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Engaging with different transport user groups for a smooth transition to Connected and Automated Mobility

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Abstract

Connected and automated vehicles could benefit society by increasing transport safety, environmental sustainability and inclusiveness. Engaging with citizens to raise awareness and discuss about the opportunities and threats they bring is paramount for a successful deployment of such technologies. This paper presents the results of several activities with women and teenagers participants: focus group discussions, demonstrations of an automated vehicle prototype and feelings' capture associated to automated vehicles, engaging with them, aiming at acquiring their knowledge, expectations and concerns for a smooth transition to connected and automated vehicles. The work conducted shows that technological innovations could result in societal benefits, once a technology is understood and accepted at societal level where the role played by knowledge sharing and dissemination are key.

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*Keywords:*Connected and Automated Vehicles; future transport and mobility; Focus Group discussions; Citizen engagement; Living Lab project.

1. Introduction

Connected and automated vehicles (CAVs) are expected to transform the transport sector by contributing to reduce transport externalities as road accidents, pollution, productivity losses due to delays and congestion (Alonso Raposo et al., 2019) and to improve the mobility of citizens, particularly for some citizens' groups (such as people with mobility impairment, older and young people) (Sharma and Zheng, 2021). Simultaneously, there is a risk of an increase in vehicle kilometres travelled when individually used private CAVs (Gruel and Stanford, 2016; Bahamonde-Birke et al., 2018). The successful introduction of CAVs will depend on their acceptance by society and on the CAVs use cases preferred by the majority of potential users. Recent studies have demonstrated that despite the enthusiasm of policy makers, the majority of citizens are not willing to use CAVs (Westenberg et al., 2018; Asmussen et al., 2020; dos Santos et al., 2022), other researches highlighted that socio-demographic characteristics, such as gender or age can influence the acceptance and willingness to use CAVs (Bornholt and Heidt, 2019). While women represent half of the world population, their views on their current and future mobility are still under investigation and little research has been made regarding their opinion on CAVs (Hortelano et al., 2021). Teenagers' opinion about transport solutions have been in general less investigated compared to adults (Barker et al., 2009), although their needs are complex and vary according to age, the economic situation of their household and location (Shaw et al., 2015).

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Although it seems that the deployment of CAVs could improve the mobility of women and youth, still research and detailed investigations on the topic are scarce. Investigating the needs and increasing the understanding of women and teenagers opinions towards (different use cases of) CAVs is a necessity in the prospect of their successful development.

This research aims at addressing this gap by exploring the perspectives of women and teenagers on different issues related to the acceptance of CAVs through the use of Focus Group (FG) discussions, a real-life demonstration of an automated vehicle prototype and a mood board activity. This research is the joint effort of three research institutes: The Joint Research Centre (JRC), the Institute of Transport Research at the German Aerospace Center (DLR) and the University of Cantabria (Unican).

The paper is organized as follows. In the next section, the current literature on the acceptance towards CAVs for women and teenagers is presented. Then, the applied methodology is described and next the main results of the study are presented. Finally, the last section provides some conclusions and indications for future research.

2. Literature Review

Previous research efforts have partially touched upon the topic investigated in this paper, the main contributions are reported hereafter for both user groups: women and teenagers.

Gender disparities were identified in relation to perception, interests, acceptance, concerns and willingness to use new transport technologies such as automated vehicles (AVs). Women tend to have less positive views regarding AVs (Wang et al., 2020) and are less likely to be interested in using them (Rezaei and Caulfield, 2020). The lower level of willingness to use AVs among women compared to men was registered in multiple studies (Hohenberger et al., 2016; Sener et al., 2019; Rahimi et al., 2020; Saeed et al., 2020). Some of the factors recognized in the literature as influencing the perception, attitude and opinion of women regarding AVs include safety aspects (Pflugfelder, 2018; Acheampong and Cugurullo, 2019), anxiety in using AVs (Liu et al., 2019), lack of human interaction (Hohenberger et al., 2016) and concerns about privacy (Gurumurthy and Kockelman, 2020). Other aspects related to gender differences and AVs have been identified in relation to environmental friendliness of an automated minibus, on-board presence of a human operator and spaciousness of the vehicle, as reported in Bernhard et al. (2020). Lee and Mirman (2018) analysis of parents' perspectives on using AVs to improve children's mobility pointed out that women perceive lower benefits and higher concerns from using such vehicles compared to men.

