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Opinions from Users Across the Lifespan about Fully Autonomous and Rideshare Vehicles with Associated Features

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Abstract

Fully autonomous vehicles have the potential to fundamentally transform the future transportation system. While previous research has examined individuals' perceptions towards fully autonomous vehicles, a complete understanding of attitudes and opinions across the lifespan is unknown. Therefore, individuals' awareness, acceptance, and preferences towards autonomous vehicles were obtained from 75 participants through interviews with three diverse groups of participants: 20 automotive engineering graduate students who were building an autonomous concept vehicle, 21 non-technical adults, and 34 senior citizens. The results showed that regardless of age, an individual's readiness to ride in a fully autonomous vehicle and the vehicle's requirements were influenced by the users' understanding of autonomous vehicles. All of the engineering students understand what a fully autonomous vehicle is and this group was the most willing to ride especially compared to the seniors, where only half of the seniors knew what a fully autonomous vehicle is and 58.8% were not at all ready to ride one. The desire to have a manual control option or the ability to override the vehicle was common (90% of the engineering students, 95.2% of the adults, and 82.4% of the seniors), especially for individuals who reported not being ready to ride in a fully autonomous vehicle. The majority of all three groups of participants (85% of the engineering students, 81% of the adults, and 52.9% of the seniors) considered it essential that the vehicle should convey information about the vehicle's status and intended behavior. Diagnostic information about the vehicle was desired by the engineering students (71.4%), who had a technical understanding of autonomous vehicles and current automotive related technologies. When autonomous vehicles are available, most participants anticipate preferring to use them as a rideshare service model (75% of the engineering students, 38% of the adults, and 27% of the seniors) rather than owning (5% of the engineering students, 19% of the adults, and 21% of the seniors) the autonomous vehicle themselves. Regarding the topic of sharing rides with strangers, both the automotive engineering students (90%) and the adults (52.6%) were comfortable with the idea of pooled rideshare in comparison to the seniors (29.4%). In future efforts, it will be important to include potential autonomous vehicle users of a wide age range as well as physical, cognitive, and visual abilities.

1. Introduction

Over the past few decades, there has been a significant push towards the development of fully autonomous vehicles (AV) due to rapid advancements in technology [1]. Autonomous vehicles have the potential to dramatically change transportation. This transformation is predicted to reduce passengers' physical and mental stress by making the ride safer and more comfortable [2]. Autonomous vehicles are anticipated to revolutionize vehicles' interior design to customize passengers' experiences. Occupant packaging is also predicted to evolve away from the current configuration where all occupants face forward. Future vehicles may allow passengers to sit face to face or even lay down. There is already a shift in focus away from the driving experience to new, innovative experiences for passengers. Automotive manufacturers, suppliers, technology companies, academic institutions, and governmental organizations are working towards providing safe, comfortable, and sustainable transportation.

Advancements in technology led to a framework for different levels of automation from human driving to fully autonomous vehicles [1]. This framework led the Society of Automotive Engineers [3] to develop standards for the different levels of autonomy. These levels have been accepted by the US Department of Transportation [4] to classify a vehicle's automation capabilities. There are six levels of driving automation, starting at level 0 (no automation) progressing to level 5 (full automation). In levels 1 and 2, the driver is responsible for controlling all aspects of the vehicle and is supported by automation. These support features help the driver with the specific driving tasks like staying in the center of the lane and/or maintaining a constant speed. From level 3 to level 4 the driver is progressively giving up the physical control of the driving task in certain situations. On the other end of the continuum, level 5 is the highest level of automation where the vehicle is capable of performing all driving functions in all conditions. A level 5 vehicle will have no steering wheel, brake pedal, or gas pedal. A fully autonomous vehicle (SAE level 5) is a self-driving vehicle that is capable of sensing its environment and moving safely with no human input.

Autonomous vehicles not only drive technological advancements, but also have the potential for societal benefits, the most significant being increased safety. If automation can increase safety with no human intervention, there is a potential to dramatically decrease traffic-related fatalities and injuries. In the US alone, more than 30,000 people each year are killed, and approximately 2.5 million people are injured in vehicular crashes. Most of the crashes are due to human error [5,6]. Autonomous vehicles also have the potential to make valuable contributions towards sustainable mobility [7], which is the transportation system contributing to the positive environmental, social and economic development of the community. Autonomous vehicles have the potential to increase car sharing solutions resulting in more efficient usage of each vehicle [8,9]. A ridesharing model is anticipated to contribute to a decrease in traffic congestion; specifically due to reduced vehicle crashes, increased throughput on the roads, and higher vehicle speed limits [6]. From an end-user perspective, autonomous vehicles are anticipated to increase time utilization [10] while in a flexible and comfortable interior [11]. Autonomous vehicles have the potential of providing mobility and independence to individuals who experience difficulties with transportation due to their inability to drive because of physical or visual limitations [12]. The aging population can experience mobility challenges with driving due to cognitive and visual declines [13]. Unfortunately, these age-related challenges frequently lead to an inactive social life [14]. These vehicles have the potential to overcome existing barriers to help at-risk populations maintain their independence and social relationships.

As the number of autonomous vehicles increases, it is predicted that private car ownership will reduce substantially [8], and there will be an anticipated growth of the ridesharing business model [15]. Ridesharing will be crucial for the sustainable development of cities by providing inexpensive mobility services and contributing to last-mile connectivity in multimodal transportation systems [16]. Research shows that the propensity to engage in productive multitasking during commuting significantly influences the mode of transportation preferred [10]. Given the option of fully autonomous vehicles on a survey of Northern California commuters, ridesharing received higher preference than biking, commuter rail, transit, etc. Along with multitasking, rideshare acceptance is dependent on the travel cost, travel time, and wait time for a commute [17]. Due to the anticipated reduction of private vehicles, fewer parking spaces will be required and thus allow for a greater physical capacity for ridesharing on city streets [6]. In a simulation study, approximately thirty million trips in New Jersey have the potential to use fully autonomous vehicles for ridesharing [18]. In another simulation study for rideshare trips in Austin, Texas, the results show that a single fully autonomous vehicle can replace nine conventional vehicles within a 24 mile by 12 mile area with an approximate user wait time of one minute [19].

The adoption of any new technology is based upon user acceptance towards that technology. The user's level of trust is a significant determinant of the acceptance of that technology [20, 21, 22]. The user's perception of the technology is largely based upon the opinion users formulate from their prior experiences and the information received about the usefulness of the technology. Research shows that users who have previously heard of autonomous or self-driving vehicles have a favorable opinion of the technology and high expectations about the benefits of the technology. The users who are not familiar with technology show very minimal trust [23]. The faith in fully autonomous vehicles is correlated positively with the trust in technology [24]. The user will likely initially be biased towards selecting manual control over automation [21]. This bias towards manual control is predominant during the initial interaction with the system. One's initial trust can be enhanced by increasing the awareness of the perceived safety, risk and usefulness [25].

