Putting Older Adults in the Driver Seat: Using User Enactment to Explore the Design of a Shared Autonomous Vehicle

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ABSTRACT

Self-driving vehicles have been described as one of the most significant advances in personal mobility of the past century. By minimizing the role of arguably error-prone human drivers, self-driving vehicles are heralded for improving traffic safety. Primarily driven by the technology's potential impact, there is a rapidly evolving body of literature focused on consumer preferences. Missing, we argue, are studies that explore the needs and design preferences of older adults (60+). This is a significant knowledge gap, given the disproportionate impact that self-driving vehicles may have concerning personal mobility for older adults who are unable or unwilling to drive. Within this paper, we explore the design and interaction preferences of older adults through a series of enactment-based design sessions. This work contributes insights into the needs of older adults, which may prove critical if equal access to emerging self-driving technologies are to be realized.

CCS CONCEPTS

• Human-centered computing → Scenario-based design; **• Social and professional topics → Seniors**; **• Applied computing → Transportation**.

KEYWORDS

Shared Autonomous Vehicles, User Enactment, Older Adults

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1 INTRODUCTION

As automated vehicle technology continues to advance, discussions about its implications for personal mobility increase. Companies such as Ford, GM, Tesla, and Volvo are working intensely on developing self-driving vehicles for use on highways starting in 2020 [51]. Google is testing its latest self-driving vehicle service, Waymo, offering shared transportation as a service (TaaS) with no driver behind the wheel [26]. Waymo serves as an example of the push towards shared autonomous vehicles (SAVs). The concept of SAVs combines ridesharing services with autonomous vehicles (AVs) [39]. Ridesharing is a more flexible, low-cost option that provides greater access to mobility for a variety of populations such as low-income households [2], older adults, and people with disabilities [7, 17, 37]. Incorporating AV technology into ridesharing vehicles may provide benefits in terms of convenience, accessibility, and safety to consumers. In particular, older adults (60+) could benefit from SAVs perhaps more so than other populations, as driving cessation is common as people age due to related declines in physical or cognitive abilities [32].

As is the case with autonomous passenger vehicles, it is essential to consider the design of SAVs to be accessible for all members of society. However, as previous work has revealed [13, 32], there is the perception that the needs of older adults are not being adequately considered in the design of autonomous vehicle technologies. This may hold for shared autonomous vehicles as well. While prior research exists for SAVs, none of this prior work focuses on design considerations for vulnerable populations.

In this paper, we present a case study using user enactment (UE) to observe the design choices for developing an SAV by older adults. We illustrate the evolution of the SAV design through each enactment session, including behaviors acted out during a scenario where participants engaged in a ridesharing experience in an imaginary SAV. Finally, we present findings from post-session focus groups on participants' reasoning for their design choices and what additional considerations should be made for SAVs. The work described in this paper is part of a larger study from which two manuscripts to date have been produced [25, 33].

2 RELATED WORKS

2.1 Accessibility in Public Transportation

Prior research has examined the accessibility of public transit for people with disabilities and older adults and technology solutions to address them. Azenkot [4, 5] studied how OneBusAway arrival times could be accessed by travelers who are blind and using Braille notetakers [22]. The ABLE Transit system and Stopinfo were implemented to provide accessible data about bus stops and arrival times and bus-stop locations [15, 29]. Hara et al. [28] studied the use of crowdsourcing to obtain and add the locations of bus stops and landmark descriptions to Google Street View for visually impaired bus riders. Studies conducted by Flores and Manduchi [23] and Kaushik et al. [38] looked at using connected information sharing for riders to data on finding the right bus to get to their destination. TaxSeeMe, a taxi-assistance smartphone app, aids persons who are visually impaired with navigating to a taxi scheduled through the app [35].

Prior work has looked at older adults and their perception of public transit regarding the frequency of use and factors that affect their use. In all associated studies, proximity to the nearest transit stop from the trip's origin is the most significant determinant in the use of public transit [30, 31, 46]. Other factors include safety within public transportation, the availability of seating and personal mobility, or a lack thereof [30]. In terms of public transit proximity, the biggest challenge lies in the rider's ability to walk to the transit stop. Older adults with limited mobility will have a challenging time navigating to their intended destination. Also, street conditions along the path to the transit stop, such as high curbs, may increase the difficulty for older adults to get to their destination or board the bus [30].

