

Lights, Camera, Autonomy! Exploring the Opinions of Older Adults Regarding Autonomous Vehicles Through Enactment

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Autonomous vehicles (AV), one of the transportation industry's biggest innovations of the past few decades, bring the promise of safer roads and significantly lower vehicle-related fatalities. While many studies have found largely positive consumer opinions regarding operating and owning such a vehicle, older adults (55+) tend to express concerns about the safety and operational risks of a vehicle with unknown capabilities. To investigate how older adults and AVs may interact, we conducted an improv-style enactment-based participatory design pilot study. We found that initial concerns about trust and safety can be diminished through training and repetitive successful vehicle operation. Additionally, our participants provided insights into the AV design considerations, needs, and interactions for older adults. These findings add to the collective body of autonomous vehicle research by demonstrating that the needs of this growing population, who may benefit significantly from access to AVs, should be considered by manufacturers.

INTRODUCTION

Autonomous vehicles (AV) represent one of the biggest technological advances in the transportation industry of the past few decades, bringing the promise of safer roads and significantly lower vehicle-related fatalities (Crew, 2015). The automotive industry, through AVs and advanced driver assistance systems, is providing automated technology which may improve the quality of life for many (Wiseman, 2019). Current literature has presented largely positive opinions by individuals regarding owning and operating AVs, however, older adults (55+) have expressed concern about AV operation (Brinkley, Posadas, Woodward, & Gilbert, 2017; Huff, DellaMaria, Posadas, & Brinkley, 2019). We believe this may result from a lack of familiarity with how autonomous vehicles function, how to operate an AV, and/or what activities can be engaged in while riding in such a vehicle.

In an effort to contribute to the growing body of research on consumer perceptions regarding AVs, we have conducted an improv-style enactment-based (Bakker, Antle, & Van Den Hoven, 2012) participatory design study focusing on older adults (55+), a population whose opinions, we argue, have been underexplored. Within our study, participants completed a demographic questionnaire, depicted their behavior while interacting with an 'imaginary' AV, and participated in an end of study focus group reflecting on the enactment experience. We believe this work furthers the understanding of the opinions, preferences, and concerns of older adults regarding AV technology, while providing additional support for the use of improvisational enactment as a research methodology.

RELATED WORK

Autonomous Vehicles and Older Adults

Autonomous vehicles, as a category, comprises vehicles that operate with minimal human manipulation of safety critical controls (e.g. steering, breaking, and acceleration) (SAE International, 2018b). The Society for Automotive Engineers (SAE) has defined six levels of vehicle automation. Level 0 has a human in complete control over all aspects of driving, levels

one through three represent escalating autonomy, while levels four and five has the vehicle driving itself with limited human input (SAE International, 2018a). According to a 2015 report, AVs may reduce traffic fatalities by as much as 90 percent, saving approximately 300,000 lives and \$190 billion in healthcare costs in the U.S. alone (Crew, 2015).

While autonomous vehicles can benefit society in general, older adults stand to benefit significantly from this emerging technology. Reports show that by 2030, 1 in 5 Americans will be 65 years and older (Knickman & Snell, 2002; US Census Bureau, n.d.). The increased growth in this population, especially for those who are licensed drivers, may result in more vehicle accidents. Decline in cognitive, physical, and visual abilities, all essential aspects for driving, may affect older adults' capabilities in operating a motor vehicle (National Institute on Aging, 2018). Even at lower levels of autonomy, where a human may need to take control of the AV, their decreased cognitive and physical abilities may make it difficult to properly control the vehicle, placing passengers, other drivers, and pedestrians in danger.

AVs may prove to be the solution to the mobility challenges of older adults as they eliminate the need for human input and can operate independently of human interactions. This, in turn, allows older adults the potential for greater independence, no longer relying solely on family, friends, or ridesharing options. However, even with the promise of AVs enabling greater personal mobility and independence, further investigation is needed to better understand how to address the needs and consideration of the older adult population and whether such a population can trust and accept this new technology.