The technology acceptance model (TAM) relies on the user's perceived usefulness and perceived ease of use as the determinants of the user's attitude towards the system; it predicts the behavior intention of the user and eventually leads to actual system use [26]. Although this model primarily targeted desktop computer users, there were several adaptations of the TAM that augmented the model with new constructs such as social influence processes and cognitive instrumental processes that can influence users acceptance of technology [27]. The TAM has also been used in driving assistance systems research. In one study, the adapted TAM version for the acceptance of GPS devices was based on the perceived enjoyment and personal innovativeness factors [28]. Other studies have used the TAM in driver assistance evaluations using the perceived system disturbance and social influence as factors that affect the users' intention to use the system [29,30].

The TAM influenced the universal theory of acceptance and use of technology (UTAUT) model [31]. The UTAUT combined several user acceptance models aiming to explain the user's intention to use a system and their subsequent usage behavior. The factors in UTAUT are performance expectancy, effort expectancy, social influence, and facilitating conditions. The UTAUT factors can be applied to the user perception of autonomous vehicles [32]. For example, a user's effort expectancy can be compared with the different autonomy levels (as vehicle automation increases, there will be lower required effort to drive). The infrastructure customized to autonomous vehicles may create facilitating conditions where users accept higher autonomy levels.

The car technology acceptance model (CTAM) [33] introduced an additional factor, perceived safety, to the UTAUT. The CTAM focused primarily on in-car technology rather than the whole car technologies like autonomous vehicles. The autonomous vehicle acceptance model (AVAM) [32] combines the elements of the technology acceptance model, the car technology acceptance model, and automation levels [3]. With the AVAM, the users perceive only two levels of autonomy: partial (level 0-4) and full (level 5). Since the level 5 autonomous vehicle has no steering wheel, gas or brake, the user is not familiar with the design of fully autonomous technologies and therefore tend to have minimal trust in the technology [34,35]

Fully autonomous vehicles aim to remove the driver, thus changing the previously active driving role of the user to passive. It is unknown how situation awareness or "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" [36] will change with this new passive role. Interestingly, a naturalistic study conducted by Endsley [37] found an increase in situation awareness from automation due to the reduction in workload, allowing the driver to scan the environment more. It was also found that the increase in situation awareness decreased over time as users gain trust in the vehicle [37] and divert attention to other tasks like using a cellphone, eating or drinking [38]. Though these studies show an increase in situation awareness and engagement in secondary tasks, it is important to note that these studies focused on experiences using available technology, which was partial automation (level 2) that requires the driver to be alert to take over control if the situation arises [3].

Our lab began research on this topic by investigating four diverse users' needs and wants for a fully autonomous vehicle [12]. The team conducted in-depth interviews and day-in-the-life experiences to understand the needs and limitations of very different types of users including: a millennial with a visual impairment, a professional in a major metropolitan area who needs to transport influential clients to meetings throughout the city but does not want to drive, a full-time working mom of 3 kids under the age of 12, and a designer who is a quadriplegic who uses a large motorized wheelchair and tries to live as independently as possible. The findings from this previous study found that each of these users had very different needs in order to utilize the vehicle. However, all four users wanted the vehicle to be safe and secure, reliable, and affordable. Future autonomous vehicles will have vastly different metrics for user satisfaction than what exists today.

Next, our lab conducted interviews with certified driving rehabilitation specialists (CDRSs) who are typically occupational therapists that evaluate and train clients who have medical conditions that impact their ability to drive due to visual, cognitive, and/or motor issues. CDRSs were chosen as the pilot participants for this research because they spend a large amount of time in the passenger's seat while working with their clients and can provide a unique perspective [39]. The interviews with the CDRSs focused on what factors made these clinicians uncomfortable when riding with their clients and during their personal time. The main factors that made CDRSs uncomfortable both when riding with clients and during their personal time were environmental (fog, unfamiliar, dense traffic), driver-related (being distracted, following too closely, changing lanes), and related to the actions of drivers in other vehicles (following too closely, being distracted). When riding with clients, CDRSs reported being more uncomfortable with the driver-related factors than during their personal time [39]. These initial interviews helped the team to develop the more structured interview used in the current study.

This current paper builds upon the interviews with the CDRSs [39] and aims to identify factors that could influence acceptance and use of future autonomous vehicles between different user groups. The primary focus is to gather user awareness towards the fully autonomous vehicle and readiness to ride in those vehicles. This study also examines how users feel about features that fully autonomous vehicles should provide to make the ride safer and more comfortable, opinions about the user experience design, and preferences on the fully autonomous vehicle as a shared vehicle. This study includes three groups of participants with different demographic backgrounds: automotive engineering graduate students who are building an autonomous concept vehicle, non-technical adults and senior citizens. The purpose of having diverse groups of participants was to explore the comfort factors from generations. These groups were selected to represent the technology adoption lifecycle, where the automotive engineering graduate students likely represent the early adopters that have a greater understanding of the technology, adults being in the middle, and seniors representing individuals that may lag in adopting new technology. The seniors were also critical to include in order to understand how requirements for comfort change with age.

2. Materials and Methods

2.1. Participants

Three groups of participants completed this study including: 1) second year automotive engineering graduate students who were building an autonomous concept vehicle, 2) non-technical adults (who were not engineers or computer scientists), and 3) seniors from a local community organization. A total of 21 engineering students participated in this study, but one person's data was dropped due to a technological recording issue. The 20 engineering students had an average age of 25.2 years old, ranging from 23 to 29 years. The students consisted of 17 males and 3 females. The 21 adult participants consisted of four males and 17 females. The adults' ages ranged from 20 to 52 years, with an average age of 34.4 years. A total of 34 seniors participated in this study, consisting of 11 males and 23 females. The average age was 72.9 years with an age range of 62 to 87 years. The goal was to gain a minimum of 20 participants in each group, but there are a larger number of seniors. There were two data collection periods held at the community center to recruit seniors to the study and all seniors that volunteered to participate during those periods were included. This study was part of a larger interview surrounding passenger comfort in vehicles.

2.2. Data Analysis

The majority of the interview consisted of "yes/no" questions followed by an open-ended question, where many participants gave more than one response. The responses from the open-ended questions were tallied based upon similar topics. The topics were then compared between the groups. The results are reported as a percentage of the total number of the responses for each group, which sums to 100%.

For statistical analysis, Chi-square Tests of Independence were completed for the "yes/no" questions to determine if there were differences between the three participant groups. Posthoc Chi-square tests were conducted using a Bonferroni adjustment method when differences between groups were discovered. For two questions, participants responded using a scale with six ratings, a one-way Analysis of Variance (ANOVA) was conducted to determine if there were differences in ratings between the three participant groups followed by Games-Howell posthoc tests.

2.3. Procedure

Individual interviews were conducted in-person. The results presented in this paper are part of a larger data set and the interview was completed within an hour. The study was approved by the university's institutional review board. Participants were compensated for their time with a $15 Visa gift card. All structured interviews were conducted using Qualtrics, which facilitated the interview process, data entry and data analysis.