2.2 Shared Autonomous Vehicles - Present Research

Shared autonomous vehicles (SAVs) combine the paradigms of ridesharing and taxis into a transformative alternative to current public transit. The implementation of SAV fleet systems may decrease the number of conventional personal vehicles on the road at a small increase to travel distance [19] and offer comparable flexibility of private vehicles for ridesharing [39]. Unlike ridesharing and taxis, SAVs can provide greater availability, safer travel to the destination, and lower cost (especially for occasional riders) [3, 19, 21]. Given the benefits and assuming a large enough fleet system, SAVs can provide a more convenient method of mobility for vulnerable populations.

Current research into SAVs falls into two main areas: 1) survey of demand, acceptance, and adoption and 2) simulation of supply and demand. In the first area, investigations have focused on estimating the potential demand of SAVs [6, 24, 27, 39]. A study conducted by Distler et al. [18] explored user acceptance and adoption of autonomous mobility on demand (AMoD), citing that effectiveness in terms of speed and wait time as the most important factors. In the second area, investigations revolved around using multiagent simulations to identify fleet optimization, operational costs [14, 20, 34, 40], the human-related impact on travel, and implications for ridesharing [34, 36, 50].

One area that has not been sufficiently examined is the SAVs design. For SAVs to become a viable mobility option, they must meet similar accessibility requirements as conventional public transit. However, as SAVs are a new technology for future transportation, there is an opportunity to integrate user needs into the early stages of design. As a vulnerable population, older adults rely more on shared-ride services than other populations; therefore, we stress the importance of introducing their perspective into the creation of this new automated innovation. This paper focuses on the design perspectives from older adults on what an SAV should incorporate for improved accessibility.

2.3 User Enactment Design Process

User enactment (UE) provides a method for exploring the interactions of technology currently not in existence, enabling us to understand the future use of technology without requiring high-fidelity instruments [47]. The following is an overview of the UE design process:

The process begins with developing conceptual designs of technology. This is typically carried out in brainstorming and bodystorming sessions with the design team reviewing any collected field data or related literature [44]. Then the design concepts are organized into thematic groups to obtain a broader picture of the many different desirable features of the new technology. Next, ideas are filtered based on criteria established by the team until a more desirable number of design concepts remain. Finally, the team develops a series of scenarios centered around the design concepts. The scenario development relies on several factors; the questions to be answered, the level of control participants have in the UE, the level of fidelity needed, and the contextual "risk factors" to be examined [45].

3 METHOD

In this section, we outline the design of an SAV concept with older adults serving as the user expert. Because SAVs are not commercially available, we employ the user enactment (UE) method to understand how users envision their interaction within the vehicle and how their interactions would drive their design choices. UE is a design approach originating in the speed dating method [16], which allows designers to observe interactions with non-existing technology. UE combines participatory design, scenario-based design, and role-playing to probe how end users engage with future technology in one or more contexts. What separates UE from other interaction design methods is its flexibility with the absence of boundaries and constraints from existing artifacts, its emphasis on embedding design concepts into scenarios for user engagement, and the affordance of offering multiple alternatives of future technology [44, 47]. There is some research in using UE to explore human-vehicle interaction [43, 48] but nothing within the context of shared autonomous vehicles and use by older adults. Through UE, our research contributes to the design implications of accessible public transit for vulnerable populations.

3.1 Initial UE Conception and Pilot

The current user enactment is grounded in the initial conception of a scenario and pilot study designed from past work with older adults, observing their opinions and attitudes relating to self-driving vehicles [32] and various literature on consumer research involving older adults. The supporting literature provided insight into older adults' interior design preferences (i.e., the presence of a steering wheel pedal) and the level of automation with which they felt comfortable. A focus group investigating older adult's opinions and attitudes about self-driving vehicles provided an understanding of their perceived interactions within the vehicle, concerns about operating the vehicle, and factors that influence buying and owning the vehicle. From the corpus of information, the team underwent an iterative process to formulate a script and scenario for the pilot study.