In general, the interest of research towards the acceptance of AVs by teenagers is quite recent and the age range investigated varies considerably among studies or does not considerr how mobility patterns vary across age ranges. Literature on the topic can be distinguished in studies which take into consideration the opinion of minors and analyses which focus on parents' perspective. The only study that explores teenagers cyclists' perceptions of AVs is the one of Ngwu (2021). The study states that teenagers believe that AVs will make the roads safer, and that they would also trust to ride their bikes alongside them in general, during the night or in poor weather conditions.

The confidence of young people in travelling alone in AVs is uncertain. Fortunati et al. (2019) showed that the trust towards AVs was barely positive among different young groups (i.e., 13–15, 16–17, and 18–25 years), and that the age had no influence on their acceptance. Tremoulet et al. (2020) showed that only 36% of young people from 8 to 16-year-old would feel comfortable riding in an AV alone. Studies investigating parents' views look at children aged between 0 and 17. According to these studies, parents are not ready to let their children travel alone in an AV (Hand and Lee, 2018 and Tremoulet et al., 2020) unless reassurance features such as microphones, camera, ability to request assistance if the vehicle breaks down are installed (Koppel et al., 2021). What could influence, positively or negatively, parents' views would depend on the children gender identity, age, place of residence, their level of knowledge about AVs, and their own level of concerns towards their children's safety (Hand and Lee, 2018, Lee and Mirman, 2018, Deb et al., 2020, Lee, Hand, and Lilly, 2020, Jing et al., 2021).

3. Methodology

The FG discussions methodology was chosen in this study to investigate different users' perspectives on issues related to the acceptance of CAVs. FG discussions research technique "collects data through group interaction on a topic determined by the researcher" (Morgan, 1996), mainly building upon and contrasting each other's ideas (Stewart and Shamdasani, 2014). According to Krueger (2014), FG discussions are described as a small group of people, with certain characteristics, that provide qualitative data in a focused discussion helping to better understand a topic of interest. The main point that differentiates FG discussions from other methods is the collection of attitudes, feelings, beliefs, experiences and reactions that would not had been possible through other research methods such as observation, one-to-one interviewing, or questionnaire surveys (Gibbs, 1997). Moreover, this method has been successfully used to gain insights and deeper understanding in transport research in general (Jacobsson et al., 2017; Naznin et al., 2017; Ferrer and Ruiz, 2018; Nikitas et al., 2019) or on new transport solutions (Trommer et al., 2016; Pudāne et al., 2019)

The study was structured into 3 phases: the first phase included the mapping of the main topics to be explored with both target groups, only adjusting or simplifying concepts for the teenage participants. During the semi-structured FG discussions, the participants, among others, were invited to share their current mobility habits and to foresee if CAVs could satisfy their future mobility needs. They were also asked to discuss any possible advantages and disadvantages that this innovative technology might

bring with its deployment. A total of 12 FG discussions took place on-line and in face-to-face setting, which then were followed by an automated vehicle prototype demonstration and a mood board activity. The second phase was dedicated to the data analysis of the results gained during the different activities, while the last phase included the discussion of the results.

From July to November 2021, 7 FG discussions with 31 women and 5 with 31 teenagers were organised. The women participants had an average age of 38.3 years with a range from 20 to 57 years while the average age of teenagers was 15.9 years with a range from 14 to 17 years. All FG discussions were audio/video recorded. The participation to this study was completely voluntary and the only requirement for participation was a good English level. Women participants were required not to have previous working experience on the transport topic to avoid any potential research bias.