3. Results

3.1. Electronic Devices Used

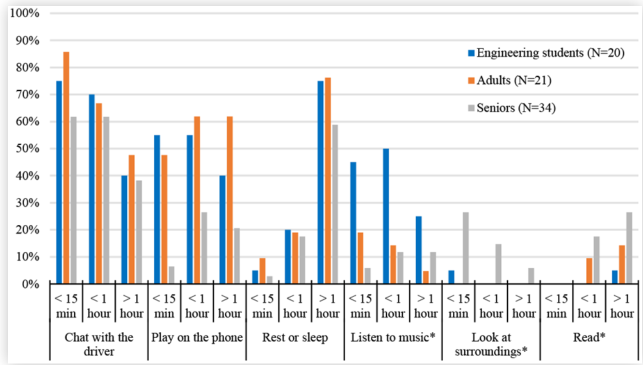
In order to get a feel for the level of technology the participants use on a daily basis, the participants were asked about both the type of cell phone and computer used. When asked about cell phone use, the participants selected from options including *smartphone like an iPhone or Android*, *flip phone or standard cell phone*, or *no cell phone*. All of the automotive engineering students and adults used a *smartphone* along with 76.5% of the seniors. *Flip phones* were used by 14.7% of the seniors, while the remaining 8.8% did not use a *cell phone*.

Computer type was assessed using the options *laptop*, *desktop*, *tablet* or *do not use*. The majority of technical students (77%) and adults (65.4%) used *laptops*, while the majority of seniors used either a *laptop* (35.7%) or a *desktop* (33.3%). *Laptop* use was the greatest for all groups, followed by a *desktop* with even fewer who reported using a *tablet*. The seniors were the only group that reported not using a *computer* (14.3%). Only 5.8% of the seniors use neither a *cell phone* nor a *computer* of any kind.

3.2. Activities Passengers Prefer to do While Traveling

The interview included questions regarding activities participants do as passengers during trips of three varying lengths, including: 1. 15-minutes or less, 2. one hour or less and 3. several hours long. The options included *play on the phone*, *chat with the driver*, *rest or sleep* and *other*. The *other* option led to three additional categories including *listen to music*, *look at surroundings*, and *read*.

FIGURE 1 Percentage of participants that reported activities during trips lasting 15-minutes or less, one hour or less or several hours. The items with an asterisk (*) indicate the topic was reported as "other".



Overall, the most common activities that passengers engage in during a 15-minute drive or less included *chat with the driver* or *play on the phone*, see Figure 1. The engineering students reported *listening to music* more than the two other groups while the seniors reported *looking at surroundings* more than the other two groups.

The two most frequent activities for all groups for trips an hour or less were the same as the two most common activities for trips 15-minutes or less, *chat with the driver* and *play on the phone*. Among all three groups, the number of responses increased for *rest or sleep*. The students once again reported *listening to music* as the third most frequent activity. In comparison to trips that were 15-minutes or less, fewer seniors reported *looking at their surroundings*, more reported they *read* during trips that were an hour or less.

For trips that were several hours long, *rest or sleep* was the most frequent activity for all groups. Participants in all groups still reported *chatting with the driver* and *playing on their phones*. Fewer students reported *listening to music* during long trips (>1 hour) in comparison to shorter trips (<1 hour). On long trips, seniors reported *looking at the surroundings* less frequently and *read* more.

3.3. Information Accessible from the Passenger's Seat

Participants were asked if there is any information about the vehicle, the environment, etc., that they would like to have access to from the passenger's seat. Seventy-five percent of the technical students, 42.9% of the adults and 50.0% of the seniors responded "yes". There were no statistical differences between the groups. For those who indicated they want information while in the passenger's seat, participants were asked using an open-ended format what information they would want access to (see Table 1). The most common responses given by the engineering students included information about the *navigation* (26.7%), *HVAC* (16.7%) and *speed* (16.7%). For the

TABLE 1 Types of information passengers would like access to when sitting in the passenger's seat.

Type of information	15 engineering students (Responses=30)	9 adults (Responses=21)	17 seniors (Responses=25)
Navigation	26.7%	4.8%	16.0%
HVAC	16.7%	19.0%	16.0%
Speed	16.7%	19.0%	12.0%
Music / entertainment	10.0%	14.3%	0.0%
Vehicle is functioning correctly / status	6.7%	4.8%	8.0%
Place / restaurants / gas station nearby / map	6.7%	4.8%	0.0%
Traffic conditions / environment	3.3%	4.8%	4.0%
Fuel / miles to empty	3.3%	0.0%	12.0%
Information from existing instrument clusters	0.0%	9.5%	0.0%
Airbags and their positions	0.0%	0.0%	8.0%
Visibility	0.0%	0.0%	8.0%
Other	10.0%	19.0%	16.0%

Note: Participants could give multiple responses.

TABLE 2 Methods to communicate information passengers would like access to while in the passenger's seat.

Methods to communicate information	15 engineering students (Responses=16)	9 adults (Responses =9)	17 seniors (Responses=17)
Visually / screen	93.8%	77.8%	82.4%
Audibly / voice	6.3%	11.1%	0.0%
Other	0.0%	11.1%	17.6%

Note: Participants could give multiple responses.

adults, *HVAC* (19.0%) and *speed* (19.0%) were the most common responses and overlapped with the engineering students. The adults also reported *music/entertainment* (14.3%) and *typical instrument cluster* (9.5%) as the next two most common responses. The most common responses for the seniors were *navigation* (16.0%), *HVAC* (16.0%), *speed* (12.0%), and *fuel level/miles to empty* (12.0%).

The participants who want information while in the passenger's seat were asked how they would like the information communicated to them using an open-ended format. Consistently, the most common answer for all groups was a *visual display or screen* with an average of at least 77.8% (see Table 2).

The same participants were asked if there was anything they want control over using an open-ended format (see Table 3). *Control of the HVAC* was the most common response for the engineering students (34.6%), adults (31.6%) and seniors (30.0%). *Entertainment/music* was the second most common response for the students (34.6%) and adults (26.3%) while the seniors' second most common response was *control over the vehicle* (25.0%).

