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Identification of older adults' needs as future users of autonomous shuttles: A serious game co-creation approach for inclusiveness

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ABSTRACT: Automated vehicles are potential disrupters of the mobility system and are expected to address inclusive mobility issues. Yet, the transition to their full implementation in cities is expected to face numerous challenges. While companies and governments interested in their future implementation have conducted pilots to understand better their implementation in cities, there is still a limited understanding of potential users' needs. This understanding becomes even more limited when considering vulnerable groups. To address this gap, we have developed a novel Serious Game named "A shuttle for everyone". We use it as a co-creation method to engage potential users, in this case, older adults in the Noordrand-Brussels region, Belgium. This study case contributes to the co-creation and transport literature as there is scarce research focused on developing new inclusive mobility public services. Three game sessions with older adults took place. The key identified needs are related to comfort, safety, ease of use, and accessibility. Our results confirm and complete previous automated vehicle studies. We can confirm that our Serious Game as a co-creation method has facilitated anticipatory needs identification. Understanding users' needs contribute to improving design and can help to create policy recommendations that aim for an inclusive implementation of automated vehicle mobility services.

KEYWORDS: Inclusive mobility; co-creation; autonomous vehicles; serious games; older adults

1. INTRODUCTION

Automated vehicles are vehicles capable of driving themselves without human intervention. These vehicles are classified as levels 4 and 5 due to their level of automatisation (Kovacs et al., 2020). These vehicles are potential disrupters of the mobility system, and there is optimism about their possible benefits (Kovacs et al., 2020). Automated vehicles are expected to make travel safer, more equitable in social terms and more efficient. They have a first and last-mile connection potential to low-dense areas (Ohnemus & Perl, 2016) and are expected to address accessibility problems of older adults (Kovacs et al., 2020; Zandieh & Acheampong, 2021). However, it is expected that various problems and challenges will arise during the transition phase of their implementation, especially when vehicles with different levels of automatisation will be deployed (Chaloupka & Risser, 2020). Among those potential challenges are the complexity of automotive technology, ethical aspects, traffic management strategies, liability issues (Martínez-Díaz & Soriguera, 2018), and those related to human behaviour, including the risk of misunderstandings between vulnerable road users and automated vehicles, which could cause fatal outcomes (Chaloupka & Risser, 2020).

Acknowledging the situation mentioned above, companies and governments are conducting pilots and studies to understand better the implementation, advantages, disadvantages and challenges (Ahangar et al., 2021; Feys et al., 2020; Gavanas, 2019; McAslan et al., 2021; Pattinson & Chen, 2020; Pereira et al., 2019). Some of these studies have focused on the intention of potential users to adopt the service (Ahmed et al., 2022; Alsalman et al., 2021; Feys et al., 2021; Hulse et al., 2018), as well as on the perceptions of vulnerable road users such as pedestrian and cyclist (Penmetsa et al., 2019). Moreover, relevant studies have been conducted to better understand the impact of automated vehicles on older adults' mobility and their willingness to use them (Hassan et al., 2021; Kovacs et al., 2020; Zandieh & Acheampong, 2021). Despite the studies conducted, there is still a limited understanding of the needs of automated vehicles' potential users. This understanding becomes even more limited when considering vulnerable groups such as older adults (Kovacs et al., 2020) and using automated vehicles as public transportation. Addressing these gaps is important to tailor appropriate and inclusive policy responses.

The inclusion of vulnerable groups in mobility policies is among the key political priorities of several European countries (Gallez & Motte-Baumvol, 2017). A socially inclusive approach, where there is an involvement of different social groups, is critical to achieving smart and sustainable cities (Yigitcanlar et al., 2019). As part of this socially inclusive approach, researchers in both high and low-income countries have advocated for the attention to include not only people with disabilities but also older adults and small children (Kett et al., 2020).

A relevant strategy to achieve a more inclusive approach is encouraging the active engagement of service users as co-creators. This approach promises to foster innovative solutions via joint experiences, resources and skills (Nabatchi et al., 2017; Torfing et al., 2019). Such a collaborative approach is expected to provide higher-quality services and services that meet users' needs (T. O'Brien, 2016; Torfing et al., 2021). Furthermore, co-creation processes seem to involve vulnerable groups better than traditional types of participation (Brandsen, 2021). Actually, co-creation can lead to greater inclusion of citizens than other traditional methods (Brandsen, 2021; Leino & Puumala, 2021). However, there is still a lack of research on integrating vulnerable groups (Amann & Sleigh, 2021). One of the reasons is that co-creation with vulnerable groups is complex (Brandsen, 2021) as well as a time and resource-intensive (Amann & Sleigh, 2021).