Consumer Opinions of Autonomous Vehicles

Opinions on AVs' perceived usefulness and adoption have been examined early in the conception of the technology. Prior work has shown that trust, reliability, and usefulness are the most significant factors in acceptance of AVs (Choi & Ji, 2015; Lee, Chang, & Park, 2018; Niranjana & de Haan, 2018; Souders & Charness, 2016). Studies conducted solely with older adults (Huff et al., 2019) reveal that there are concerns about how AVs

actually work and whether the technology would work reliably in certain situations (i.e. slowing down at a yellow light). We suspect most of these concerns relate to the possibility that older adults may not understand an AVs capability. Given the rarity of such vehicles on the road, most people are unfamiliar with autonomous vehicles broadly. This study seeks to bring clarity to the older adult population using an enactment study where participants engage in activities they perceive as possible within the confines of an autonomous vehicle.

METHOD

An enactment study based on the method used in both Bakker et al. (2012) and Hochleitner et al. (2017) was chosen as a generative research methodology given that fully autonomous vehicles are not yet commercially available. The goal of enactment studies is to identify metaphoric mappings between movements and commands which can be translated into interaction concepts (Hochleitner et al., 2017). Using this method, we extracted concepts from our participants' interactions with conceptualized vehicle.

Apparatus and Setup

The autonomous vehicle for this study is imaginary and was set up as shown in Figure 1. We used blue masking tape to create an outline of a three-row sport utility vehicle (SUV), 190 inches in length by 75 inches in width. Six chairs were initially positioned in three rows of two, resembling a six-passenger vehicle. Basic table chairs were used to allow participants full control over the AVs seating configuration.



Figure 1. Imaginary AV Setup

Participant Recruitment

Interested individuals were invited to participate if they were aged 55 or older and had transportation to a designated location in central [State Anonymized]. Participants were recruited by email and flyers at a center serving older adults. Interested persons were asked to call or email for additional information and scheduling. The Institutional Review Board of the authors' university approved this study and each participant provided informed consent on the day of his or her session. Participants were compensated with a \$10 prepaid gift card for their participation.

Description of Participants

Two sessions were conducted on one day at a center serving older adults in central [State anonymized]. In total, ten partic-

ipants were involved in the study, split in two groups of five people. Study participants had a mean age of 65.5 (range = 57 to 71 years old) and a household annual income that ranged from under \$15,000 to \$55,000.

Procedure

Each session lasted no more than one hour, and the procedure was identical for each. After participants were read the informed consent document, they completed a nine-question demographic questionnaire. Participants were then asked to act out their behavior in three "scenes": 1) before the drive, 2) during the drive, and 3) after the drive (see Figure 2). Participants were asked to think aloud (Fonteyn, Kuipers, & Grobe, 1993) while engaged in the enactment process. At the end of each session, we engaged the participants in a focus group, which provided an opportunity to ask study participants to reflect on their experience.

Data Capture and Transcription

Each session was video recorded and transcribed verbatim by a professional transcriptionist. Prior to analysis, the completed transcript was verified by a member of the research team against the original recordings.

Analysis

In preparation for analysis, all transcripts were entered into MAXQDA (MAXQDA, n.d.) a qualitative data analysis program. Two investigators independently coded all participant quotations with a small set of a priori codes, based on a prior study within the same context (Brinkley et al., 2017), then new codes were added when inductively identified by the data. Both independent analyses were merged into a single version by a third researcher, who settled any coding and/or categorization disagreements.



Figure 2. Imaginary AV Setup

RESULTS

Results of the analyses were organized into three major thematic findings: 1) perceived interactions, 2) design considerations, and 3) trust in AV technology. Across the sessions, perceived interaction was mentioned 104 times, design considerations 91 times, and trust in AV technology 80 times. In many instances more than one theme was addressed in a single conversational turn.

Perceived Interactions

Desired features based on interactions. A variety of desired features were raised naturally from participants' enacting how they would approach, interact with, and handle destination arrival of the autonomous vehicle.

During discussions on user interactions with AVs, participants indicated that they would do so using voice commands: "It's got to be voice-controlled" (Session 1: Participant 3).

The use of voice commands began before participants entered the AV, with seven out of ten participants explicitly using voice commands to open the door: "I'd say 'Open the door, please'" (S2:P3).

One participant expressed a desire that the vehicle could hold a conversation, to keep her company while traveling by herself on a long trip: "I would like my car to talk back to me if I'm there by myself, to kind of keep me company" (S2:P1). This request creates a higher requirement for AV beyond the basic safety and efficiency functionality.