As specified, the FG discussions took place according to different settings: on-line and face to face, which allowed the research team to tailor the methodological approaches as follows:

- In the online FG discussions, the participants were involved in one single discussion of 2 hours.
- During the face-to-face activities, the participants had the opportunity to get involved in more activities: 2 hours FG discussion, a real-life demonstration of an AV prototype, Rob.Y, developed by the Italian SME e-Shock and a related mood board activity aiming at capturing participants' feelings after the automated vehicle prototype demonstration. While the FG discussion was taking place on a separate day as an initial contact with participants, the demonstration in a dedicated open-air test track closed to traffic was organised during a second appointment with participants and immediately followed by the mood board activity. Mood board is a visual representation -also known as collage- consisting mainly of images but which can also include text or other materials. Mood boards, according to Endrissat et al. (2016), are collaborative and creative activities and are commonly used as a visual expression of intangible qualities (an idea or vision for a new product). In this way, participants can better express their thoughts, feelings and abstract concepts by focusing more on the different meanings of the picture than on the picture itself (Pimlott-Wilson, 2012). During this activity, participants received a folder with 16 cards, which were showing 8 emotions presented twice each: one through a facial expression or human interaction and one related to nature, animals, etc. The feelings were based on Robert's Plutchik categorization (known as wheel) where he suggested eight bipolar emotions; joy versus sadness; anger versus fear; trust versus disgust; and anticipation versus surprise, each one linked with a color. After the distribution of the cards, participants were asked to pick up as many cards representing the emotions that they felt during the demonstration. They were also allowed to write a few words or short sentences on the back of the cards explaining how these emotions were linked to the demonstration. At the end, each participant had to orally elaborate on the choices made and then all the cards were put on a white board divided in three main sections; positive, negative and mixed emotions based on participants' elaborations to create a map of emotions. The activity, audio-recorded, aimed firstly at capturing the emotions derived directly after the AV demonstration, secondly it was a way to identify any change in participants' views after experiencing an AV under semi or real-life conditions. The physical activities were organized at the JRC Ispra site in Italy, within the framework of the JRC Future Mobility Solutions Living Lab.

All FG discussions were word-to-word transcribed. The transcripts were used as a basis for a content analysis. In an iterative process, all mentioned aspects were categorized using a deductive-inductive approach (using the guiding questions as categories, but also including new aspects, i.e., categories, that came up during the discussion. The analysis software MAXQDA was used for the data analysis. The following figure illustrates the methodological approach followed through the entire research process.