Acknowledging the previous research gaps and the potential benefits of co-creation processes, we have developed a novel Serious Game named "A shuttle for everyone" as a co-creation tool. This game is part of the Policies for inclusive autonomous mobility solutions for cities (CATAPULT) project. The project aims to create and adapt policies to improve target group-specific, inclusive, and demand-driven automated mobility solutions in cities and urban regions. For the development of this game, we considered previous experiences identified in the co-creation and gamification literature.

Vulnerable groups tend to be underrepresented (Brandsen, 2021). Hence, this paper aims to contribute to the co-creation and transport literature as there is scarce research focused on developing new inclusive public services (Rodriguez Müller et al., 2021) to identify potential users' needs, here referred to as anticipatory needs. To address this gap, we have developed a novel Serious Game named "A shuttle for everyone". We use it as a co-creation method to engage older adults in the Noordrand-Brussels region, Belgium. By focusing on older adults, we also address the lack of research on the journeys of vulnerable groups, their needs, and journey experiences from a participatory perspective (Kett et al., 2020). The rest of the article includes five sections.

The next section explains the game's development, while the third section presents the game itself; the fourth section contains the results and the fifth section the conclusion and discussion.

2. METHODOLOGY, THE DEVELOPMENT OF THE GAME

The serious game development considered gamification and co-creation literature to enhance the involvement of vulnerable groups to participate and express their needs. While a game is defined as a structured play that has rules, goals and challenges with the aim to entertain (Krath et al., 2021), gamification considers the "use of game elements in non-game contexts" (Deterding et al., 2011, p. 11). This type of participatory game has proved useful in illustrating complex urban issues and helps make the participatory process more accessible (Ampatzidou et al., 2018; Panagiotidou et al., 2022a).

Understanding that co-creation by nature is often a small-scale (Brandsen, 2021), we developed a game that considered a maximum of four players per session. The game consists of a small-scale meeting that allows older adults to discuss and identify in small groups their potential needs if autonomous vehicles are implemented in the future. The game is primarily based on the Cog-nito game and collaborative storytelling approach. Storytelling can be key to making a game memorable; it also gives purpose to the players and keeps them motivated throughout the game (Gamito & Martinho, 2021). Moreover, collaborative storytelling games can assess anticipatory assumptions, a method that allows imaging technological futures (Belton & Dillon, 2021).

Cog-nito is a participatory physicalisation game that supports collaborative urban mental mapping through storytelling, where multiple individuals narrate experiences in the first person (Panagiotidou et al., 2022b). Cog-nito has been developed by researchers at KU Leuven (Belgium), which was very helpful in exchanging ideas and discussing the game's application to other contexts. Besides the storytelling approach, Co-gnito also captures the feelings experienced by the participants in a certain space by including feeling cards as part of the game (Panagiotidou et al., 2022b).

To tailor the game to our objective, we had three meetings with the Co-gnito creators between February and March 2022. We also critically reviewed literature within the co-creation and gamification literature, including the storytelling approach. A revision of storytelling games literature allowed us to identify the study conducted by Belton and Dillon (2021). Their research expands the literature on the public perception of autonomous flights by presenting results based on an exploratory study of non-expert anticipatory assumptions (Belton & Dillon, 2021). The authors acknowledge that collaborative storytelling games are part of narrative future methods as they allow intersections between stories and anticipation in future studies (Belton & Dillon, 2021). While the authors focus on the Anticipatory Assumption concept to understand the concerns and implicit beliefs (perceptions) of non-experts, due to the aim of our game, we retake the concept of Anticipatory Needs. This concept refers to identifying "what needs to be done in order to move toward a specified future" (Wade, 1989, p. 116), in our case, the implementation of inclusive autonomous shuttles. Therefore, here we redefine Anticipatory Needs as the identification of future needs based on the current perceptions of non-experts.

Another relevant aspect to mention about the game is that after the literature review and consultations with experts on collaborative approaches and serious game development, such as Nancy Duxbury[1] and Andrew Vande Moere[2], we decided to develop a physical version of the game instead of an online version. As pointed out by co-creation scholars, users' digital engagement might pose limitations in inclusiveness and accessibility (Rodriguez Müller et al. 2021). Moreover, this analogue format is more familiar to play for older adults.