Upon arrival at the destination, eight out of ten participants expressed the importance of the autonomous vehicles ability to find the closest parking spot available, while three participants preferred that the AV have a drop-off / pick-up feature. This would allow riders to be dropped off as close to the destination's entrance as possible while the vehicle would self-park. When ready to be picked up, the vehicle would allow the user to share their exact position and readiness.

And if you can't find one spot close to the entrance, you let me out at the entrance and you find a parking spot. (S2:P5)

And I have a thing when I get ready to come out and say, 'Car, I'm ready to be picked up at the front door.' (S1:P1)

Design Considerations

Autonomous vehicle interior design. When asked about the overall design of AVs, participants expressed the opinion to keep the current general vehicle design, but with a more flexible arrangement of seats. Seats that could move out, fold down when not needed, or turn around would provide more possibilities for in-vehicle activities. All participants expressed their desire for more room in vehicle to relax, both in the front row and the back row.

And that way, with them seats turned like this everybody gets the opportunity to see. (S1:P5)

You can put your luggage in and everything on a long trip. And for the people go with me, they won't be so crowded with more seats. And if they're not going, I can always fold it down. (S1:P5)

A majority of participants expressed the view that they would prefer an AV with four doors, while one participant expressed a more novel door design: "Mine would have, I guess, one door and it would go up" (S2:P1).

Needs being considered. The discussion of seating design highlighted the needs of older adults by proposing accommodations to assist with ingress and egress: "I could have a seat that could swirl a little bit for when you get out" (S1:P5).

Trust in AV Technology

Risk and trust. Participants expressed a broad range of views related to trust, especially in terms of safety and reliability of autonomous vehicle technology. Seven participants clearly indicated that trust in AV would be a big concern while they became familiar with the vehicle: "Well, if this is gonna be a self-driving car, I won't be trusting this car. I mean I got to be very familiar with the car enough to trust it" (S1:P3).

Seven participants stated they would not be willing to sleep in an AV, with one participant strongly stating that they should stay alert and be kept aware of the surroundings in case an emergency situation required her to take control of the vehicle. This was echoed in the seating preferences of our participants, as five participants preferred to remain in the driver seat: "I'm gonna sit on this side, where I can really see behind me, in front of me, with my rear-view mirror ... Because if I sit back, I won't feel comfortable. I want it to be like I'm driving" (S1:P5).

Concerns about reliability were also raised, with three participants worried about problems with the autonomous vehicle technology taking them to the wrong destination: "Because all of these glitches and whatever you do, there's always glitches. I can tell it I might be going, 'Take me to' one place, and I end up somewhere else. I'd just have to be cautious like that" (S2:P4).

Vehicle safety. The safety in an autonomous vehicle was a constantly revisited topic of discussion, with all participants stating that safety was the most important issue. Seven participants strongly expressed their desire for extra protection devices, including interior barriers, airbag and seatbelts.

In a case of a crash I want to make sure what's in front is a well-protected barrier. (S1:P2)

The most important thing to me, it would be the safety, to make sure that each seat would have at least an airbag in the back of the vehicle on the seats in case of a crash. (S2:P1)

Training and licensure. Given the potential policy changes for operating an AV (Brinkley, Daily, & Gilbert, 2019b), we asked questions about training and licensing for AVs. Nine out of ten participants expressed that training has the potential to increase their trust in autonomous vehicles: "I would be comfortable in a car like this if I had training. I mean I got to be very familiar with the car enough to trust it" (S1:P3).

When asked who should be responsible for this training, five participants responded that the manufacturers should handle this with approval from the state.

Interactions with non-autonomous vehicles. Skepticism was expressed by four participants on how well AVs would be able to successfully operate on road with non-autonomous vehicles. Their concern came mostly from the unpredictability of human drivers: "See, even though my car is driving for me, we don't know what the other person might come out and do, so I have to be alert at all times" (S1:P2).

DISCUSSION

Enactment Activity

Individuals' expectations when entering or interacting with an AV has been previously explored (Huff et al., 2019), but in this study we used the enactment method to encourage our participants to use their imagination while physically acting and verbalizing their interactions with such a vehicle. Our pilot study found the overarching opinion of older adults is that an autonomous vehicle should resemble vehicles currently available, but with a notable differences.

