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Implications for inclusive designs

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Older passengers' expectations about highly automated driving: Implications for inclusive designs

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Abstract

Understanding older adults' overall expectations about automated vehicles (AVs) is crucial for inclusive designs. The work-in-progress presents an exploratory study based on semi-structured interviews with 27 older adults in the Netherlands. A thematic analysis revealed an open-minded attitude towards AVs, optimism for improved safety, and pragmatic concerns about reliability. Participants expected AVs to be "well-behaved", delivering safe, predictable, and socially considerate driving styles. Participants also showed a desire for AVs to be communicative, providing feedback to reduce uncertainties. The findings provide implications for inclusive AV designs.

CCS Concepts

• **Human-centered computing** → **HCI design and evaluation methods**; **HCI theory, concepts and models**.

Keywords

Older adults, Expectation, Automated Vehicles

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1 Introduction

The real-world deployment of automated vehicles by companies like Waymo makes it crucial to understand potential users' overall expectations about automated driving. Technological expectations, defined as beliefs in future technological situations and capabilities, are a key determinant of adoption [5]. While low expectations can hinder uptake, unrealistically high expectations can lead to disappointment and subsequent resistance. Therefore, understanding public expectations can help predict adoption [16, 25] and inform the development of user-centred designs for enhanced user experiences [11, 19].

Including older adults in this loop is a matter of social equity [7]. AVs are expected to significantly benefit this demographic group by enhancing mobility and independence, particularly for those who can no longer drive due to physical or cognitive impairments [9]. By providing access to social activities, shopping, and medical services, AVs can improve individual well-being and strengthen this demographic's connection with their community, and society as a whole [2, 23]. Understanding older users' expectations at an

early stage is therefore vital for creating accessible and inclusive AV design.

Much of the previous research on older users' views of AVs used quantitative approaches [3]. For example, [25] surveyed drivers and found that factors like age and driving experience influenced their expectations about automated driving. Younger drivers, in particular, reported higher expectations for effectiveness and safety. While quantitative approaches offer certain advantages, they often fail to provide a deeper understanding of the contextual experiences of users. [4] conducted interviews with older adults about their needs, experiences, expectations, and concerns when they interacted with shared AVs in a Swedish village. This study provided a range of recommendations, such as physical accessibility, comfortable internal layouts, and suitable routes for the shared vehicles. [15] interviewed older drivers after they experienced a highly automated vehicle using a driving simulator, uncovering their needs for human-machine interactions. These needs included a desire to retain control over the AV, a willingness to engage in non-driving-related activities (NDRAs), and the need for guidance and support from the information system. While providing driving trials using prototype AVs or simulators could help participants reflect on their needs, the results might be limited to the vehicle layout and trial context. Moreover, the above study primarily focused on experienced drivers and overlooked the perspectives of non-drivers who are also potential users of AVs.

We present an exploratory study that used semi-structured interviews to investigate a group of Dutch older adults' expectations about AVs. This study contributes to a more in-depth understanding of older adults' expectations and enriches the existing literature by offering a new perspective from a specific national context.

2 Method

2.1 Participants

Participants were recruited from the Delft research panel via an advertisement. Prospective participants registered for a time slot using Calendly, which provided information about the study's aim, location, and expected duration. All participants were required to be proficient in English; a driving license was not required. After registration, a confirmation email with detailed location and time information was sent.

Twenty-seven older adults (all over 60 years, 10 female, 17 male) with a mean age of 69.4 years (SD = 6.20) participated in the study. The sample included a mix of driving experiences: while most owned a car, five participants did not, and four of these five identified as non-drivers. Twenty-five of these participants reported having trade/technical/vocational training or university degrees. The study received ethical approval from the Human Research Ethics Committee of Delft University of Technology.

2.2 Procedure

Semi-structured interviews were conducted in June and July 2023. Upon arrival, the interviewer explained the study procedure, provided an information sheet, and obtained signed informed consent.

It is worth mentioning that this manuscript focuses exclusively on the pre-ride interview data from the older adult group of a larger study [20]. While the full study included a pre-ride interview, an automated vehicle ride, and a post-ride interview with a broader age range of participants, our analysis here focuses on participants' expectations regarding high-level automation before their automated ride experience. In this pre-ride interview, we asked participants about their comfortable and uncomfortable experiences as passengers in current transport modes (e.g., taxi, bus or train), and then about their expectations regarding automated driving. Specifically, for this work-in-progress, we analysed responses to the question: "Before you came to this study, what were your expectations about self-driving cars?" The interviewer used follow-up questions to encourage detailed responses and facilitate the conversation, for example, "Any specific expectations?", and "How would you expect it to drive?" At the end of the entire study, participants completed a demographic questionnaire. All interviews were audio-recorded using the Voice Memos application on an iPhone.