3.4. Describing a Fully Autonomous Vehicle

The participants were asked if they know what a fully autonomous vehicle is. All of the engineering students (100.0%), 85.7% of the adults and 50.0% of the seniors responded "yes", indicating that they knew what a fully autonomous vehicle was. The Chi-square test indicated a significant difference among the groups ($\chi^2(2) = 18.39$, $p < .05$). The posthoc Chi-square tests determined that the number of seniors that reported knowing what is a fully autonomous vehicle was significantly lower than the engineering students ($\chi^2(1) = 14.60$, $p < .008$) and adults ($\chi^2(1) = 7.16$, $p < .008$). Next, those participants who indicated that they knew what a fully autonomous vehicle was were asked to describe an autonomous vehicle using an open-ended format. The most common characteristics given by the engineering students were *no human intervention / self-driving in all weather conditions* (36.7%), *no steering wheel* (16.3%) and *sensors /controllers all over* (12.2%). The most common responses by the adults were *no human intervention / self-driving in all weather conditions* (54.5%) and *no steering wheel* (9.1%). For the seniors, *no human intervention / self-driving in all weather conditions* (78.9%) was the most common response, the next most frequent descriptions were only reported by 5% of the participants. Remaining descriptions used by the groups include *avoids collision/stops before an obstacle*, *auto-navigate*, *auto-park*, *avoids traffic*, *emergency manual steering*, *good safety features*, *human control only in HVAC & infotainment*, *level 4 without human input*, *level 5*, *makes decisions itself*, *multitasking*, *no hands/legs used*, *no pedals*, *pick up*, *read in news*, *stops itself*, *taxi without a driver*, *vehicle does as user requests* and *vehicle-to-vehicle communication*.

TABLE 3 Items participants wanted to have control over from the passenger's seat.

Items wanting control over	15 engineering students (Responses=26)	9 adults (Responses=19)	17 seniors (Responses=20)
HVAC	34.6%	31.6%	30.0%
Entertainment / music	34.6%	26.3%	10.0%
Nothing	7.7%	5.3%	15.0%
Navigation	7.7%	0.0%	0.0%
Control of the vehicle by steering wheel and pedals	3.8%	5.3%	25.0%
Windows	3.8%	10.5%	0.0%
Lighting	3.8%	5.3%	0.0%
Seat adjustments	3.8%	0.0%	5.0%
Other	0.0%	15.8%	15.0%

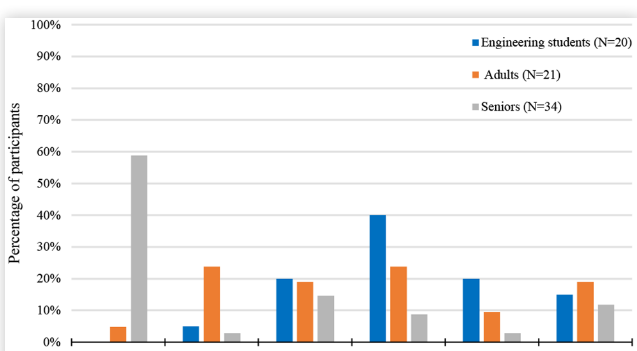
Note: Participants could give multiple responses.

3.5. Readiness to Ride in an Autonomous Vehicle

After being given an explanation of what an autonomous vehicle is, participants were asked how ready they are to ride in an autonomous vehicle using a 6-item scale where 1 was *not at all* and 6 was *absolutely ready* to ride. Figure 2 shows the percentage of participants in each group with each rating. The students' top three ratings were *four* (40.0%), *three* (20.0%) and *five* (20.0%). The top ratings for the adults were *four* (23.8%) and *two* (23.8%). For the seniors, the most common ratings were *one* (58.8%) and *three* (14.7%).

A one-way ANOVA was conducted to determine if there were differences between the engineering students ($M = 4.20$, $SD = 1.11$), adults ($M = 3.67$, $SD = 1.56$), and seniors ($M = 2.29$, $SD = 1.80$). The results of the analysis of variance were statistically significant ($F(2, 74) = 10.56$, $p < 0.05$), indicating a difference between the groups. Posthoc Games-Howell tests were used to determine where the differences were because Levene's test can be used to check the homogeneity of variance assumption. Since Levene's test was significant, the homogeneity of variance assumption was violated ($F(2, 72)$, $p<0.05$). The Games-Howell tests revealed that the seniors' ratings were significantly lower compared to the engineering students and the adults, though there were no differences between the engineering students' and adults' ratings. Though transformations were applied, normality could not be restored, nor did the outcome of the Analysis of Variance change with the transformations.

FIGURE 2 Participant ratings of their readiness to ride in an autonomous vehicle.



3.6. Ability to Switch Between Autonomy and Driving

A common topic associated with autonomous vehicles is the ability to switch between driving and autonomous modes. Participants were asked if they would prefer to have a vehicle that could switch between the two modes, driving and autonomous. The results showed that 90.0% of students, 95.2% of adults and 82.4% of seniors responded that they would like a vehicle that can switch between being fully autonomous and a vehicle one can drive. There were no statistically significant differences between the groups.

Participants that want the ability to switch between the two modes were asked when and why they would switch between the modes using an open-ended question. Table 4 shows the results for the reasons why participants want to be able to drive the vehicle. The students' most common reasons were because they *like to drive* (26.1%), *when uncomfortable / emergency situation* (13.0%), *on mountain/curvy roads* (13.0%) and in *urban areas* (13.0%). For the adults, they *like to drive* (25.0%) and *when uncomfortable / emergency situations* (25.0%) arise were the reasons to switch to driving themselves. The seniors' most common responses were they *like driving* (13.8%), *when uncomfortable/emergency situations* (13.8%) and *override the system/manual control* (13.8%).

Table 5 shows the reasons why participants want to use the vehicle in autonomous mode. Across the lifespan, the most frequent response was for *long distance trips or the highway.* The seniors had three additional primary situations in which they would like an autonomous mode including simply based upon their *mood* (18.2%), while in *heavy traffic* (18.2%) and when they feel *sick* (18.2%). The second reason the students and adults want to use an autonomous mode is also based upon their *mood* (25.0% and 14.3%, respectively). The adults would like to use the feature for their *daily destinations* (14.3%).

3.7. Features Needed to Feel Comfortable in a Fully Autonomous Vehicle

Participants were asked what a fully autonomous vehicle needs to include in order for them to feel comfortable while riding.

TABLE 4 Reasons why participants want to drive a vehicle.

Reasons to drive the vehicle	16 engineering students (Reponses=23)	16 adults (Responses =24)	22 seniors (Responses=29)
Like to drive	26.1%	25.0%	13.8%
Uncomfortable / emergency situations	13.0%	25.0%	13.8%
Mountain / curvy roads	13.0%	4.2%	6.9%
Urban areas	13.0%	4.2%	0.0%
Poor road conditions / weather	8.7%	8.3%	3.4%
Heavy traffic	8.7%	4.2%	10.3%
Empty roads / less traffic	8.7%	0.0%	0.0%
Bored as a passenger	4.3%	0.0%	3.4%
Go fast	0.0%	12.5%	3.4%
Override the system / manual control	0.0%	8.3%	13.8%
Highways	0.0%	0.0%	10.3%
Don't trust the automation	0.0%	0.0%	6.9%
Wants to drive all the time	0.0%	0.0%	6.9%
Other	4.3%	8.3%	6.9%

Note: Participants could give multiple responses.

TABLE 5 Reasons why participants want to use the vehicle in an autonomous mode.