Perceived Interaction

Preference for human-vehicle interactions is a topic that has been heavily discussed in prior work (Brinkley, Daily, & Gilbert, 2019a; Brinkley et al., 2020; Brinkley, Posadas, Sherman, Daily, & Gilbert, 2019). In a study by Brinkley et al. (2017), participants described their interaction with an AV human-machine interface and their preferred method of interaction. Like the current study, participants desired voice input as the main interaction method with the vehicles. Our participants used voice commands to task the AV with everything from opening the doors to conversing with a solo rider. Such findings also stand in contrast to those of Schoettle and Sivak (2015), who found most survey respondents preferred touchscreen interaction.

Another important area of interaction with the autonomous vehicle is the drop off and pick up process. Participants preferred the vehicle to drop them off as close to the destination's entrance as possible and then to park autonomously. In conjunction with this, our participants wanted a remote way of contacting the vehicle, so they could inform the AV when they are ready to depart and where to pick them up.

Design Considerations

As for the design of the vehicle itself, discussion focused on the number of doors, seating arrangement, and special needs for older drivers. The current SUV model was found acceptable for the autonomous vehicle, but participants preferred to change the seating to a provide more room and flexibility. They expressed the desire to have seats which can fold down or turn around within the vehicle since they would like to relax and/or be entertained during longer trips. Participants anticipated AVs would be like a "living room" for them to socialize, watch movies, play games, and read.

While, most participants chose to keep the vehicle a four-door model, one participant stated a preference for only one door that would open upwards. As for the special needs of the older driver, they expressed an interest in seats that could swivel, thus making ingress and egress easier.

Additionally, our participants requested that the AV retain traditional features such as a steering wheel, pedals, and mirrors. Half of our participants stated they would still sit in the driver's seat ready to take control of the vehicle at a moment's notice. This is consistent with the studies by Huff et al. (2019), Molnar et al. (2017), and Schoettle and Sivak (2015), which found that older adults desired AVs to keep manual controls so they could take control when needed.

Trust in AV Technology

The need to trust an autonomous vehicle is of high importance due to the concern of physical injury and material damage if something goes wrong. Additionally, our participants expressed concerns regarding the vehicles' ability to navigate to correct destinations, handle emergency situations, and to generally operate safely. This led to a particularly negative attitude towards trust in the vehicle. These results are similar to prior work on understanding the attitudes of older adults and blind or visually impaired persons towards AVs (Brinkley, Daily, & Gilbert, 2018; Huff et al., 2019).

Many participants strongly stated that they would not fall asleep while traveling in an autonomous vehicle, indicating the need to keep alert and aware of the surroundings. Concerns about AV reliability was raised through questions about being driven to the wrong destination. Trust, our participants indicated, needed to be gained. They stated that safe completion of several trips in the AV and/or training would help increase their level of trust. In terms of training, participants expected manufacturers to provide this service to customers, with approval from the state. Further research could explore whether training increases trust in a real operational scenario.

Related to the lack of trust was the strong desire for extra vehicle safety devices. More airbags and barriers were expected to be installed within autonomous vehicles to provide better protection when collisions happened. Further research is warranted to determine whether these protective devices would actually result in higher customer trust.

Many participants expressed their concerns about the ability of AVs to deal with unpredictable human drivers. Participants were interested in how the vehicle would handle these situations and expected to be alerted to unpredictable drivers in non-autonomous vehicles so they could take control. These concerns show a continued lack of trust in AVs.

CONCLUSION

This pilot study examined how an improv-style enactment study could help older adults better understand and provide input into the design, function, and control of autonomous vehicles. The series of enactments enabled participants to develop a sense of potential for the future of advanced transportation. Our findings on older adults' trust and safety concerns aligned with previous research, but we found that these concerns could be lessened through training and successful trip completion. However, due to lack of availability and unfamiliarity, trust in AVs is still uncertain and hesitancy in their perceived usefulness persists.

Additionally, through the enactment process, we uncovered important insights into AVs from the perspective of older adults, including design considerations and the specific needs of older adults especially regarding seat arrangement and functionality, as well as the preference for vocal communication between the participant and the vehicle.

Further work will increase the level of immersion in the enactment process, allowing for a more precise study of human / autonomous vehicle interactions.

Overall, these findings show that the enactment method can

successfully be used for research into the design and functionality of vehicles not currently in commercial production. Specifically, the insights gleaned from the opinions and perspectives of our older adult participants on AVs demonstrate the importance of conducting research with underexplored populations.

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