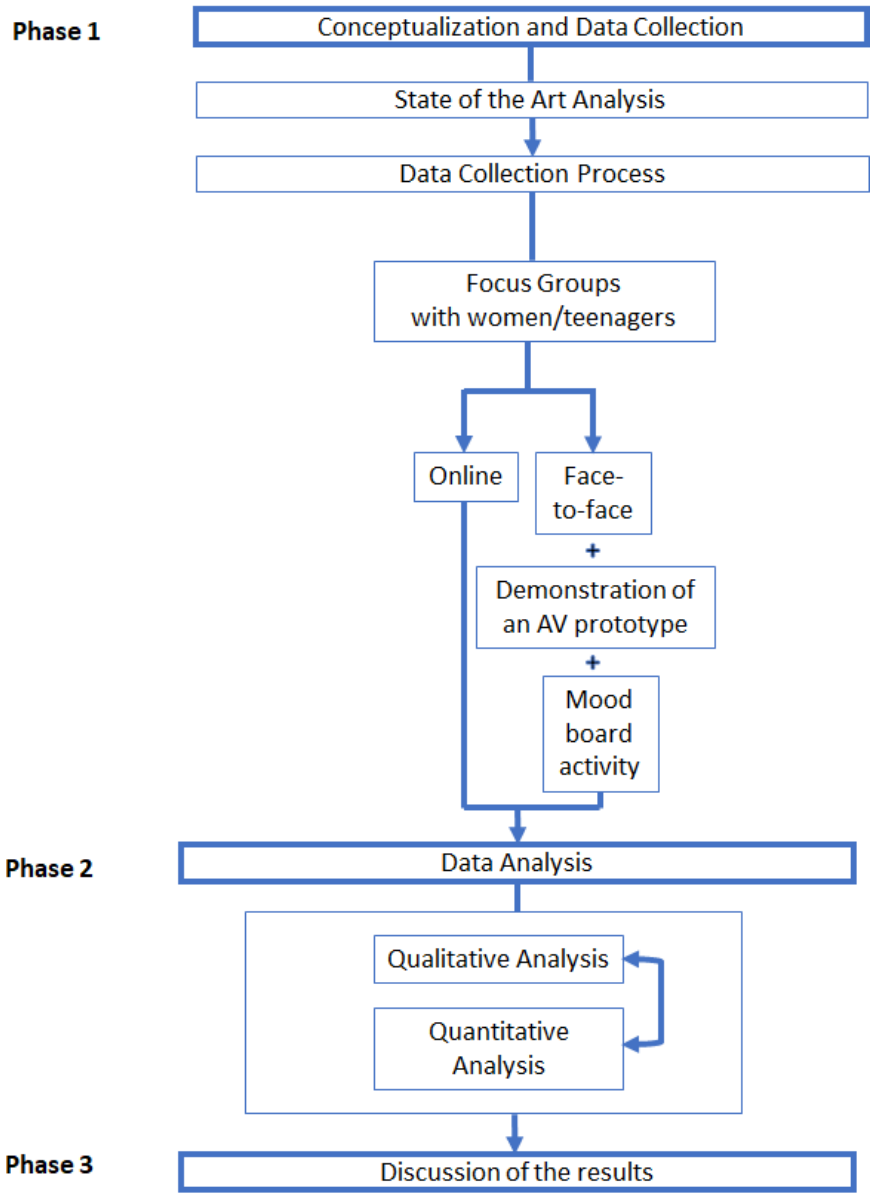

Fig. 1. Study description

4. Results

In this section, the main outcome of the FG discussions and the other activities is presented, making a distinction between the two users' groups, providing details on how CAVs could fit the mobility needs of women and teenagers and what are the advantages and disadvantages they associate to CAVs.

4.1 Women FG participants views regarding automated vehicles

The women participating in the FG discussions showed different points of view when asked if AVs would satisfy their *daily mobility needs*. Half of them provided a positive answer, while the other half was more sceptical about the usefulness of such vehicles. Some participants that answered positively added that CAVs could improve their daily mobility experience, due to better use of travel time by working or performing other activities while commuting, others pointed out that CAVs could perform the driving task, which they do not like, and that CAVs could make the travel more comfortable and relaxing. Some participants thought that CAVs could satisfy their mobility needs if designed as a public transport option. The more negative attitude was supported by elements referring to geographical context (e.g., rural areas), satisfaction with the current used transport modes and the legislative challenges associated to such vehicles or the limitations of CAVs in specific situations.

When talking about possible *advantages and disadvantages linked to the deployment and use of CAVs*, both at personal and societal level, the given reasons were various and contrasting. The main benefits referred to the possible improvements of the travel experience, namely to the possibility to perform other activities or sleep while travelling, lowering the stress related to traffic, improved travel safety and a gain in flexibility due to the increase in independence of children. Others referred to the increase of

safety and a reduction of accidents, due to the reduction of human errors, in relation to higher compliance with driving rules compared to human drivers. Benefits were also linked to increase in accessibility for people without a driving license or for those with mobility impairments, as well as improvements of the traffic conditions and reduction of traffic jams, due to CAVs technology efficiency. Additional beneficial aspects were associated to the use of shared mobility and the possibility of travelling in a more sustainable and predictable manner. When looking at the negative aspects, participants mentioned threats for their personal safety in relation to cybersecurity and hacking of CAVs, problems related to a combination of mixed traffic context, and the incapacity of CAVs to react to natural or external disasters or loss of connectivity in remote areas. Challenges related to the protection of privacy and also lack of control over the vehicle behaviour, could be linked to a lack of "trust" towards the vehicles or the "fear of giving up on" human capabilities. Other raised problematic aspects linked to legal responsibility in case of accidents or speed limits that could increase travel time. Participants also mentioned that the deployment of CAVs could create more loneliness in general and reduce human interactions and that CAVs could trigger "even more a society of production and productivity" where people need to be always available and productive.