Reasons for autonomous mode	10 engineering students (Responses=12)	10 adults (Responses=14)	9 seniors (Responses=11)
Highway / long distances	33.3%	28.5%	18.2%
Depends on mood / optional	25.0%	14.3%	18.2%
Daily destinations	8.3%	14.3%	0.0%
Sleep / tired	8.3%	7.1%	0.0%
Heavy traffic	8.3%	0.0%	18.2%
Sick	0.0%	7.1%	18.2%
Other	16.7%	28.6%	27.3%

Note: Participants could give multiple responses.

TABLE 6 Features needed to feel comfortable riding in a fully autonomous vehicle.

Features needed to feel comfortable riding in an autonomous vehicle	20 engineering students (Responses=33)	21 adults (Responses=36)	34 seniors (Responses =39)
Entertainment / music	18.2%	5.6%	5.1%
Comfortable interior / seats and legroom	15.2%	13.9%	5.1%
Safety information / instructions	15.2%	5.6%	2.6%
Override option / manual control	9.1%	16.7%	33.3%
Status of vehicle / what it's doing	9.1%	16.7%	5.1%
More development / proven track record	9.1%	11.1%	2.6%
Navigation / vehicle progress	6.1%	8.3%	7.7%
Nothing / satisfied	6.1%	2.8%	7.7%
Windows / good visibility	3.0%	5.6%	2.6%
Not ready	0.0%	2.8%	5.1%
Current driver assistant technologies	0.0%	0.0%	5.1%
I don't know	0.0%	0.0%	5.1%
Other	9.1%	11.1%	12.8%

Note: Participants could give multiple responses.

The results from the open-ended question in Table 6 show that for the engineering students, *entertainment/ music* (18.2%) and a *comfortable interior / seats and legroom* (15.2%) are desired. For the adults, having *override option / manual control* (16.7%), *information about the status of the vehicle/ what it's doing* (16.7%) and a *comfortable interior/ seats and legroom* (13.9%) will make them feel comfortable. The most common responses for the seniors were having an *override option /manual control* (33.3%), *navigation/vehicle progress* (7.7%) and *nothing/satisfied* (7.7%).

3.8. Features Needed to Feel Safe in a Fully Autonomous Vehicle

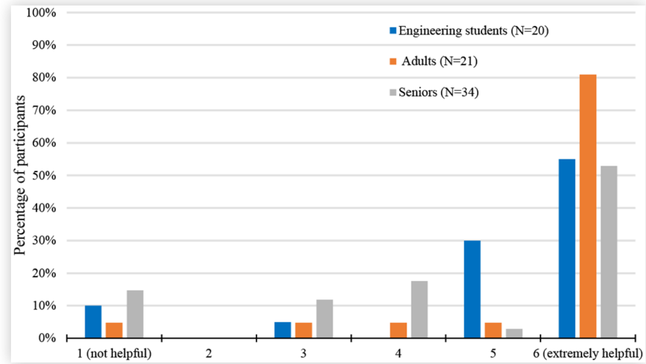
Participants were asked what a fully autonomous vehicle needs to include in order for them to feel safe while riding. The open-ended format led to the most diverse answers for the three groups. For automotive engineering students, an autonomous vehicle has to have *active safety features /modern technologies* (19.4%) and *passive safety features like seatbelts / airbags* (16.7%) to feel safe. The adults reported the need for *passive safety features like seatbelts/airbags* (21.4%) and the *status of the vehicle* (19.0%) in order to feel safe. For the seniors, the need for an *override option/control* (30.0%) was rated highly in addition to *simply not being safe/not ready* (22.5%) for an autonomous vehicle, see Table 7.

3.9. Helpfulness Having Information About the Status of the Autonomous Vehicle

Participants were asked to imagine they are riding in an autonomous vehicle and rate how helpful it would be to have information about the status of the vehicle on a display. Participants responded on a 6-item scale, where 1 was *not helpful* and 6 was *extremely helpful*. Figure 3 shows that 55.0% of the students, 81.0% of the adults and 52.9% of the seniors thought that it would be extremely helpful (6) to have information about the status of the vehicle. Thirty percent of the students gave a rating of 5. Ten percent of the students, 4.8% of the adults and 14.7% of the seniors thought it would not be helpful (1).

A one-way ANOVA was conducted to determine if there were differences between the engineering students ($M = 5.05$, $SD = 1.57$), adults ($M = 5.48$, $SD = 1.29$), and seniors ($M = 4.53$, $SD = 1.85$). All three groups violated the normality assumption, and a log transformation was implemented. Though the log transformation reduced the skewness, this transformation was not able to restore normality. The ANOVA results were not statistically significant, indicating no differences between the groups.

FIGURE 3 Participant ratings of the helpfulness of having the status of the vehicle displayed.



As a follow-up question, the participants were asked what information they want about the status of the vehicle using an open-ended format (see Table 8). The engineering students most frequently requested *navigational information* (24.5%), *vehicle condition / diagnostics* (12.2%) and *speed / what the vehicle is doing* (10.2%). The adults wanted to know the vehicle's *speed / what the vehicle is doing* (30.0%), *navigation* (22.0%) and *information about the surrounding environment* (14.0%). The seniors also wanted to know the vehicle's *speed / what the vehicle is doing* (26.8%) and *navigation* (19.6%).

Participants were then asked how they would prefer to have the information communicated to the passenger using an open-ended format. Table 9 shows the majority of participants in each group wanted the information to be communicated *visually using a screen*, which included 82.6% of the engineering students, 71.4% of the adults and 55.6% of the

TABLE 7 Features needed to feel safe riding in a fully autonomous vehicle.

Features needed to feel safe riding in an autonomous vehicle	20 engineering students (Responses=36)	21 adults (Responses=42)	34 seniors (Responses =40)
Active safety features / modern technologies	19.4%	7.1%	15.0%
Passive safety features like seatbelts / airbags	16.7%	21.4%	10.0%
Override option / manual control	11.1%	16.7%	30.0%
Status of the vehicle (speed, safety)	11.1%	19.0%	0.0%
Navigation / vehicle progress	11.1%	2.4%	0.0%
Safety information / instructions	8.3%	4.8%	0.0%
More research / proven track record	5.6%	7.1%	5.0%
Should not drive fast / speed limiter	2.8%	2.4%	0.0%
Windows	0.0%	7.1%	0.0%
I don't know	0.0%	2.4%	5.0%
Not safe / not ready	0.0%	0.0%	22.5%
Nothing	0.0%	0.0%	10.2%
Voice assistant to guide like a driver	0.0%	0.0%	4.1%
Other	13.9%	9.5%	7.5%

Note: Participants could give multiple responses.

TABLE 8 Information participants would like to know about the status of the vehicle.

