car is driving by itself?

Parking preferences:

- Would you consider sending the vehicle further from your location provided it was financially rewarding?
- What would be your main reason for this?

(c) Expectations and requirements from the pedestrian, cyclist, etc. perspective (15 min.).
Vulnerable Road Users perspective:

- How comfortable would you feel as a cyclists or pedestrian with CAVs on the street?
- What would make you feel uncomfortable/ unsafe or more comfortable/safer?

Part 3: General consideration, opinion changed after FG (15 min.).

- Would you say that CAVs are good or bad? Why?
- Has your opinion changed throughout today's discussion, and if so, in what way?

Annex D. - proportion (%) of participants' replies to each question

Do you have experience with ADAS?	
Yes	78
No	15
NA	7
If you had the opportunity, would you be ready to use CAVs?	
Yes	57
No	8
Unsure	8
NA	26
Do you think that a CAV suits your mobility needs?	
Yes	42
No	33
Unsure	3
NA	22
How comfortable would you feel as a cyclists or pedestrian with CAVs on the street?	
Comfortable	64
Not comfortable	11
NA	25
Would you say that CAVs are good or bad?	
Good	42
Bad	6
Balanced opinion	44
NA	8

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