2.3 Data analysis

The audio recordings were transcribed verbatim. An initial transcription was generated using the automated transcription software, Happy Scribe (https://www.happyscribe.com), and then checked for accuracy against the original audio recording by the lead author.

We performed an inductive thematic analysis to identify patterns within the data [6]. This bottom-up approach allowed themes to emerge directly from the interviews. The analysis followed the six standard steps: (1) data familiarisation, (2) generating initial codes, (3) searching for potential themes, (4) reviewing themes, (5) defining and naming themes, and (6) producing the report.

The lead author acted as the primary coder, a practice supported by some qualitative research [22]. To enhance the analysis rigour, AI tools (Google Gemini and the MAXQDA AI Assistant) were used as a reflective partner, a novel approach that has been explored in some studies [18]. For example, the tools helped re-assess code phrasing and categorisations of codes, with the lead author making all final decisions. The categorisation was further refined in the internal revision process with coauthors' feedback. The coding and thematic categorisation were managed using MAXQDA software (https://www.maxqda.com).

3 Results and Discussion

The thematic analysis yielded 140 codes, which were categorised into four overarching themes and 10 sub-themes, as detailed in Table 1. The four themes are 1) current stances and future outlook, 2) expected benefits, 3) Trust and reliability, and 4) role of the human and interaction with AVs. This section presents each theme and its constituent sub-themes, supported by illustrative participants' quotes.

3.1 Theme 1: Current stances and future outlook

This theme characterises participants' initial attitudes toward AVs, revealing a mixture of open-minded curiosity for AVs and pragmatic scepticism regarding the timeline for adoption.

Table 1: Themes, sub-themes, and example quotes. Sub-themes are categories of codes. Numbers in parentheses represent the number of participants mentioning each category/theme presented.

Theme	Sub-theme	Example quotes
Current stances and future outlook (22)	Curiosity and initial stance (19)	"I'm very curious how it feels being in a self-driving car." (P32)
	Pragmatic timelines for adoption (9)	"But what I read in the papers, it's not going like that at the moment." (P17) "I don't think it's really serious that self-driving cars will be publicly available within 5 or 10 years." (P36)
Expected benefits (20)	Comfortable driving style (15)	"Not a fast acceleration, also not a fast deceleration. Anticipating on what's going on so you don't have to decelerate very fast." (P12) "It should be at least driving the same as I do. Maybe better, right?" (P17)
	Improved safety (11)	"If everybody was driving automated, then the unexpected actions would be much fewer than probably in traffic nowadays." (P23) "Because they're programmed to adjust to the road and the people around it, so there won't be any accidents. They have sensors around, I suppose." (P26)
	Benefits for occupant experience (7)	"It will be comfortable in a way that you can do something else." (P29) "I would rather be able to do something else, like having a nap or do some work or listen to music or whatever." (P33)
	Improved mobility (3)	"I'm getting older, so my sight is getting worse and things like that. I guess a self-driving car does that correctly all the time. That's my expectation." (P17) "I hardly drove a car … Now I do everything on the bicycle … But I'm hoping before I get too old to ride a bicycle, the self-driving cars will take over, so I don't need to practice myself." (P36)
Trust and reliability (11)	Reliability concerns (7)	"With a lot of traffic in the Dutch cities, I don't think so. It's too busy." (P13) "What will happen if the GPS falls down, if the system goes down?" (P40)
	Trust and control (6)	"When you have done it and you know what is possible, well, I trust it." (P18) "I don't feel safe if the car can take over." (P30)
Role of the human and interaction with AVs (10)	User role, preferences, current habits (8)	"I dislike modern functions in driving: lane assist, braking assist. I don't like it at all." (P30) "I was wondering about if they would have to be any technical knowledge, you know, to get to get the car going…"(P8)
	System interaction and feedback (2)	"I like to have some kind of feedback that I'm put at ease because I see, oh, I've seen this or that happening." (P34) "What I also expect is that you give the driver the feedback of what's going to happen." (P12)

3.1.1 Sub-theme 1.1: Curiosity and initial stance. A prominent initial stance among participants was curiosity rather than preconceived expectations. Several expressed a general desire to experience automated driving and how it would interact with other traffic. While no particular expectations were mentioned, a participant stated having generally high expectations. Overall, this sub-theme indicates a neutral-to-positive stance towards automated driving. While this might suggest a generally open-minded attitude among older adults, aligning with [1]'s findings on older adults' willingness to use vehicle automation, it is also possible that our sample did not include less technology-savvy individuals. This potential bias might stem from the fact that most of our participants had higher education and resided in a developed area.