Helpful information about the status of the vehicle	20 engineering students (Responses=54)	21 adults (Responses=56)	34 seniors (Responses =63)
Navigation	24.5%	22.0%	19.6%
Vehicle condition / diagnostics	12.2%	2.0%	1.8%
Speed / what is vehicle doing	10.2%	30.0%	26.8%
Fuel / energy course gauge / battery level	8.2%	6.0%	7.1%
Information about the surrounding environment	6.1%	14.0%	0.0%
HVAC	6.1%	0.0%	3.6%
Music / entertainment / infotainment	6.1%	0.0%	1.8%
Warnings / alerts	4.1%	6.0%	0.0%
Vehicle's decision making	4.1%	2.0%	0.0%
Local area information / weather	4.1%	0.0%	1.8%
Rating / feedback system for riders	4.1%	0.0%	1.8%
Distance / position to other vehicles	2.0%	2.0%	5.4%
Capabilities / features	2.0%	2.0%	0.0%
Information from existing instrument clusters	2.0%	0.0%	0.0%
Tutorial / guidance to ride	0.0%	6.0%	5.4%
Maintenance	0.0%	4.0%	0.0%
I don't know	0.0%	2.0%	1.8%
Ability to take over	0.0%	0.0%	7.1%
None	0.0%	0.0%	7.1%
Not interested in AV	0.0%	0.0%	3.6%
Any / all information	0.0%	0.0%	3.6%
Other	4.1%	2.0%	1.8%

Note: Participants could give multiple responses.

TABLE 9 Method to communicate information about the status of the autonomous vehicle to the passenger.

Means of communicating information	20 engineering students (Responses=23)	21 adults (Responses=28)	34 seniors (Responses =36)
Visually / screen	82.6%	71.4%	55.6%
Audibly / voice	13.0%	28.6%	27.8%
NA / don't need / don't know	4.3%	0.0%	16.7%

Note: Participants could give multiple responses.

seniors. *Audio / voice* was the second most common response across the three groups with 13.0% of the students, 28.6% of the adults and 27.8% of the students.

3.10. Ownership or Rideshare Service Model

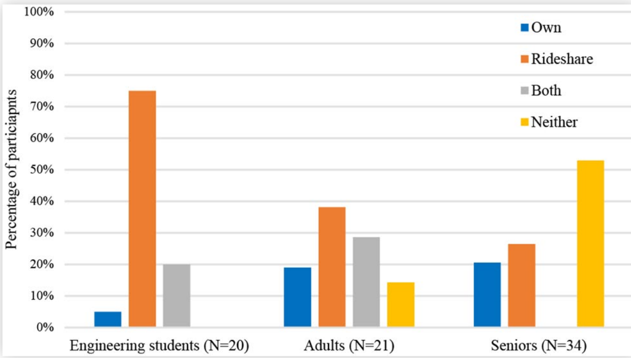
It is unclear if autonomous vehicles will be owned or shared, therefore participants were asked if they are interested in owning an autonomous vehicle or using an autonomous vehicle as a rideshare service like Uber. Participants selected one of four options: own, service like Uber, both or neither. The majority (75.0%) of students selected a rideshare service model followed by both (which includes both ownership and rideshare) (see Table 10). The adults were split, where 38.1% predict they would use an autonomous vehicle as a *rideshare service*, 19.0% anticipate *owning their own*, and 28.6% want a combination of *both options*, to own and use as a service. The seniors were the only group with the majority (52.9%) not wanting to own or use an autonomous vehicle as a service; they were also the only group where no one (0%) selected both own and use as a service. The seniors that were interested in riding in an autonomous vehicle were split between *owning* (20.6%) and *using a rideshare service* (26.5%).

TABLE 10 Preference between an ownership or rideshare service model.

Ownership versus service	20 Engineering students	21 Adults	34 Seniors
Own	5.0%	19.0%	20.6%
Rideshare	75.0%	38.1%	26.5%
Both	20.0%	28.6%	0.0%
Neither	0.0%	14.3%	52.9%

The Chi-square test on autonomous vehicle owning or sharing indicated there was a significant difference between

FIGURE 4 Preference of ownership or rideshare model between the engineering students, adults, and seniors.



these groups ($\chi^2(6) = 32.60$, $p < .05$). The post hoc Chi-square tests determined that the seniors had significantly different responses from the engineering students ($\chi^2(3) = 26.13$, $p < .004$) and the adults ($\chi^2(3) = 15.38$, $p < .004$). This could be due to approximately half of the seniors did not want to own or use an autonomous vehicle unlike the students and adults (see Figure 4).

3.11. Riding in an Autonomous Vehicle with Someone You Know

It is unknown if multiple riders will share one autonomous vehicle to travel to a given destination. Therefore, participants were asked if they would be comfortable riding in an autonomous vehicle with someone they knew. The results show that 100.0% of the students, 94.7% of the adults and 67.6% of seniors would be comfortable riding in an autonomous vehicle with someone they knew. The Chi-square test indicated there was a significant difference between these groups ($\chi^2(2) = 11.93$, $p < .05$). The posthoc Chi-square tests determined that the number of seniors that reported feeling comfortable riding in an autonomous vehicle with someone they knew was significantly lower than the engineering students ($\chi^2(1) = 8.126$, $p < .008$).

For the participants who were not comfortable sharing a ride with someone they know, they were asked a follow-up question to determine what would make them feel comfortable from either three given options (*massage seat*, *entertainment* or *headphones*) or an item they propose (see Table 11). One adult reported that a *massage seat*, *entertainment* and *headphones* would help to improve comfort. For the seniors, the most common responses were *nothing / none* (30.8%), a *massage seat* (23.1%) and *entertainment* (15.4%).

3.12. Riding in an Autonomous Vehicle with a Stranger

Participants were then asked if they would be comfortable riding in an autonomous vehicle with a stranger. The results show that 90.0% of the students, 52.6% of the adults and 29.4% of the seniors would be comfortable riding in an autonomous vehicle with a stranger. The Chi-square test indicated there was a significant difference between these groups ($\chi^2(2) = 18.53$, $p < .05$). The posthoc Chi-square tests determined that the number of engineering students that reported feeling comfortable riding in an autonomous vehicle with a stranger was significantly higher than the seniors ($\chi^2(1) = 18.52$, $p < .008$).

For the participants who did not feel comfortable riding in an autonomous vehicle with a stranger, they were asked what would make them feel more comfortable using an open-ended format (see Table 12). For the students, having *information on the other rider* (50.0%) and *not knowing what would make them feel comfortable* (50.0%) were the only responses. Similarly, *knowing information about the other rider* (20.0%) and *not knowing* (10.0%) were the top responses for the adults. The remaining responses for the adults did not overlap with other adults or other groups (e.g., cost, multiple passengers, knowledge of the vehicle, etc.). The seniors' most common responses were *nothing / I do not want to share* (35.7%),

TABLE 11 What is needed to feel comfortable riding in an autonomous vehicle with someone known.

Needs to feel comfortable	1 adult (Responses=3)	11 seniors (Responses=13)
Massage seat	33.3%	23.1%
Entertainment	33.3%	15.4%
Headphones	33.3%	7.7%
Nothing / none*	-	30.8%
Seat adjustments*	-	7.7%
Don't want to sit in AV*	-	7.7%
Only in an emergency*	-	7.7%

Items with an asterisk (*) indicate the topic was not on the list but was reported as "other".