Three game sessions with older adults took place between March and April 2022. When looking for participants, we could confirm that engaging vulnerable people in co-creation processes require additional efforts and a targeted approach (Brandsen, 2021). To identify the players/potential users, we searched for residential care homes for older people and older adults' associations in the Zaventem area. This area is at the heart of the Noordrand region, and we identified two, WZC (Woon– en zorgcentrum) Sint-Antonius and OKRA (Open, Kristelijk, Respectvol en Actief).

OKRA[3] is an association for people over 55 years old. OKRA provides opportunities to meet peers and do activities together. In addition, the association also encourage the development of talents, remaining active and participating in this evolving world. WZC[4] is a residential and care centre that aims to take care of highly dependent elderly people in a home-replacement environment. Elderly people with dementia are also included. In the case of OKRA, a previous contact was established as part of a study conducted with different stakeholders to understand the potential challenges concerning implementing automated shuttles in the Noordrand region. The researcher who conducted that study shared the contact with us. The contact in OKRA was reached on two occasions before having an answer from his side. Once he replied, he asked us to schedule a meeting on February 28th, 2022, at his office in Zaventem. The first and second authors attended the meeting and explained the objective of the CATAPULT project and the game session. The OKRA representative provided us with some

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1 Nancy Duxbury is an expert on imaginative cartography, emphasizing the importance of the creative process that engages with the "felt sense" of community experiences.
2 Andrew Vande Moere is an expert in use design-oriented research methods within the practices of citizen engagement, interactive architecture, robotic fabrication and digital humanities. He is one of the developers of Co-gnito, a participatory physicalisation game that supports collaborative urban mental mapping through storytelling.
3 https://www.okra.be/
4 https://www.sintantoniuszaventem.be/

available dates for the game session and mentioned to us that they would like to have the session at the university. Afterwards, we exchanged some emails, and we agreed on a first date, but unfortunately, they cancelled us, so we rescheduled it for April 8th. A total of four 60+ players attended, and we had the game session, which lasted one hour. Based on this experience, we agreed with previous research that found that for co-creation processes, it is helpful to have a pre-established relationship with some members of the vulnerable groups, in this case, older adults (Amann & Sleigh, 2021).

Regarding WZC, the approach was different. In this case, after identifying the place, we contacted them via phone, and the people from the front desk provided us with a name and an email to contact the person in charge of this type of request. We emailed the person, but we did not have an answer even after sending a reminder. Therefore, we decided to contact them again via phone and this time; we were referred to another person. During the call, we explained the game and its objective. The new contact person was very enthusiastic, and she immediately proposed tentative dates to have the game session at WZC. Unfortunately, the first agreed date was cancelled, but they immediately proposed a new date that same week. So, we visited WZC on March 4th, and we had two game sessions with people over 68 years old. For the first session, we had four participants, and for the second session, three.

In the end, two out of the three sessions took place in a habitat that was familiar to the older adults. The participants saw the session at the university as an opportunity to have a one-day activity. By showing a flexible approach and interest in going to their location, we believe that the participatory process was less intimidating, and they felt more familiar (Brandsen, 2021). Furthermore, we can corroborate some associated challenges when aiming for this co-creation process, such as defining appropriate times and locations for the meetings (Amann & Sleigh, 2021). Despite being flexible about the location, we were also flexible with the dates of the meetings.

Before starting the game session, a presentation on fully automated vehicles took place. First, we introduced the CATAPULT project and then explained to them what an automated shuttle is and its general characteristics. As part of the key characteristics and hypothetical scenario, we mentioned that there is no driver, the vehicles have an interval of 10 minutes between each other, the maximum speed is 30 km/hr, and the capacity is of a maximum of 12 passengers. This information was obtained from meetings with mobility service providers in the Noordrand region. The presentation included a video of pilots that have taken place in Belgium. The video and the pictures helped the players better understand the new technology and how users would interact with it. The main information provided during the presentation is based on research and pilots conducted by the CATAPULT project. This included a collaborative activity on December 16th, 2021, where Brussels and Flemish mobility authorities and mobility providers shared with us how they would expect the autonomous shuttle service to run in the region of our study. After presenting this background information on the game's development, the next section will describe the game.