4.2 Teenagers FG participants´ views regarding automated vehicles

When asked if CAVs would satisfy their *daily mobility needs*, a part of the teenage participants considered that CAVs could satisfy their daily mobility needs for traveling to school or other activities. Some students added that CAVs could reach a comparable or even lower error rate than human drivers. Some teenagers mentioned that CAVs would be useful for long distance travels and would work better in a transport system where all vehicles are connected and automated. Some others also added that CAVs would be comfortable and trusted after safety tests and when compliant with existing safety requirements. Those that expressed some reluctance, but were interested in using CAVs under specific conditions, mentioned that they would prefer a driving solution that enables the person to choose between automated and non-automated modes. They also mentioned that they would feel 'scared' or 'nervous' using them the first time and that gaining trust in the technology would help them overcome these feelings and convince them to use CAVs more frequently. On the other hand, teenagers who did not expect that CAVs could satisfy their daily mobility needs, expressed safety concerns related to a lack of control. These participants, once obtaining the driving license, would be eager to drive by themselves as they would consider the driving activity as a 'fun' experience which CAVs could not provide. Safety concerns were also pointed out by teenagers who were undecided whether CAVs could satisfy their mobility needs, but these concerns were not only related to the vehicle itself but also to the interaction with pedestrians and other vulnerable users and to the currently inadequate infrastructure (e.g., narrow roads in specific areas).

Secondly, FG participants were asked to provide details about the *advantages and disadvantages* they could anticipate from the deployment and use of CAVs. Some of the societal advantages identified were related to an improved travel system (e.g., less traffic, reduced travel time, increased efficiency of public transport), a potential reduction of accidents, improved accessibility for certain passenger categories (old, disabled, children or persons without driving license), emissions' reduction and creation of new jobs. At individual level, teenagers mentioned the possibility to perform other activities while driving (e.g., reading, doing homework, sleeping) that, together with the partial or inexistent concentration on driving, could offer an improved travel experience, in terms of comfort and safety, compared to conventional vehicles. The disadvantages identified were related to the strong belief of teenagers that a part of the population will not be convinced to use CAVs, and especially that the high price at the beginning of their deployment will increase inequality, since low-income households could not afford such purchase. At the same time, teenagers highlighted possible negative impacts on the environment that could result either from the increased energy consumption that CAVs require or from the need to adapt the existing road infrastructure. Job losses and a potential risk of CAVs travel increase were also mentioned as societal threats. The individual disadvantages were associated to safety concerns, as lack of control over the vehicle, and from software bugs. Moreover, some threats were identified thinking of children possible use of CAVs, who would explore and activate CAVs functions randomly. Teenagers also focused on the lack of trust towards CAVs mainly attributed to the fact that a human is able to take better decisions in critical situations compared to an artificial intelligence software. They also expect that CAVs will make people lose their driving skills since they will not have to drive anymore, and they will increase person's isolation in case that CAVs will be deployed and used only as private vehicles.

4.3 Participants engagement activities

In this section, the main outcome of the real-life demonstration of an AV prototype, Rob.Y*, and the results of the mood board activity are presented for the women and teenage participants.

After the real-life demonstration of an automated vehicle prototype, the women could link their experience with the feelings that it stimulated: out of the 8 initially identified feelings, 6 were chosen, for a total of 24 cards. Those cards reflected to the feelings of joy, anticipation, anger, fear, surprise and disgust. The remaining cards were associated to sadness and trust, but they are excluded from the analysis as they were not selected by the participants.