The pilot study took place at a center that services older adults in northwestern South Carolina. We set up the imaginary autonomous vehicle for this study, as shown in Figure 1, by using tape to create the outline of a sports utility vehicle (SUV) exterior with dimensions of 190 inches in length and 75 inches in width; on par with many three-row crossover SUVs. Six chairs were initially positioned in pairs in three rows, resembling a six-passenger, three-row vehicle. Two one-hour sessions were run in one day with a total of ten participants (five each session). Participants were asked to act out their behavior and think aloud while engaged in three "scenes": 1) before the drive, 2) during the drive, and 3) after the drive. Scenes were timed to limit them to no more than 20 minutes. Immediately following the enactment session, we conducted a focus group interview, in which we asked our participants follow-up questions regarding their experience.

Figure 1: Pilot study autonomous vehicle

3.2 Participant Recruitment

Email and flyers were used to recruit participants at a center serving older adults. Interested individuals were asked to call or email for additional information and scheduling. Those 60 years of age or older, were invited to participate.

The Institutional Review Board of the authors' university approved this study. Participants provided informed consent on the day of his or her session. Participants were compensated with a $10 prepaid gift card for their participation.

3.3 Description of Participants

Seven sessions were conducted over seven days at a center serving older adults in northwestern South Carolina. In total, 30 participants were involved in the study in seven groups of three to six people. Study participants had a mean age of 85.5 (range = 73 to 93 years old) and an annual household income that ranged from under $11,500 to $76,500. See Figure 2 for the distribution of participants' ages.

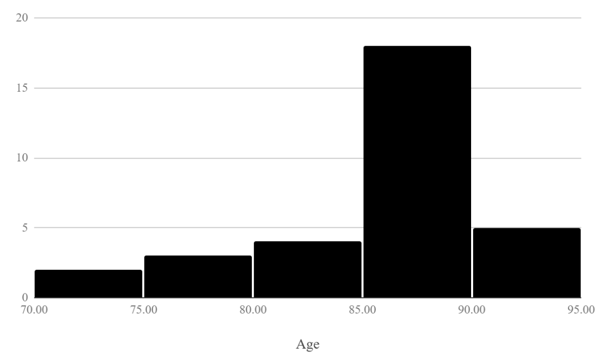


Figure 2: Distribution of participant ages

3.4 Apparatus

To construct the study's shared autonomous vehicle (SAV), we used blue tape to create the exterior outline of an SUV of the same dimensions as the pilot study (190 inches by 75 inches). Chairs were placed inside the outline, equal to the number of seats determined by the previous day's group of participants, with additional chairs available in the room to be added if requested. We designated the front and rear of the vehicle by using foam tri-fold display boards. Additionally, features added to the vehicle by the participants (e.g., running boards and heated seats) were written on foam core boards and placed along the left side of the SAV to represent their addition to the vehicle.

In addition, props were made available to the participants for their use during the enactment. The props served as tools to enhance the participants' portrayal of carrying out their activities in the vehicle (e.g., a book for reading during the ride). Some examples of the props provided for the sessions included a book, a cell phone, an old non-functional laptop, cups, and bags. See Figure 3 for all the props that were utilized. For certain items that we were unable to procure (e.g., a golf bag), foam core board was used and labeled with the name as a substitute for the object. Even without the real object, it is possible to recreate a mental model of the object with a substitute object.

3.5 Procedure

The sessions lasted no more than one hour, and the procedures for each session were identical. After being read the informed consent document, each participant completed and signed the necessary documents. Then participants were verbally provided the scenario of the enactment. The enactment process started with participants observing the SAV as designed by the previous group of participants

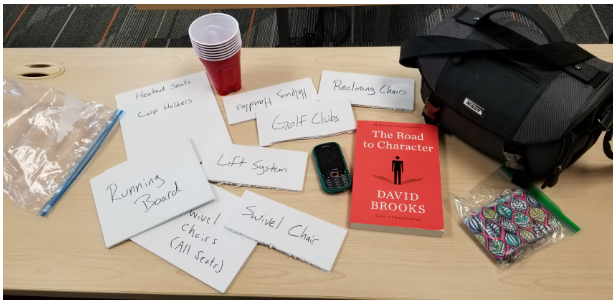


Figure 3: Props for the enactment sessions

and given time to make their changes. Immediately following, the pre-trip scene had participants acting out how they would approach the vehicle, enter the vehicle, greet other passengers, and inform the SAV of their intended destination. The en-route scene featured passengers portraying their desired actions during the trip, whether it be socializing with the other passengers or other activities (i.e., reading a book, looking out the window). In the destination arrival scene, participants acted out how they expected to be notified of their arrival at their destination, where the SAV would stop, and how they would exit the vehicle. Once the enactment session concluded, participants were asked to participate in a short focus group to describe their experience in the enactment and their attitudes about SAVs.