2.1 The game

We describe our serious game, "A shuttle for everyone", as an anticipatory needs game. This collaborative and storytelling game focuses on identifying the future needs of older adults under a scenario where autonomous shuttles are implemented. The identified needs will support the development of policy recommendations that aim at an inclusive mobility approach. The game is focused on the Noordrand region[5]. This is a complex and dynamic area with significant spatial challenges and is part of the study area of the CATAPULT project in Belgium. Transport companies have considered it a critical area where automated vehicles could be implemented in Belgium. Figure 1 shows the area on an image from OpenStreetMap in a 2D representation.
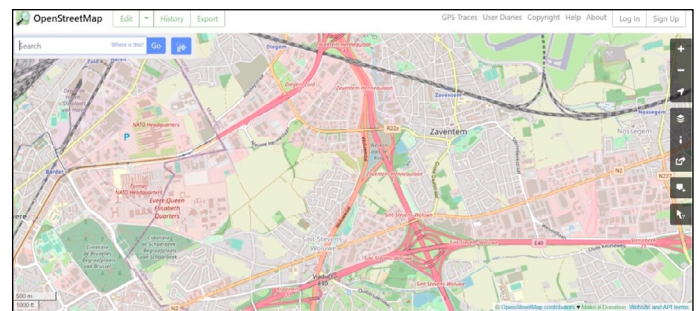

Figure 1. Image of the area zoomed in from OpenStreetMap

The game can be played in different spatial contexts (city or district maps). This means that the layout of the game can be changed depending on the area where it is going to be played.

The general materials that the game includes are:
– A printing of the area in oversize A0 (1245 mm x 900 mm).
– Printings of bus stop signs, shuttles, and bus stops
– Feeling cards: ☺ Happy, ☹ Concerned, 😨 Stressed, ☹ Sad, 😠 Angry and ☼ Solution
– Destination cards:
  – Zaventem Airport, Hospital, Haren station, Diegem station and Anne Frankbos Park
– Images of the shuttle from pilots by CATAPULT partners
– Shuttle printed in 3D
– Bus stop printed in 3D
– Consent form of participation, Social and Societal Ethics Committee, KU Leuven.

Instructions for first session Woon– en zorgcentrum (WZC) Sint-Antonius

Round 1
– The map of the area is presented to the players. Since the players are familiar with the area, first, they are asked if they agree and find the route of the autonomous vehicle that we traced for the game useful or if they have a suggestion.
– Each player receives a pawn representing him/herself travelling with the shuttle.
– Every player randomly selects a card with a destination.
– The player must imagine and narrate in first person the "perfect trip". This means that the autonomous bus is not too crowded, drives smoothly and arrives at each bus stop at the scheduled time.
– Under this scenario, the player thinks about their experience and needs when waiting and coming inside the vehicle, during the trip and getting off the vehicle. The facilitator adds an example to clarify how the narrative is expected: "I feel happy when the shuttle arrives on time, but when I get inside the shuttle, I feel anxious that the shuttle will depart too abruptly, risking that I might fall when I am not yet seated".
– Each player narrates their experience, and the facilitator fills the feeling cards based on the player's story. The feeling cards were used to describe the players' sentiments during the different stages of the trip.

5 https://www.topnoordrand.be/

Round 2
- Each player randomly picks a challenge card. This is the challenge they will encounter when returning to their trip's starting point.
- Each player must explain what new challenges and needs can be found in this situation, and the rest can participate by adding to the story. The facilitator may give an example: "When the shuttle stops due to a technical issue, I might become frustrated or angry if I do not receive any information about what the problem is and how long it will take to solve it."
- The facilitator takes notes and matches the challenges with the feeling cards.

Round 3
- The players will be asked what can help them sort out the challenges and needs identified during the two trips (with and without challenges).
- The solutions are written on the solution card by the facilitator.

Instructions second session Woon– en zorgcentrum (WZC) Sint-Antonius and session with OKRA
Due to the complexity perceived during the first game session, we reduced the rounds from three to two. We realised that the players found it difficult to return to the problems described in the first round. In the new instructions, the players first focused on the perfect trip to their randomly picked destination, identifying the challenges and their needs. Then, they immediately discussed the solutions. Meanwhile, in the second round, the players focused on the trip back and identifying their needs and solutions to the challenges in the card they randomly picked.

3. RESULTS OF THE GAME SESSIONS

The game session results are divided per residential care homes, WZC (Woon– en zorgcentrum) Sint-Antonius and OKRA (Open, Kristelijk, Respectvol en Actief).