3.1.2 Sub-theme 1.2: Pragmatic timelines for adoption. While participants were generally supportive of technological innovation, their optimism was grounded in realism. A view was that widespread, public availability of fully automated vehicles was still a distant prospect. This sub-theme indicates that while older adults are open to the ideas of AVs, their expectations for short-term implementation are low. The low expectation for the adoption timeline may reflect the current status of automated driving in Europe, a factor that could be compared with other regions in future studies.

3.2 Theme 2: Expected benefits

This theme characterises participants' expected benefits from automated driving, including improved comfort in driving, improved safety, benefits for passenger experience, and enhanced mobility.

3.2.1 Sub-theme 2.1: Comfortable driving styles. This sub-theme details how participants defined a good automated "driver". The good AV was expected to exhibit a smooth, cautious, "well-behaved", and considerate driving style. This included maintaining a consistent speed, avoiding sudden braking or acceleration, and keeping an appropriate distance from other vehicles. Interestingly, one participant imagined that AVs might enable closer distances with regard to other vehicles because they could "respond faster". Overall, this sub-theme suggests a desire for safe, comfortable, predictable, and pro-social AV behaviour, which aligns with previous studies investigating user comfort and acceptance of automated driving styles [12, 19, 21].

3.2.2 Sub-theme 2.2: Improved safety. Participants expected AVs to have better capabilities than humans, which would lead to increased road safety. For example, AVs were envisioned to be equipped with multiple sensors, comprehensively monitoring their surroundings, and having constant alertness. Consistent and correct performance

was also expected. The belief in improved safety was related to the idea that removing dangerous human behaviour would result in fewer accidents. The expectation for improved safety aligns with the prior findings that safety and reliability are top concerns for older adults [17]. It indicates that helping older adults understand the safety mechanisms is important, as these concerns affect individuals' intentions to use AVs [1].

3.2.3 Sub-theme 2.3: Benefits for occupant experience. Participants anticipated a relaxing and "worry-free" trip with automated driving. They looked forward to feeling calm and having more freedom and time to engage in non-driving-related activities, such as looking around, napping, or working. This desire for relaxing experiences and engagement in NDRAs supports the argument by [3] to view ageing as a natural transition, not an impairment. By focusing on enjoying the journey itself, these participants saw the AV less as a tool to compensate for lost mobility and more as an opportunity to enhance their daily lives.

3.2.4 Sub-theme 2.4: Improved mobility. One significant perceived benefit was the potential for AVs to support mobility and independence as participants age. Participants envisioned that future AVs could play a role in compensating for the mobility restrictions due to age-related declines. This sub-theme highlights that for older adults, the value of AVs is connected to the aspiration for preserving personal mobility and autonomy after ageing.

3.3 Theme 3: Trust and reliability

This theme characterises concerns about system reliability, trust, and considerations in complex real-world scenarios.

3.3.1 Sub-theme 3.1: Reliability concerns. Despite the optimism about safety, participants raised numerous concerns about the system's reliability. They worried about technological failures, such as GPS breakdowns, and cited media reports of accidents involving Tesla vehicles. The busy and complex Dutch cities were seen as a particularly challenging environment.

3.3.2 Sub-theme 3.2: Trust and control. Trust in the AV was seen as something to be obtained through actual and successful experiences. This lack of initial trust might be linked to the expectation of retaining some form of control. The desire to take over from AVs is related to a need for maintaining safety. In contrast, a participant believed humans possess a better ability to anticipate the unpredictable actions of others, such as cyclists, based on subtle cues.

This theme reiterates the importance of assuring older adults about AV safety and reliability, as these are primary concerns. Similarly, [8] suggested that effectively communicating AV safety and reliability to older users could enhance their trust and acceptance.