Generally, the comments from participants were associated with the initial emotions linked to the cards when these were selected by the research team. However, in some cases, the comments were linked to the character or the situation presented on it, more

* More information are available here: https://www.e-shock.it/products/rob-y

than to the feelings that the image evokes. This was the case for one comment on joy and one about anger and all the comments associated to disgust. As those comments did not reflect the feelings towards the image itself. Also, in this case the CAV they have not been pertinent to the analysis and were not taken into account in the analysis.

Joy was used to emphasise the improvement in terms of life quality that the disappearance of the driving task will bring to their life, allowing "quality time with family" or "time to enjoy life". When referring precisely to Rob.Y, some participants mentioned that their feeling was linked with the sensation of "relaxation" and lack of "anxiety while it was moving around"; while *surprise* was used to highlight the positive impression made by the complexity of the technology. *Anticipation* was associated with the barriers that "need to be overcome" in order to innovate, as well as the positive impact of CAVs on the environment. *Fear* was used to describe the apprehension to use CAVs at the beginning of their deployment, while *anger* was linked to the disagreement that one could have with the decisions of the vehicle. A specification is needed for the different feelings that were associated to safety aspects. The concept of safety was mentioned several times and in many cases the cards chosen and linked to the safety concept were picked up precisely because of the images on them, rather than for the feelings that they would evoke in relation to the previous AV prototype demonstration. It is nonetheless important to report on these choices as the comments associated to them were rather interesting for our research purposes. Choosing the cards associated to *anger* and *joy*, participants highlighted that roads would be safer for children (e.g., avoiding accidents as children cross unexpectedly the streets), or that the safety will be improved due to the absence of aging people driving. Other participants that choose the *disgust* card, expressed worries related to unexpected situations where the algorithm would not be prepared to intervene. Finally, *fear* was used to highlight the risk for the vehicle to not stop, while the one depicting *anticipation* was related to the positive impact on road accidents. After commenting on the different pictures chosen, the research team classified them according to the nature of the feelings (i.e., positive, negative or neutral) based on the supporting description provided by the participants: 16 out of the 24 cards were classified as positive, 5 as negative, and 3 as neutral.

Concerning the teenagers group, they choose all the 8 feelings depicted on the cards, commenting on a total of 40 cards. The most selected and commented cards were those representing feelings of anger, trust, surprise and anticipation. *Anger*, contrary to our estimations, was perceived differently by teenagers and these cards were used to describe apprehension to the big impact that such technology could have to society and to a potential climate change that it might bring. The lack of experience towards these vehicles in terms of human interaction made them also feel overwhelmed. The feeling of *trust* was explained by the fact that CAVs will connect people by facilitating their daily commuting habits; moreover, the participants linked their feeling of trust with the research community that works on CAVs development. Cards representing the feeling of *surprise* were the most chosen among the distributed ones, and 11 out of 15 students picked them up. Their surprise was due to the advanced technology level of the prototype and the artificial intelligence technology in it, its reaction with pedestrians and its size, as they were expecting something smaller. While all of the 11 students mentioned the surprise during their elaborations, three of them coupled it with hopefulness for the technology progress and confusion because of the amount of information received and their lack of knowledge on artificial intelligence. It is important to mention that none of the participants was negatively surprised. A*nticipation* was related to the space of improvement for the prototype in the near future. According to their elaborations, they expect that vehicles similar to the AV prototype will consist of a more sustainable solution, able to contribute to the environment's protection by reducing emissions while increasing the space efficiency. A participant who picked up one of the cards of anticipation was surprised that this technology has already reached Europe, thinking that it was developed only in the United States. The least chosen cards represented the feelings of *disgust, fear, joy and sadness.* Participants who chose the cards representing *disgust,* perceived the illustrated feeling differently than what researchers anticipated and mentioned it as terror of seeing a vehicle driving by itself and disappointment because this vehicle was not as advanced as they expected it to be. The card related to *fear* was picked by 2 participants who explained that, apart from the fear that they felt during the demonstration due to the lack of readiness' of the vehicle to travel on a real road, they also felt skeptical and intrigued. The cards of *joy* were chosen in two cases by participants because this innovation is close to be ready in the near future and they were excited for this progress. Finally, one participant selected a card representing *sadness* to describe the feelings evoked during the demonstration. According to this participant, AVs are often presented as risky and dangerous, while during the demonstration none of these feelings evoked. The participant concluded that scientists and relevant stakeholders need to work hard on the rehabilitation of AVs' reputation and to a more user-friendly appearance; this thought would make the participant sad about the situation. The research team, supported by the indications provided by the teenagers, was placing the cards of the participants in a whiteboard, divided in three categories according to their descriptions: positive, neutral, negative. 27 cards were placed as evoking a positive feeling, 8 as neutral and 5 as negative. This mapping reveals overall positive feelings and attitudes towards the AV prototype demonstration.