3.1 The game
The elderly group was between 68 and 94 years old. During the game session, the caretaker was present too. There were a few cases in which the caretaker also commented from her point of view based on her experience with the older adults. While the explanation of the objectives of the CATAPULT project was not really of interest to the target group, the topic of automated vehicles was of their interest. The images and video included in the presentation gained the attention of the group. Before starting the game session, the participants explored the map and the route. They agreed with the route, and we started the game session once it was clear to them. Yet, regarding the route of the autonomous shuttle, they mentioned the following:

One person commented that it would be nice if the route of the autonomous vehicle had a direct connection from Sterrebeek to Zaventem, to go to the market. Today, there is only a school bus that directly connects, but they are not allowed to take this school bus. Other persons would not go as far as Diegem or Haren. They would prefer to move between their home and the day-care centre or to the park Mariadal. The results of session 1 are presented in Table 1 and 2, which contains two columns. The first column contains the identified challenge or needs of the older adults, and the second column contains the solution that they consider more appropriate.

In the second game session, there were three participants and the caretaker. Tables 3 and 4 present the results.

Challenges	Solution
The players were concerned about walking alone to the bus stop (what if something happens on the way: risk of falling).	Someone from the family or caretaker should accompany them to the stop.
In some cases, physically not capable of going to the bus stop (even with a walking aid).	Someone of the family or caretaker should drive them by car to the bus stop.
Mental health not sufficient to find the way to the bus stop or even to take the bus trip on their own.	Guidance throughout the whole trip.
Not knowing when they reach the right bus stop.	A voice-over that announces the name of the stops or a screen that also displays the name of the stop.
No help if needed.	An emergency button, but this button should be very clear that it's an emergency button (e.g., red colour, easy to access when seated).
Difficult to contact the central operator.	The communication channel should be clear to use (e.g., buttons, screen interface, etc.).
Falling inside the autonomous bus.	Sufficient poles or handles.
If there is no place to sit.	To take the next bus.
Doors/ramp that do not open automatically.	A button to manually open the door/ramp.
Not having sufficient time to step on the bus, find a seat, store the waking aid, out on the seat belt / to get out of the bus.	Program the shuttle in such a way that doors may stay open for longer or shuttle stands still for longer when needed.

Table 1. Results of game session 1, round 1 in (WZC) Sint-Antonius.

Specific challenging situations	Solutions
The autonomous vehicle stops too much because of the high number of cyclists/pedestrians on the road.	A bell/ringtone to scare away the cyclists/pedestrians or to warn them not to come too close to the bus.
Bus too crowded.	Take the next bus, most of the older adults do not mind waiting a bit longer. There is not much problem about waiting.
Wrongly parked car.	They are willing to wait. There is no problem about waiting.

Table 2. Results of the game session 1, round 2 in (WZC) Sint-Antonius.

Challenges/Needs	Solution
Challenging if they do not find a place to sit that is close to the door, and if there is room to place the walking aid.	If there is no place: they prefer to wait and to take the next bus.
Physically unable to walk the distance from the centre to the bus stop.	Family or caretakers can drop them off by car.
Concerned that the door/ramp will not work.	Manual operation of the door/ramp.
Concerned to fall or to have difficulties getting on or off the bus.	Good support, poles or handles.
Concerned to not know where to get off.	Voiceover or screen that shows where to get off.

Table 3. Results of game session 2, round 1 in (WZC) Sint-Antonius.

Specific challenging situations	Solutions
If the shuttle is crowded.	Take the next bus, no problem, they have time to wait.
If there are technical issues with the shuttle.	They will call the central operator. They can call and explain the problem.
If there is a wrongly parked car that is affecting the route of the shuttle.	They can wait. No problem they have time to wait

Table 4. Results of the game session 3, round 2 in (WZC) Sint-Antonius.

3.2 Game session with OKRA

The players from OKRA were more mentally fit than the players from WZC Sint-Antonius to play the game. This led to a livelier discussion among them. The age range was between 60 and 85 years old. They were a total of four players. After the presentation, the discussion on the route of the autonomous shuttle took place, and the players who live in Zaventem and know the region very well made some suggestions. They mentioned where they would like to take the shuttle. Table 3 presents the results of the third game session.