Note: Participants could give multiple responses.

TABLE 12 What is needed to feel comfortable riding in an autonomous vehicle with a stranger.

Needs to feel comfortable	2 engineering students (Responses=2)	9 adults (Responses=10)	24 seniors (Responses=24)
Rider's personal information / ratings / documents verified	50.0%	20.0%	12.5%
Don't know	50.0%	10.0%	0.0%
Nothing / I don't want to share	0.0%	0.0%	35.7%
Prior experience	0.0%	0.0%	12.5%
Technology has matured	0.0%	0.0%	8.3%
Other	0.0%	70.0%	25.0%

Note: Participants could give multiple responses.

knowing the rider's information (12.5%), *prior experience* (12.5%) and *technology maturing* (8.3%).

4. Discussion

This study aimed to investigate attitudes about future fully autonomous vehicles from three diverse groups of users. The participants included individuals across the lifespan including automotive engineering graduate students who were building a fully functioning autonomous concept vehicle, non-technical adults, and senior citizens. Structured interviews were conducted with all three groups in order to understand how perceptions of autonomous vehicles may inform the design of future autonomous vehicles.

In order to understand familiarity with technology in general, participants were asked about their cell phone and computer use. The seniors were the only group that had members that did not use cell phones (8.8%) or computers (14.3%). Low-tech *flip phones* were used by roughly 15% of the seniors. This result suggests that at least a subset of the seniors is neither familiar nor comfortable with technology in general. This reduced use of technology trend was also reflected in the activities the seniors reported when riding as a passenger, where a much smaller portion of the seniors reported *playing on their phones* during trips of varying lengths. These findings are important for the rideshare service companies to consider in order to increase their customer base. Rideshare services are operated mainly using smartphone apps to request a ride. This can limit the seniors from using rideshare services. The rideshare service companies should give an option to their users to request a ride in other ways. For example, the ride can be requested through a phone call such as a toll-free number, since seniors are familiar with making a phone call [40,41]. The discrepancy between the seniors and the younger generations is most extreme for trips less than 15 minutes; it is unknown if social factors contributed to this difference, specifically where seniors may consider *playing on the phone* as a sign of poor manners. More seniors commented that they *look at their surroundings* and *read* than their younger counterparts.

To help the participants imagine what type of information they may find helpful in an autonomous vehicle, participants were asked what information they would like to have access to while riding as a passenger in a current vehicle. The two items that were consistent for all three groups were *HVAC* and *vehicle speed*. Interestingly, *navigation* was the top choice for both the engineering students and seniors, but it was not in the top three choices from the adults. When asked how they would like the information communicated to them, the most frequent response was *visual*. Interestingly, some of the students (6.3%) and adults (11.1%) preferred auditory communication over visual communication, but none of the seniors wanted auditory information only. This may be related to age-related hearing loss. When asked what participants want to have control over when riding as a passenger, *HVAC* was the most common response for all groups. Other common responses for the students and adults include *control over the entertainment or music*, where the seniors want *control over the steering wheel and pedals*.

Prior to providing a description of a fully autonomous vehicle, participants were asked if they knew what a fully autonomous vehicle is. All of the engineering students and 86% of the adults acknowledged knowing what an autonomous vehicle is. Only half of the seniors know what a fully autonomous vehicle is; this lack of understanding likely contributed to why nearly 60% of the seniors reported they were *not at all* ready-to-ride in an autonomous vehicle. Even though most of the students and adults know what autonomous vehicles are, their readiness-to-ride ratings were spread across the six ratings of *not at all* ready-to-ride through *absolutely* ready-to-ride in an autonomous vehicle. Only 15% of the engineering students who were working on building a fully autonomous vehicle reported *absolutely* ready-to-ride. While the students' trend was in support of riding in autonomous vehicles, 58.8% of the students were in the mid-range with a trend towards riding in autonomous vehicles. The ready-to-ride item suggests there will likely be innovators, early adopters, the early majority, the late majority and laggards as Rogers' proposed in his Diffusion of Innovation theory with autonomous vehicles [42,43].

In order to understand why users were or were not ready-to-ride in an autonomous vehicle, a follow-up question asked if they would prefer to have a vehicle that could switch between the two modes, driving and autonomous. The participants were very much in favor of having the ability to switch between the two modes with group responses per age group ranging between a low of 82% for the seniors to a maximum of 95% for the adults. The most frequent reason for wanting to drive the vehicle across all age groups was because participants like *driving*. The adults and seniors had multiple responses for their most frequent answer, with *feeling uncomfortable / in an emergency situation*. The third response for the seniors that was tied for the most common was *wanting to override the autonomous functionality* to have manual (aka driving) control over the vehicle. On the opposite end of the continuum, when it came to reasons why participants want autonomy, one of the most common responses across all groups was that it *depends on the mood* or *situation of the user*. Because participants do not currently have the option for automation to take over the driving task, participants may not know when they would use autonomy just yet. Other common responses for situations to use autonomy for the students were on *highways*, for the adults during *long trips*, and for seniors were in *heavy traffic* or if they were *sick*.

In terms of features to include in autonomous vehicles to make riders feel more comfortable, unlike the older groups, the students focused on *entertainment* and a *comfortable interior with legroom*; safety information about the vehicle was also important to this group. The adults and seniors wanted an *override option to allow for manual control* of the vehicle to feel comfortable, with the frequency of this response by the seniors being double that of the adults. The adults also want to know what the vehicle is doing. In comparison, the primary feature participants desire to feel safe while riding in an autonomous vehicle varies by age. The seniors (30%) once again requested an *override option to allow for manual control* of the vehicle to feel safe (as well as comfortable). The second most frequent response was they simply do not believe they will feel safe and are *simply not ready* (22.5%); this is not surprising since 58.8% of the seniors responded they were *not at all* ready-to-ride in an autonomous vehicle in a previous question. The adults wanted passive features, such as seatbelts, in addition to information to understand what the vehicle is doing, such as the speed, in order to feel safe. Like the adults, the engineering students, reported wanting passive safety features but their primary response was active safety features. Due to the students' specialization in automotive engineering, they may have a greater understanding of the modern autonomous technologies than the other groups.

When asked if having information about the status of an autonomous vehicle would be helpful using a one to six scale where *one* is not helpful and *six* is extremely helpful, the majority of the participants across all three age groups rated having information about the status of the vehicle and what it is doing as extremely helpful, with 55% of the students, 81% of the adults and 52.9% of the seniors. When combining the ratings of both *five* and *six*, the percentage increases to 85% of the students. Due to the high number of students, adults and seniors who gave ratings above *four*, the non-significant result of the Analysis of Variance is clear due to the clumping of response scores. A follow-up question asked participants what information they want. Across the three age groups, *navigation*, *speed* and *information* about what the vehicle is doing were the most common responses. The students also want information regarding the vehicle's condition and diagnostics, due to the students' area of interest, they likely have a better understanding of diagnostic information in comparison to the other groups. The participants' preferred method of communication about this information was predominantly *visual* (students 82.6%, adults 71.4% and seniors 55.6%).