3.6 Data Capture and Transcription

A professional transcriptionist transcribed each session's video recording verbatim prior to analysis. A member of the research team verified the completed transcript against the original recordings.

3.7 Analysis

In preparation for analysis, transcripts for each session were entered into MAXQDA [41], a computer program for conducting qualitative data analysis. After initial familiarization with the data, two investigators independently coded all participant quotations. Each researcher began with a small set of a priori codes based on the pilot study's codes, then new codes identified within the data were added.

The researchers independently categorized and refined each coding. A third researcher settled any disagreements in the coding and categorization then merged both independent analyses into a single definitive version.

4 RESULTS

4.1 SAV Design Decisions

As part of each session, participants provided input on the current design of the imaginary SAV based on their needs and the perceived needs of their peers. Figure 4 presents the initial design of the SAV provided to the first group. The setup resembles Figure 1 from the pilot study, with three rows of two chairs and the same length of the vehicle. From the initial session, the layout of the SAV was changed from six seats to five seats with two in the front row and three in the second row (see Figure 5a). From the second session, the seating layout reverted to six-seats with three rows of two seats. Additionally, a single chair in the rear of the vehicle represented the cargo area. Participants also added the need for integrating a running board into the SAV. Many of the participants believed that an SAV would resemble the transportation shuttle they normally use and therefore determined a running board to help them enter the vehicle would be necessary. The second iteration of the SAV can be seen in Figure 5b. For subsequent sessions, the seat layout of the SAV did not change. Additional features were added to the SAV, including the following:

- swivel chairs for easier ingress and egress
- lounge chairs
- helper handles to supplement the running boards and assist with ingress and egress
- heated seats
- a lift system to lower and raise the height of the vehicle

The final design of the SAV can be seen in Figure 5c

Figure 4: Initial shared autonomous vehicle design

4.2 Qualitative Analysis

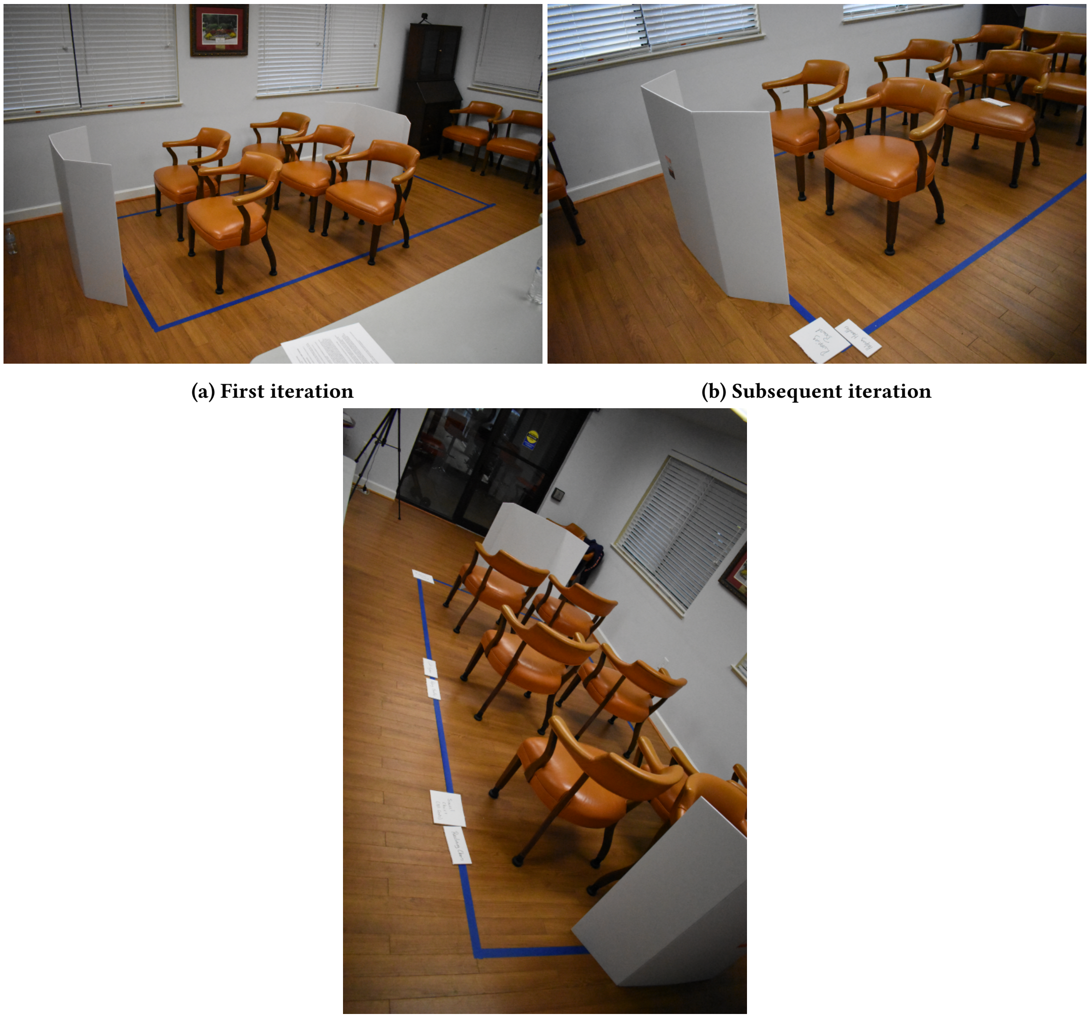
We uncovered five major themes from the results of the analyses of the enactment and focus group data and ordered them by the total number of mentions throughout the seven sessions. Additionally, multiple themes composed many of the conversational turns. Table 1 presents our major themes and their main findings.