Challenges/Needs	Solution
Challenging to step inside an autonomous shuttle.	Be informed. It can be via internet by providing information on the website. Also, newspapers or community information that comes via the post office (for those who are not familiar with websites). Likewise using panels at the bus stops.
If they become unwell during the trip.	Communication with the operator should be easy to use. An emergency button is important.
Concerned to fall or to have difficulties getting on or off the bus.	Good support, poles or handles.
Concerned about not knowing where you are in the trip or where to get off.	Follow the route of the vehicle on a map in the app. Maps should also be available on paper (either you can get them at bus stops or being distributed by post) Note: this was a heated discussion between one older adult who is able to use a smartphone and favours an app – and the others who did not like the idea of being dependent on the smartphone. They concluded that both digital and analogue solutions need to be available to include everyone. Another option is to be able to see the route of the vehicle on a screen. The screen should also include a map, not only the names of the bus stops.
Delays.	Communication via app (for those who have smartphones). Also, clear communication at the bus stops (via screens).
If they cannot hear well what is said in the voice-over (e.g., announcement of bus stops).	Additional screens to clearly see what's the next stop.
A high reliance on smartphones, for the route, for the tickets etc. The smartphone's battery can die.	Charging stations inside the bus, prepared in case that you also forgot the charger. So, the system could include specialised batteries and charging platform.
Unclear communication with the remote operator.	The panel inside the bus to communicate with the operator should be easy to use. Also, communication inside the app would be useful.
If it is winter and it is snowing/raining/freezing, and the platform is slippery when they get off the bus.	Have a rough surface. Install a floor that heats up to clear out the area where you get on and off the shuttle.
Falling inside the bus in case all seats are taken.	Provide sufficient handles.
To have to pee during the trip (as the shuttle drives slowly and it might take some time to get to your destination).	Public toilets at several bus stops. With a map to see where they are located. You can get off the shuttle to go to the toilet and then take the next shuttle.
During summer could get too hot inside the shuttle (see all the glass windows and the small size of the shuttle).	Automatic climatizing system or system operated by the central operator.

Table 5. Results of game session 1, round 1 in OKRA

Specific challenging situations	Solutions
If there are construction works.	There is a need for clear communication, to know what the problem is, how long it would take to solve it or what they can do to arrive home safely. Operator needs to reprogram the route, because taking the next shuttle is not a solution as it will be stuck at the same place, so best option is to remain seated and wait for the issue to be solved.
If the shuttle is too crowded	Wait for the next vehicle. However, there are concerns that they will not be on time for an appointment if that was the case. So, consider adding more vehicles at rush hours (every 5 minutes interval, instead of 10). Also, consider using larger buses at rush hours.
If there is a wrongly parked car that is affecting the route of the shuttle.	Use claxon. Also, the vehicle could have cameras on the front side to take photos of the car and send it later to the police.
If the shuttle has technical issue and stops.	Call operator, get off the vehicle and take the next one.

Table 6. Results of the game session 1, round 2 in OKRA.

4. CONCLUSION AND DISCUSSION OF RESULTS

This last section is divided into two subsections. The first discusses our conclusions on the game approach as a co-creation tool, while the second focuses on the results obtained regarding the needs of older adults.

4.1 Conclusion and discussion on the co-creation game approach

Based on our research experience, our results align with previous studies that consider that the inclusion of gamification elements helps to increase interest, making participation an entraining experience (Brandsen, 2021). We could perceive, in general, that the older adults were engaged and participated actively. Our co-creation process allowed the participation of a small group of persons and focused on individuals who are not commonly included in participatory processes due to the complexity of their participation. In this regard, we agree with previous research that states that while co-creation is unlikely to work with everyone, it has proven to work with various vulnerable groups, including welfare recipients and mental health patients (Brandsen, 2021). Indeed co-creation nature has been acknowledged to address policy areas sensitive to social changes (Jukić et al., 2019). In this regard, we also agree that it is important to continue developing strategies that support the involvement of vulnerable groups (Jacobi et al., 2022). In participatory processes, highly educated citizens commonly tend to be overrepresented (Brandsen, 2021).

Similarly, our research demonstrates the value of collaborative storytelling as a flexible method that facilitates discussion of futures involving new technologies (Belton & Dillon, 2021). The relevant results also confirm that co-creation processes facilitate the integration of experiential knowledge and it does not require specialist scientific knowledge (Brandsen, 2021; Regeer & Bunders, 2009).

We can also confirm that our game as a co-creation method has facilitated the anticipatory needs' identification. Understanding these factors can contribute to improving the design and the development of policy recommendations that can support a more inclusive implementation of autonomous vehicles. Non-expert input into policy decision-making is becoming increasingly important in the policy context; furthermore, previous research identifies storytelling games as a facilitator in futures research to assess emergent technologies with non-experts in an accessible manner (Belton & Dillon, 2021).

