FINAL REPORT

PROJECT A3

AUGUST 2022

UF & UAB's Phase II Demonstration Study: Developing a Model to Support Transportation System Decisions Considering the Experiences of Drivers of All Age Groups with Autonomous Vehicle Technology

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UF | Transportation Institute UNIVERSITY of FLORIDA

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. Project A3	**2. Government Accession No.**	**3. Recipient's Catalog No.**

4. Title and Subtitle UF & UAB's Phase II Demonstration Study: Developing a Model to Support Transportation System Decisions Considering the Experiences of Drivers of All Age Groups with Autonomous Vehicle Technology (Project A3)	**5. Report Date** 8/10/2022 **6. Performing Organization Code**
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9. Performing Organization Name and Address University of Florida, Occupational Therapy, PO Box 100164, Gainesville, FL 32611 / University of Alabama at Birmingham, Department of Civil, Construction, & Environmental Engineering, Hoehn Engineering Bldg., Rm 140, 1075 13th Street, Birmingham, AL 35294	**10. Work Unit No.** **11. Contract or Grant No.** Funding Agreement Number 69A3551747104
12. Sponsoring Agency Name and Address *University of Florida Transportation Institute/* Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE) 365 Weil Hall, P.O. Box 116580 Gainesville, FL 32611 *U.S Department of Transportation/Office of Research, Development & Tech* 1200 New Jersey Avenue, SE Washington, DC 20590	**13. Type of Report and Period Covered** 3/1/2020 to 8/10/2022 **14. Sponsoring Agency Code**

15. Supplementary Notes N/A

16. Abstract - The deployment of autonomous vehicle (AV) technologies may hold health and safety benefits for drivers across the driving lifespan (>18 years of age). However, up until now, the perceptions of such drivers about AVs have not been examined with a combined approach of using surveys and pre- and post-exposure to the actual technology. Lived experiences of drivers engaging with AV technologies, i.e., experiencing a driving simulator in autonomous mode and riding in an autonomous shuttle (AS), in combination with surveys, can more accurately reveal the perceptions of drivers toward AV technologies. This project (Phase 2) had two objectives: (1) Quantify the younger and middle-age drivers' perceptions of AVs before and after "driving" a simulator (Level 4, SAE Guidelines) and after riding in a highly AS (Level 4, SAE Guidelines); and (2) Deliver predictive models of facilitators and barriers from data collected in Phase 1 (older drivers; N=104, Mage= 74.30, SD= 5.95) and Phase 2 (younger and middle-age drivers; N=106, Mage= 36.22, SD= 15.04), combined. The study included three different age cohorts, i.e., younger, middle-age, and older drivers. As such, the findings reveal important foundational information about driver acceptance, their intention to use AVs, barriers to AV technology, and well-being related to AV technology across the driving lifespan. Particularly, our findings have generated new knowledge and documented how demographics, optimism, ease of use, life space, driving exposure, and driving difficulty—not previously examined to this extent in the AV and driver literature—inform the field of the predictors of AV acceptance. We have provided strategies that may inform mobility managers, policy makers, and industry partners alike in improving upon deployment practices of AV technology (autonomous simulator and the AS) for the near future.

17. Key Words Autonomous shuttle; Autonomous simulator; Older, middle age, and younger drivers; Intention to use; Perceived barriers; Autonomous vehicle acceptance	**18. Distribution Statement** No restrictions

19. Security Classif. (of this report) N/A	**20. Security Classif. (of this page)** N/A	**21. No. of Pages** 57 pages	**22. Price** N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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ACKNOWLEDGEMENT OF SPONSORSHIP AND STAKEHOLDERS

This work was sponsored by a contract from the Southeastern Transportation Research, Innovation, Development and Education Center (STRIDE), a Regional University Transportation Center sponsored by a grant from the U.S. Department of Transportation's University Transportation Centers Program. The University of Florida Institute for Mobility, Activity and Participation (UF I-MAP) provided infrastructure and support for this study. The University of Alabama at Birmingham Transportation Engineering and Development (TREND) lab provided support for data analysis.