4.3 Desired Features

The process of exploring the features desired by our participants commenced with introducing the current SAV design, which was created by the previous session (or from data collected from the pilot study for those in the first enactment session). Participants were asked their opinion of the current SAV design; then, they were given the option to accept the vehicle as-is or add, remove, or modify any aspect of the vehicle's design. Many of the participants' desired features came from current vehicle options.

> *"...they have GPS, I assume." (G2:P1)*

As our participants began interacting with their version of SAV design, the focus switched to features that would improve ease



(a) First iteration

(b) Subsequent iteration

(c) Final iteration

Figure 5: Progression of autonomous vehicle mockup through the enactment sessions.

of vehicle ingress and egress. Many of these features were also available in current vehicles.

> *"And it has something like a handhold to help you get in." (G2:P5)*

Interspersed with the currently available design features were non-standard vehicle features, which our participants wanted to be included in all SAVs.

> *"So, I swivel to get out ... and then step away from the door." (G2:P3)*

Additionally, some presented features that would provide higher levels of assistance and accessibility.

> *"I'd want a place to park walkers" (G7:P2)*

> *"...'I'm feeling very unwell. Please contact emergency services.'" (G7:P5)*

Finally, as the SAV is technologically advanced and still resides in the future, a few features were included that are not available in today's vehicles.

> *"It's very advanced. I would hope that the door would open as I was getting ready to get off." (G2:P4)*

4.4 SAV Concerns

4.4.1 Privacy. During the en-route enactment scene, the topic of privacy surfaced with participants expressing concerns about the potential for the SAV listening to their conversations.

> *"Isn't that an invasion of privacy, though?" (G5:P2)*

Others expressed concern for how the SAV would distinguish casual conversation from commands. They questioned if the vehicle would be equipped with technology to recognize keywords and listen for commands from the passengers.

Table 1: Qualitative Analysis of Participant Preferences

Theme	Findings
Desired Features	•Assistive features for vehicle ingress and egress •Storage for mobility aids •Emergency service contact system
SAV Concerns	•Maintaining privacy of passenger conversations
Design Considerations	•General consideration for older adults in the design of SAV's
Social Experience and Interactions	•Design provides passengers with direct access to essential features
SAV-Rider Interactions	•Multimodal passenger alerts •Ability to communicate with the SAV by voice •Method of changing the destination mid-trip •SAV stops so passenger exits vehicle facing their destination

> *"Well, what would concern me is: if we're talking amongst ourselves, it's gonna affect the car. Does it have a receiver? . . . if I'm talking to other people in the car, will it pick up on that?" (G1:P4)*

An additional conversation arose concerning the potential benefit for the vehicle to know specific information about passengers (e.g., medical information in the event of an emergency). Many participants believed that it could be appropriate to disclose such information, provided the vehicle was designed to contact emergency services or drive to the nearest healthcare facility.