Regarding the game's dynamic, we would like to highlight that during the first round, the Feeling Cards were not used as we expected. The older adults were not speaking in terms of "I am angry when..." but rather explaining "I cannot step onto the bus myself". This resulted in the ones who are healthier and more fit just saying, "yes, I can do that, no problem, I would easily take the bus". Yet, we wrote on the feeling card which, from our point of view, could better match their feeling. We felt this way of processing the information triggered them to think about solutions.

We also realised that it was difficult to go back to the feelings and challenges of the first person after the first round. It was necessary to read again the cards, and many "solutions" were already discussed more naturally. Therefore, in the following two game sessions, we adapted the game to two rounds. This approach worked better. The advantage of conducting the game session with older adults is that they are patient. This allowed everyone to be focused on one player at a time.

4.2 Conclusion and discussion on the users' needs

While previous research identified that older adults prefer automated public transportation over private ones (Zandieh & Acheampong, 2021), our findings are aligned with the concerns identified via pilots with automated vehicles in Brussels Capital Region (Feys et al., 2020) and surveys. Among the concerns are that the vehicles might not be faster, more efficient or easier to use (Feys et al., 2020). However, in terms of the route, an interesting finding was that some of the older adults found the implementation of autonomous shuttles useful if they covered new routes to which they do not currently have access, so they could be complementary to regular buses. This confirms and complements previous research that has recognised autonomous vehicles as a first or last-mile connection for the public transport service (Feys et al., 2020; Piao et al., 2016a), instead of a circuit route, suggested by some mobility service suppliers.

Our research also confirms previous studies that identified that comfort, safety, ease of use, and accessibility are key factors that positively affect the use and acceptability of automated vehicles (Feys et al., 2020; Kyriakidis et al., 2015). Despite the trust in the technology, the company or help from a trusted person when older adults use the autonomous vehicle is also important. Moreover, we found that independently of the presence of some older adults are incapable of making a trip alone; they need guidance at every step. Safety before, during and after the trip is important. Several elements such as a safe ramp that guarantees safe access to the vehicle, communication with the operator (incl. via app), guidance during the trip and announcements in different formats, were confirmed as safety components via our co-creation process (Pigeon et al., 2021).

Moreover, we confirmed that communicating automated vehicles with other road users is also important (Chaloupka & Risser, 2020). Stop buttons, emergency buttons, sufficient

poles and handles that facilitate the move inside the vehicle and cameras that take pictures of vehicles that disrupt the trip and are sent to the police are also seen as elements related to safety. Regarding the latter, we can confirm that despite surveillance concerns around cameras (Acheampong et al., 2018), older adults consider them important.

Ease of use can be related to the existence of digital and analogue channels of communication that can help the potential user with the journey. In this vein, we confirmed that information on the multi-modal route and bus stop should be available in the smartphone apps (Piatkowski, 2021; Pigeon et al., 2021) as well as in traditional channels. In case of an emergency, easy contact with the operator is important. Also, a screen that includes a map with the stops and the surroundings was mentioned.

Among the elements that support accessibility are poles and handles, seats, information on the route and space for walk aid. Entering and leaving the vehicle should be accessible. This includes providing enough time to do it, as older adults might move slower than other users. Therefore, it is important to consider the compatibility between automated vehicles and current mobility infrastructure for accessibility aids and usefulness (Feys et al., 2020; Hwang et al., 2021). In this respect, older adults who participated in the serious game perceived the use of existing infrastructure as natural. Yet, there were concerns about the non-existence of infrastructure, which we relate to comfort aspects, such as public toilets.

Finally, elements of comfort, which are an acceptability factor of automated vehicles (Chen, 2019; Eden et al., 2017) were identified. Some of them are the availability of seats, aircon, availability of toilets and charging stations for the phones. The game sessions showed that passengers enjoy the smooth rides (Feeley et al., 2020; Feys et al., 2020; Portouli et al., 2017). Through the serious game sessions, we confirmed that older adults were fine with the vehicle driving slow (Chen, 2019) and that air-conditioning (Pigeon et al., 2021) was seen as important. Table 4 below summarises and classifies our findings:

Concerns about potential emergencies on the road, technical failures and the interaction of the shuttle with regular traffic situations (Feys et al., 2020) were part of the discussions. The older adults agreed that clear communication with the passenger about the situation and the existence of alternatives, including a short waiting time (ten minutes), could easily help to overcome the situation. In this regard, for example, in the two groups from WZC Sint-Antonius, most of the older adults mentioned they had enough time, and a slow bus or unexpected delay was not an issue for them if they could get to their destination before night.