Funding Agreement Number – 69A3551747104

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ABSTRACT

The deployment of autonomous vehicle (AV) technologies may hold health and safety benefits for drivers across the driving lifespan ($\geq$18 years of age). However, up until now, the perceptions of such drivers about AVs have not been examined with a combined approach of using surveys and pre- and post-exposure to the actual technology. Lived experiences of drivers engaging with AV technologies, i.e., experiencing a driving simulator in autonomous mode and riding in an autonomous shuttle (AS), in combination with surveys, can more accurately reveal the perceptions of drivers toward AV technologies. Using our existing STRIDE Region 4 (UF and UAB) collaboration in UF & UAB's Demonstration Study (Phase 1) and including stakeholders and industry partners, this project (Phase 2) had two objectives: (1) Quantify the younger and middle-age drivers' perceptions of AVs before and after "driving" a simulator (Level 4, SAE Guidelines) and after riding in a highly AS (Level 4, SAE Guidelines); and (2) Deliver predictive models of facilitators and barriers from data collected in Phase 1 (older drivers; N=104, M_{age}= 74.30, *SD*= 5.95) and Phase 2 (younger and middle-age drivers; N=106, M_{age}= 36.22, *SD*= 15.04), combined.

For the first objective, a series of t-tests were used to assess baseline differences between group 1 (simulator first; SF) and group 2 (autonomous shuttle first; ASF) for four Autonomous Vehicle User Perception Survey (AVUPS) scores (i.e., *intention to use*, *barriers*, *well-being*, and *acceptance*). Next, a series of two-way mixed ANOVAs were deployed to test the main effects of group (group 1 SF and group 2 ASF) and time (baseline, post-visit 1, and post-visit 2), and group × time interaction, on the four AVUPS scores. The results have been detailed in the report, and we have provided insights pertaining to each of groups and the AVUPS outcomes.

For the second objective, four multiple linear regression models were conducted to predict AVUPS subscales (i.e., *intention to use*, *perceived barriers*, and *well-being*) and the *total acceptance* score. The four regression models have R^2 values ranging from 0.22 (*barriers)* to 0.36 (*well-being*). The results of the regression analyses indicated that *optimism* and *ease to use* positively predicted *intention to use*, *perceived barriers*, *well-being*, and the *total acceptance* score. *Driving difficulty* significantly predicted *barriers*, whereas *miles driven* negatively predicted *well-being.* The regression analysis results indicated that predictors of user *acceptance* of AV technology include *optimism*, *ease of use*, *race*, *and age*, with 33.6% of the variance in *acceptance* being explained by the predictor variables.

The study included three different age cohorts, i.e., younger, middle-age, and older drivers. As such, the findings reveal important foundational information about driver *acceptance*, their *intention to use* AVs, *barriers* to AV technology, and *well-being* related to AV technology across the driving lifespan. Particularly, our findings have generated new knowledge and documented how *demographics*, *optimism*, *ease of use*, *life space*, *driving exposure*, and *driving difficulty*—not previously examined to this extent in the AV and driver literature—inform the field of the predictors of AV acceptance. We have provided strategies that may inform mobility managers, policy makers, and industry partners alike in improving upon deployment practices of AV technology (autonomous simulator and the AS) for the near future.

Keywords (up to 5):
Autonomous shuttle; Autonomous simulator; Older, middle age, and younger drivers; Intention to use; Perceived barriers; Autonomous vehicle acceptance.

EXECUTIVE SUMMARY

This project directly addressed the **STRIDE Strategic Area 2: Performance Measurement & Management Using Connected & Automated Vehicle Data.** Specifically, the proposed study had two objectives: (1) Quantify the younger and middle-age drivers' (N=106) perceptions, values, beliefs, and attitudes, before and after "driving" a simulator (Level 4, SAE Guidelines) and after riding in a highly autonomous shuttle (AS) (Level 4, SAE Guidelines); and (2) Build a predictive model of facilitators and barriers from the data collected in this Phase 2 project, in combination with the Phase 1 older driver data (*N*=104) collected via UF & UAB's Demonstration Study: Older Driver Experiences with AV Technology; 15 Aug 2018-28 Feb 2020; STRIDE D2.