> *"Any hardships that I have or anything that might be wrong with me that might occur... It would be nice if it understood how everybody was more or less involved in case and what to call an emergency for. Or if all of a sudden I can't breathe..." (G7:P3)*

4.4.2 Control of SAV. An area of concern for many participants was the idea of not having direct control of the SAV. Participants expressed disdain at the idea of a vehicle without a steering wheel and pedals and the inability to take control during an emergency. This may be due to older adults typically having substantial driving experience; therefore, it becomes increasingly difficult for them to relinquish control, particularly to a non-human operator.

> *"As I said earlier, after years of driving myself, to trust something else and not have the control, you lose that sense of being able to do anything if something happens. It's a little frightening." (G2:P3)*

4.5 Design Considerations

4.5.1 Seating. The seating arrangement of the SAV was predominantly consistent, except for enactment session one, with participants choosing a configuration resembling the pilot study's seat layout.

> *"Three rows of two, so that you don't ever have to get into the middle seat." (G2:P3)*

In the first session, participants preferred changing the seat layout to five seats. The configuration resembles specific shuttles that participants are familiar with from their routine travel.

> *"Well, it probably should hold five, being with two in the front and three in the back." (G1:P2)*

4.5.2 Consideration of Auto manufacturers. Participants were asked about the necessity of auto manufacturers considering the opinions of older adults in their design. Nineteen participants believed that manufacturers must include their thoughts and needs when designing SAVs and self-driving vehicles in general.

> *"I think they have to. We're getting older. I mean, that population is growing and it will grow for a while..." (G2:P4)*

However, some participants did not believe their opinions would have much effect on convincing manufacturers. Reasons include the inability to afford such a vehicle and not being the manufacturer's target market for self-driving vehicles.

> *"I expect the market's with young people that currently drive pick-up trucks, SUVs and sportscars..." (G1:P1)*

When asked if they believe manufacturers are currently taking into consideration the needs of older adults in their design, half of the participants believed that they are and half believed they are not.

4.6 Social Experience and Interactions

We explored participants' opinions on the viability of an SAV as a hub for social engagement and interaction with other passengers. When asked if an SAV could increase the likelihood of forming connections with other passengers, most of them were dismissive of the prospect, citing that passengers typically don't engage with others on current public transportation, especially strangers.

> *"Not necessarily. I think it's like any other mass transportation. You take an airplane, a train, bus. You know, how many friends or contacts do you make in those situations?" (G2:P3)*

Of note, some passengers stated they would be reluctant to engage in social interactions within an SAV due to a lack of trust in the vehicle, given a lack of evidence of its reliability.

> *"I'd be too busy watching the front to be sure that it was working right to try and make friends." (G1:P2)*

4.7 SAV-Rider Interactions

4.7.1 Identifying the SAV. Participants voiced the need for the SAV to provide notification when it arrives to pick up the rider. We encouraged participants to enact how they would imagine or expect the vehicle to let them know it had arrived. Most felt that the notification should take the form of a visual or auditory role. Three participants recommended having flashing lights, four wanted the SAV to honk the horn, and three requested phone calls.

> *"Maybe a flashing light ... to let you know it's there... if you've got a crowded area..." (G3:P2)*

Another set of participants determined they would rather wait outside for the SAV to arrive at a designated time.

> *"... right now I live in a back corner, and when anybody is gonna be picking me up, I go out and watch for 'em. So, I guess I would watch for the car to come at the time I specified." (G6:P3)*

4.7.2 Setting the Destination. After participants entered the vehicle, they were tasked with providing the SAV with a destination. Twenty-eight of our 30 participants completed this portion of the enactment by verbally providing the destination to the SAV.

> *"I'd like to be able to talk to it." (G1:P3)*

Although voice control was the primary choice for interacting with the SAV, participants were not consistent in how they stated their destination. The information ranged from very specific, providing both the business's name and address, too vague, providing only the name of the destination.

> *"Okay. I need to go to South State Bank building..." (G2:P2)*

In addition to providing an initial destination to the SAV, we explored the concern of how to change the destination.