When combined with sub-theme 2.2 (improved safety), this theme reveals a contrast in attitudes: participants expressed both optimism about the potential for "superhuman safety" and a pragmatic scepticism regarding reliability. While our focus is on highly automated driving, this finding adds depth to previous work, such as [13], who identified older drivers' preference for SAE Level 2 vehicles and a desire for control. Our theme potentially explains this dynamic: scepticism about reliability likely contributes to the desire for control, while optimism about safety might explain the general willingness to use driver-assist features.

3.4 Theme 4: Role of the human and interaction with AVs

This theme summarises participants' envisioned role in AVs, preferences for driving, their current habits, and expectations about interaction with the AV system.

3.4.1 Sub-theme 4.1: User role, preferences, current habits. Participants showed mixed feelings about relinquishing the driver's role. While some mentioned a good experience with advanced driving assistance systems (ADAS), such as cruise control, some other participants indicated a preference for driving because, for example, "automation is boring (P20)". Moreover, the issue of liability was considered, as one participant wondered: "I've read that it's technical, not a problem; but theoretical, for the law: When something happens, who's responsible? (P5)". This suggests the importance of both assurance of technical capability and a clear framework for legal responsibility for user adoption.

Notably, a non-driver participant raised a unique concern: whether technical knowledge would be required to operate the AV. This highlights barriers for individuals not accustomed to driving, suggesting the importance of including non-drivers for a deep and comprehensive understanding of potential users' needs. This also points to the need for personalised and customised designs, for example, using simple language for instructing non-driver AV users. Such designs align with general guidance for enhancing technology usability for older adults, like keeping interfaces simple and intuitive [14]. We emphasise the importance of considering non-drivers' perspectives, as they may not be familiar with existing vehicle controls and interfaces.

3.4.2 Sub-theme 4.2: System interaction and feedback. When moving from driver to passenger, the need for system feedback becomes critical. While it was noted that being a passenger on a shared bus does not require feedback, being alone in an AV would lead to the need for feedback from the AV. A range of methods for interaction and feedback from AVs were mentioned. Participants anticipated being able to easily adjust the AV's driving style and receive feedback about its upcoming actions, especially confirmations that the vehicle has "seen" potential hazards. This theme suggests a desire for the AV to be a communicative assistant that builds confidence and reduces uncertainty, rather than just a silent operator. This need for enhanced human-AV interaction aligns with the findings of [15], who observed that older drivers desired an in-vehicle system that would provide them with information, such as the AV's current status or actions. In addition, it suggests that future studies could compare these interaction needs across different AV services, such as private AVs, robotaxis, and shared shuttles.

4 Overall remarks

This exploratory study offers several key takeaways for the design and implementation of automated vehicles for older adults. First, participants' motivation extended beyond compensating for age-related decline; they aspired to retain mobility and enhance their travel experiences. This supports a design philosophy that

views older adults as active users seeking to improve their quality of life, rather than merely passive recipients of assistive technology [24]. Second, participants expressed both optimism regarding the safety benefits of AVs and concerns about their reliability. This aligns with previous work indicating that safety and reliability are top concerns for older adults considering AV adoption [3, 17]. Addressing such concerns necessitates carefully guiding and designing for user trust, which would be earned over time through consistent, reliable, and transparent operation. Third, while helping older adults understand AV safety is critical, their expectation for smooth, "well-behaved", and socially considerate driving styles indicates that ensuring passenger comfort through driving styles is also important. This aspect has been identified as a contributor to user acceptance [10, 19]. Lastly, the desire for clear system feedback suggests a crucial design requirement. To enhance acceptance and trust, AVs should be designed as communicative partners that clearly explain their intentions. This highlights the importance of a transparent and understandable system. Moreover, careful design of interaction strategies, ensuring ease of usage, is particularly crucial for non-driver AV users, who are not accustomed to driving.

Acknowledging the limitations of the present study would pave the way for future studies. First, our findings are based on interviews with Dutch residents only, primarily from the Delft area, and many of them were highly educated. Future studies could explore older adults' expectations in diverse cultural contexts, particularly in non-Western and developing countries, to build a more comprehensive global understanding of older adults' needs and expectations. Second, while we included non-drivers, their small number in our sample limits the deep understanding of this group. Future studies could aim to recruit a larger number of non-drivers for a more balanced sample.

The next step is to move from understanding expectations to actual designs. Building upon the findings of this study, future co-design and participatory research initiatives could facilitate more active involvement of older users, potentially enhancing the acceptance and adoption of forthcoming vehicle technologies.

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