5. Conclusions

The present work investigated women and teenagers' mobility needs and how CAVs could satisfy such requirements in case they are finally deployed. While previous studies pointed out the gender differences in AVs acceptance (Bansal et al., 2016; Rezaei and Caulfield, 2020) highlighting a general more cautious approach of women as compared to men, there is limited evidence of the underlying reasons of such differences; at the same time research on teenagers' perceptions and views about AVs is scarce

(Ngwu, 2021). This paper provides additional insights on these research topics, providing question, using empirical evidence based on FGs discussions and participation activities involving both groups of women and teenagers.

When analysing the outcome of the women FG discussions, it appears clear that there are still acceptance barriers for CAVs. At the same time, potential safety improvements or more sustainable individual mobility options linked to make CAVs seen as promising solutions for some road users and in general for a more sustainable and accessible future transport system. Safety aspects are at the core of women CAVs concerns, which need to be addressed by independent entities who could prove their standards' adequacy. The present analysis allows to shed some light on women mobility and discussing on how CAVs could fit into their needs and habits, showing that although green mobility choices and safety concerns characterize their mobility, still no clear evidence was found on the way CAVs would serve as women mobility problem solvers or how CAVs could improve or mitigate their travel behaviour impacts. It was nonetheless possible to draw conclusions on the anticipated positive effects CAVs would bring into women mobility in relation to daily transport activities and time management. The mood board activity was an opportunity for the participants to emphasize certain points discussed during the FG discussions. While expectations and concerns related to safety issues were associated with different feelings and pictures, the wellbeing that CAVs could bring in the life of the participants was always associated with the feeling of happiness. The demonstration of Rob.Y was associated with positive feelings (i.e., surprise and happiness), showing the positive impact of the real-life experiment on participants attitudes.

Teenagers participants expressed safety concerns about the simultaneous co-existence of CAVs, pedestrians and other road users that contradicts the findings of Ngwu (2021) where teenagers bikers would feel comfortable riding while surrounded by CAVs. Teenagers' perspectives regarding CAVs, as future users of such vehicles, help understanding better their concerns (e.g., how the vehicle reacts in emergency situations, the lack of trust and safety) and provide policy makers indication about areas that need to be further developed and adequately explained to build trust and ensure a smooth deployment of CAVs in the transport system. Additionally, the mood board activity showed that the majority of the most commented cards represent positive feelings (trust, surprise, anticipation, anger) compared to the least commented ones that in their majority evoke negative feelings (disgust, fear, sadness, joy). This outcome, even coming from a small-scale activity, showed a positive tendency of teenagers towards CAVs. The cards associated to surprise, most frequently chosen by the participants, meant as a positive feeling, makes us consider the importance of showcasing the technology and its advancement to the young generations who will be the future users.

The evidence showed during the real-life demonstration indicates that citizen's views and opinions can be supported by multiple and more consistent arguments deriving from a more complete and clear idea of the technology features and functionalities offered through a direct experience with the CAV technology. Future research should support real-life testing and engagement activities that may provide even more insightful feedback for policy actions. Moreover, participatory approaches as used in this study allows potential users to be considered as co-creator of the future mobility option and transport system. Further studies in this field should therefore aim to involve participants more in a discussion of how these mobility options might be developed rather than solely capturing evaluation of currently discussed concepts.

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