> *"Well, I would hope they had like a little thing where you can push a button and say 'I'm changing my direction to...'." (G3:P3)*

4.7.3 Identifying Arrival at Destination. As the SAV approached the destination, participants enacted how the SAV should notify the rider of the imminent arrival. Voice interaction between the passengers and the SAV was a common theme throughout the enactments, and that trend continued in the form of an arrival announcement.

> *"Well, I think it would have the ability to tell you that it has arrived." (G1:P2)*

While speech was the primary method participants enacted being informed of arrival by the SAV, it was not the only method. The idea of a visual notification was also offered as a solution.

> *"Have a light up on the dashboard that would make the 'We're here'." (G6:P4)*

4.7.4 Dropoff Location. Upon the SAV's arrival at the participant's requested location, the enactment explored where participants expected to be dropped off. Participants across sessions consistently stated they expected to be dropped as close to the building's entrance as possible.

> *"Well, I suppose most of those buildings have kind of a loading zone ... where you can get off and then would be right at the entry." (G2:P4)*

In addition to the proximity to the entrance, four participants wanted to make sure that the SAV parked so that the rider's door faced the curb in front of the destination.

> *"Yeah, the vehicle should pull up so that your exit door is facing the place where I want to go to." (G2:P3)*

5 DISCUSSION

5.1 Common Desired Features

We found that many of the participants' desired features can be found in vehicles available today. These include features like GPS, sound systems, and heated seats. Features like these may have come from the features that the participants currently appreciate in their vehicles and would want to make sure they are also available in SAVs. In terms of accessibility features, our participants being older adults focused on the inclusion of features to make ingress and egress of the vehicle easier for persons with mobility concerns. The addition of a lift system, swivel seats, running boards, and handles, while not common in most conventional vehicles, these features are available to be added to most of today's commercially available vehicles. With our participants' desire for SAVs to contain many available features, whether readily available or custom made, on the market today, we explored whether this was connected to a feeling that their needs were not being considered.

Discussions with participants concerning their needs being considered in the design revealed a divide in opinions with half the participants believing their needs are being considered and the other half believing their needs are not being considered. This is consistent with the findings from a study conducted by Huff Jr. et al. [32]. In contrast, the work of Brinkley et al. [11, 13] which examined the opinions of persons with visual impairments, saw that most of the participants believed their needs to be largely ignored. Findings from this study as well that from both [32] and [13] illustrates a potential gap in the perspectives of how future technology is being designed with the needs of all end-users being considered. Additional research is required to discover possible design solutions that can adequately meet the needs of potential riders.

5.2 SAV Concerns

When discussing human-vehicle or human-human interaction within an autonomous vehicle, privacy is a critical topic of concern. This was based on the idea that current artificial intelligence assistants are ubiquitous and "always listening," which prompts questions about what potential consumer data is being recorded and stored by the system. The issue of privacy, both in terms of data disclosure and security risk, in autonomous vehicles has been explored in past work, noting such factors can consumers' trust and willingness to use them [8, 13, 49]. Participants expressed concerns about what the vehicle may be recording during the trip, in particular their conversations. It is worth noting that some participants found it beneficial for some types of information to be shared with the autonomous vehicle, specifically medical information, in the case of an emergency. Both findings aligned with the work of Huff Jr. et al. [32] when discussing potential benefits and concerns of self-driving vehicles in a focus group. Until new research can satisfactorily address the privacy concern, it may be a significant roadblock for people wanting to purchase autonomous vehicles.

Control of autonomous vehicles is another area of concern, in particular for older adults. From past studies, it has been revealed that older adults are not comfortable with relinquishing complete control of a vehicle nor feel comfortable with a vehicle without a steering wheel and pedals [1, 32, 42, 49]. In the context of shared autonomous vehicles, participants prefer to have a human operator in control of the vehicle. This is due, in part, to the absence of SAVs on the road and available for use. Participants noted that until they witness the emergence and successful use of SAVs, they are not likely to accept or adopt them.

5.3 Takeaways for AV Design

Amongst our findings, we uncovered some key takeaways we believe are beneficial in advancing the design of SAVs, especially for older adults.