Previous research suggests positive attitudes toward automated vehicles (Azad et al., 2019; Chen, 2019; Guo et al., 2020; Herrenkind et al., 2019) from potential users and different stakeholders are positive about implementing autonomous vehicles in different urban contexts (Feys et al., 2020). However, our findings from the three groups aligned with the studies where older adults have expressed concerns about the technology, the main one being the lack of a driver and their low interest in the implementation of autonomous vehicles (Piao et al., 2016b; Zandieh & Acheampong, 2021). This confirms the results of previous research on autonomous vehicles (Zandieh & Acheampong, 2021) and autonomous flights (Belton & Dillon, 2021). The lack of a driver not only affects older adults in terms of social interactions (Zandieh & Acheampong, 2021), but it also plays a key role if the user is facing a problem in the vehicle.

Older adults mentioned that they would start using the automated shuttle only if they were sure that it was safe to use or if a person they trust travelled with them. The relevance of safety has been identified by previous studies (Zandieh & Acheampong, 2021) and was the aspect that received the main attention from older adults. Moreover, some older adults mentioned they might be unable to use the automated shuttle due to physical or mental impairments. In this regard, we found that for older adults, trust in the vehicle is increased if they have the support of someone they know. While information campaigns about automated vehicles' can decrease safety concerns (Chikaraishi et al., 2020; Chng et al., 2021; Golbabaei et al., 2020; Hussain et al., 2021; Roche-Cerasi, 2019), we found that such a campaign can also help to inform potential users about how the automated vehicle works to increase familiarity. In this regard, the older adults emphasised the importance of available information about this new service.

Various issues mentioned in the four categories (safety, ease of use, accessibility and comfort) are not only an is-

Safety	Ease of use	Accessibility	Comfort
Emergency button.	Easy contact with the operator.	Reachable poles and handles.	Enough seats.
Sufficient poles and handles.	Emergency button easy to use.	Accessible seats.	Aircon.
Secure access to the vehicle with a rough surface or a heating up area that melts snow.	Easy access to information of the route via analogue and digital channels.	Sufficient time to access and leave the vehicle.	Public toilets in some stops. Include in the map of the app the stops that have toilets.
Announcements in different formats to know the location, including screens and voiceover.	The screen should include the map with streets and not only the stops.	Accessibility to information service.	Charging stations for phones inside the vehicle.
Ramp and door that can also be controlled manually.		App with information of the route.	
Sounds and warnings when bikes or cars are getting close to the vehicle.		Space for walk aid.	
Communication with operator (via the app)			
Guidance during the trip.			
External cameras to take pics of vehicles disrupting the route and send them to the police.			

Table 7. Summary and classification of the older adults' anticipatory needs

sue for automated vehicles. Previous research has identified that older adults face some of those issues with public transportation nowadays. For example, in terms of safety, studies previously conducted identified the importance of guarantying a safe trip and avoiding criminality/accidents or falls (Broome et al., 2010; Shrestha et al., 2017). Regarding accessibility and ease of use factors, including the availability of information and information about the scheduling and routes, have also been pointed out (Lamanna et al., 2020; Shrestha et al., 2017) by older adults. Finally, in terms of comfort, public toilets availability has been discussed as an important issue in the public transport literature (Greed, 2004; Shrestha et al., 2017).

Acknowledging the relevance of many of the challenges mentioned above and their nature beyond automated vehicles, the Belgian partners of CATAPULT are engaging with the JUSTICE[6] and SmartHubs[7] projects to exchange experiences and results. The two projects aim to improve accessibility and inclusiveness in public transportation in Brussels region employing co-creation approaches. We hope that this exchange of experiences and results can support a more inclusive development of public transportation in Brussels.

Based on our results, experience, and conclusions, we invite scholars to continue conducting research with other vulnerable groups, such as children or persons with impairments in different contexts. The findings could help us to build a body of literature on inclusiveness in autonomous mobility. This information is key for governments and companies, too, as the future of autonomous mobility is highly dependent on the users' acceptance, and this can be achieved by properly addressing their needs.

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