The ownership model for autonomous vehicles is unknown. Therefore, participants were asked if they are interested in having their own autonomous vehicle, using a rideshare service like Uber, using both their own vehicle and using a rideshare service or none of these. Overwhelmingly, the students envision using a *rideshare model* (75%). The adults were the only group that were spread between all four options including using a *rideshare model* (38.1%), both a *rideshare model* and *owning* (28.6%), *only owning* (19.0%) or *neither model* (14.3%). The majority of seniors reported *neither* (52.9%), indicating that most feel they do not want to use autonomous vehicles. Interestingly, the remaining seniors reported anticipating wanting to use a *rideshare service* (26.5%) or *own their own* (20.6%), but none of the seniors wanted to both *own* and use a *rideshare service*. The only other group to have a 0% was the students because they all anticipate either using *rideshare* (75%), using both their *own* and *rideshare* (20%), or having their *own* (5%); none of the students used the response of not using autonomous vehicles. Fully autonomous vehicles have the potential to increase ridesharing solutions [9]. Fagnant & Kockelman's [8] model analysis showed that personal vehicle ownership would reduce substantially with the increase in autonomous vehicles.

The final aspect of the study focused on ridesharing experiences in an autonomous vehicle. All participants are more open to riding in an autonomous vehicle with someone they know in comparison to a stranger. All of the students, 94.7% of the adults and 67.6% of seniors are comfortable with the idea of sharing a ride with someone they know but those percentages drop to 90.0%, 52.6%, and 29.4% respectively when sharing a ride with a stranger. Many studies have highlighted early users of ridesharing using autonomous vehicles are young riders and older adults are more hesitant [41,44, 45, 46]. From an energy use perspective, the decrease of only 10% for the students versus the decreases of 42.1% and 38.2% for the adults and seniors is encouraging and may result in growing up within an era of pervasive computing. Travelers expect the autonomous vehicle to have the desired features to multitask productively during the ride [3]. The model showed that the ability to use a laptop/tablet/notebook during the ride was significant for travelers to select their mode of transportation. Shared autonomous vehicles have the potential to provide a convenient and flexible transportation system without the burden of driving by oneself [4]. Shared autonomous vehicles allow riders to relax or do productive activities while traveling. Sharing the ride usage needs to be visible, providing opportunities for trial and generating positive word-of-mouth communications about the benefits of shared autonomous vehicles [5].

Throughout the study, generational differences were observed. The students had the most favorable attitudes and willingness to try autonomous vehicles. The automotive engineering students have an interest in the automotive field and had the greatest understanding of these concepts in comparison to the other groups and that likely contributed to why the students were not as concerned with having control. Rather, the students were more interested in being entertained and physically comfortable. Though the majority of adults understood and were willing to ride in autonomous vehicles, they were more concerned with what the vehicle was doing, especially the speed of the vehicle. Unlike the other groups, many of the seniors did not have an understanding of autonomous vehicles. This unfamiliarity may have been the primary influence of their responses, especially those who are not ready to ride in an autonomous vehicle. The seniors were primarily concerned with the ability to have physical control of the vehicle and would desire that level of control if riding in an autonomous vehicle. The user-specific requirements' for individual needs and wants have to be obtained from a broad range of fully autonomous vehicle users [12]. This requirement is essential while designing the autonomous vehicle and considering the end-user perspective.

The theme of being in control was obvious with the adult and senior groups in the context of riding in an autonomous vehicle. To increase user acceptance, autonomous vehicles may need to identify ways to engage the rider to make the user feel as though they are in control even when there are no physical controls (steering wheel and pedals) in the vehicle. A key component to making users feel in control of the vehicle may be related to how information is communicated. The participants want information about the status of the vehicle in order to understand what it is doing. The participants want to have an understanding of what the vehicle is doing. Providing essential and system transparent information about the vehicle may improve trust [47]. This is particularly important, given the reduced level of confidence in fully autonomous vehicles in comparison to traditional human-driven vehicles.

Ultimately, understanding who the vehicle user is, what information they need and how to communicate it, will be key factors in making the user feel comfortable and safe in fully autonomous vehicles.

5. Conclusions

An investigation of users' views of fully autonomous vehicles across the lifespan was conducted with three diverse participant groups, including 20 automotive engineering graduate students, 21 non-technical adults, and 34 senior citizens. During the interview, participants were asked questions to understand their opinions, awareness, and acceptance of future autonomous vehicles as owned or used as rideshare services. The results showed that acceptance of autonomous vehicles is influenced by their knowledge of these novel vehicles. Participants with an understanding of autonomous vehicles were more accepting or ready to ride, whereas participants without an understanding of autonomous vehicles were not accepting or ready to ride in the vehicles unless there was an option of manually controlling the vehicle. This was apparent in the differences observed between the engineering students, adults, and seniors, where all of the engineering students had knowledge of fully autonomous vehicles compared to 85.7% of the adults and only 50% of the seniors. The engineering students were the group most ready to ride, especially when compared to the seniors (58.8% not at all ready to ride). When fully autonomous vehicles are available, all participants prefer to use them as rideshare services (with known people) than owning them. On sharing the ride with strangers, automotive engineering students (90%) and adults (52.6%) were comfortable sharing a ride compared to the seniors (29.4%). The majority of all three groups of participants (85% of the engineering students, 81% of the adults, and 52.9% of the seniors) wanted to have information conveying the status of the vehicle, navigation details, and what the vehicle is doing. The results of the study suggest that enhancing awareness of the large population and real-time communication between the fully autonomous vehicle and the occupants will heavily influence users' acceptance of these vehicles.

5.1. Limitations and Future Research

While age related declines are common in seniors, it is unknown if any of the seniors in this study had any physical, visual or cognitive limitations. Future research should include a variety of users with physical, visual and cognitive impairments to understand how views of autonomous vehicles relate to different levels of functioning. The current study began to understand the factors that may influence users' opinions, awareness and acceptance of autonomous vehicles. Future research should further explore vehicle to user communication and information for various situations to understand what is crucial to make the user feel comfortable and safe, especially when the user is stressed or uncomfortable. The current study is more exploratory to know the users' opinion of autonomous vehicles designed for personal use or as a shared service. Future studies should explore the further design requirements from the user's perspective.

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Abbreviations

ANOVA - Analysis of variance

AV - Autonomous vehicle

AVAM - Autonomous vehicle acceptance model

CDRS - Certified driving rehabilitation specialist

CTAM - Car technology acceptance model

HVAC - Heating, ventilation, and air conditioning

M - Mean

SD - Standard deviation

TAM - Technology acceptance model

UTAUT - Universal theory of acceptance and use of technology

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