5.3.1 Ingress and Egress. Participants expressed a desire for features that would assist with vehicle ingress and egress. An example mentioned was the presence of an automatic door. While there are many vehicles today that offer power-sliding and self-opening doors, these vehicles require input from a passenger. The implementation of automated doors that open upon arrival at the vehicle's destination without any user input would minimize any hindrance caused by a passenger's impairments. Another feature mentioned by participants, and used during the enactment process, were swivel seats. When considering the needs of older adults, it is important to note that these passengers may have limited mobility, which can make twisting their bodies into a conventional seat problematic. Implementing swivel seats into current AV designs would allow passengers to rotate the seat from its original orientation to facing the entryway for ease of entry and exit.

5.3.2 Mobility Aid Storage. Participants also felt that it was important for SAV design to address the storage of mobility aids such as canes, walkers, and wheelchairs. Many older adults who utilize current ridesharing vehicles store these mobility aids in the trunk and rely upon the driver's assistance to store the device. However, this presents a design challenge for SAVs as there may not be another occupant in the SAV to assist with the storage of mobility aids. Future AV designs should consider solutions for mobility aids to be stored automatically after the user has entered the vehicle. One solution, specifically for wheelchair users, would be to include a wheelchair lift, which could eliminate the passenger's need to exit their wheelchair.

5.3.3 Emergency Assistance. A noteworthy concern voiced by participants was how the vehicle would handle emergencies. This led to the desired feature of an emergency service contact system. The expectation was that a fully autonomous vehicle should be able to recognize an emergency, notify the proper personnel without the need for user input, and potentially drive the passenger directly to medical services. This would require current AV design to evolve methods of recognizing passenger distress and the need for medical attention.

5.3.4 Traveling Alone with Others. We initially assumed that older adults would see SAVs as an opportunity for social interaction with the other passengers. However, the participants had little concern as to whether they experienced any engagement with the other passengers. This makes sense when considering that while current forms of public transportation allow for social interaction, it is certainly not required. The main focus is to get from one location to another. Based on this finding, future SAV design should focus more on the experience of the individual. Similar to the user experience on current public transport, this new design should equip each passenger with the essential features that will allow them to travel without the need for interaction with the other passengers in the vehicle. For example, instead of a passenger in the back seat having to request the front seat passengers to make a navigation change through the user interface, this passenger should be able to make this change themselves. This new design will enhance the freedom that each passenger has within the vehicle.

5.3.5 SAV User Interface. Finally, the participants felt that it was necessary to include multiple ways for the SAV user interface to alert the passenger of events occurring, such as the arrival at a pickup location or destination, a change in the navigation, or the approach of an emergency vehicle, similar to the ATLAS system [9, 12]. This is important for future SAV design for a few reasons. First, it removes the reliance on a single method of notifying the passengers. For example, relying solely on a voice assistant does not consider older adults who may have a hearing impairment. Using multiple forms of notification increases the likelihood that the passenger will be made aware of the event. Also, many of the participants in the enactment study were not proficient in the use of technology. Instead, they envisioned themselves simply waiting at a pick-up location for a vehicle to arrive. This emphasizes the necessity for future SAV designs to include notification systems that do not solely rely on the passenger's use of a smartphone or other device. Designing a notification system that can grab the attention of passengers with a wide range of abilities and disabilities will increase SAV service's usability.

6 CONCLUSION

This study explored the design choices and user experience of older adults within the context of a shared autonomous vehicle. We employed user enactment to observe the behavior and actions of older adults as they participated in an improv-style setting simulating what travel would resemble in an SAV. Findings from their input have provided a viable and accessible first-look at an SAV that can support the older adult population's needs, which is crucial for increasing their mobility. Findings from the focus group sessions revealed that SAVs are also anticipated to increase older adult independence. The participants' preferences and concerns centered around assistive features and accommodations, emergencies, privacy, and in-vehicle interactions. Such findings provide further evidence for a supportive legislature for improving the accessibility of self-driving vehicles currently in development [10]. Furthermore, participants did not view SAVs as a venue for social interaction and instead were concerned with travel from one location to another. When questioned about auto manufacturers and their consideration of older adult's needs, the participants' opinions were split on whether their input should be considered and if they are being considered now. This provides an understanding of the emphasis on the design of self-driving ridesharing vehicles and the integration of the needs of vulnerable populations who could substantially benefit from this technology.

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