For the first objective, each of the drivers (younger: n=53, 18–39 years old; middle-age: n=53, 40–64 years old) completed baseline surveys and was exposed to "driving" a high-fidelity Realtime Technologies Inc. (RTI; Royal Oak, MI) driving simulator and in an autonomous shuttle (AS; EZ10, TransDev), both operating at Level 4 according to the Society for Automotive Engineers (SAE). Participants' perceptions were measured with the Autonomous Vehicle User Perception Survey (AVUPS) prior to and after exposure. The main predictor variables were *age*, *optimism*, *ease of use*, *life space*, *driving exposure*, and *driving difficulty*; whereas the main outcome variables of interest were the AVUPS' *intention to use*, *barriers*, *well-being*, and the total *acceptance* of autonomous vehicle technology. A series of statistical tests were run to indicate the between-group differences for each one of the outcome variables. Next, a series of two-way mixed ANOVAs were deployed to test the main effects of group (simulator first exposure, AS first exposure), time (baseline, post-visit 1, and post-visit 2), and group × time interaction effects, on the four AVUPS scores. The results have been detailed in the report, and we have provided insights pertaining to each of groups and the AVUPS outcomes.

For the second objective, four multiple linear regression models were conducted to identify the predictors of the AVUPS subscales and acceptance score among three groups combined (older drivers: N=104, M_{age}= 74.30, *SD*=5.95; younger and middle-age drivers: N=106, M_{age}=36.22, *SD*=15.04). The findings suggest that *optimism* and e*ase of use* positively predicted *intention to use*, *perceived barriers*, *well-being*, and the *total acceptance* score. *Driving difficulty* significantly predicted *barriers*, whereas *miles driven* negatively predicted *well-being.*

This project was not without challenges as it occurred during the pandemic. It was halted from March 2020–September 2020 due to a University mandate that issued COVID-19 restrictions on all research activities. Upon resumption of the research, the CDC guidelines (i.e., personal protective equipment, restricting the number of passengers, sanitation before, during, and after exposure, social distancing, temperature checking, short COVID-19 screening questionnaire) were implemented. An extension of the AS route occurred on June 1, 2021, adding four more right turns, one left turn, and one stop. The team did not control for this route extension in the analysis.

The project team completed the data collection at the end of September 2021. Limitations and strengths of the study are detailed in the report.

Overall, we concluded from the regression analysis results that positive predictors of user *acceptance* of AV technology include *age* (older), *race* (White), *optimism*, *ease of use*, which together explained a third of the variance in the total *acceptance* score. We have provided strategies that may inform mobility managers, policy makers, and industry partners alike to improve upon deployment practices of AV technology (autonomous simulator and the AS) for the near future.

1.0 INTRODUCTION

Every year, roughly 1.3 million road users die in car crashes worldwide (Beltz, 2018). In the U.S., where 9 out of 10 serious roadway crashes occur due to human behavior, autonomous vehicle (AV) technologies promise to prevent the four Ds of hazardous driving (i.e., drinking, drugs, distraction, and drowsiness), which are particularly prevalent in younger and middle-age drivers (Begg et al., 2003), and provide mobility to not only the general population but also to those who are mobility vulnerable with chronic, progressive or other disabling conditions (Fagnant & Kockelman, 2015; National Highway Traffic Safety Administration & United States Department of Transportation, 2017). The U.S. Department of Transportation (USDOT) and National Highway Traffic Safety Administration (NHTSA) are committed to establishing transportation equity and reaching an era of crash-free roadways through deployment of innovative lifesaving technologies such as AVs. In 2017, they issued *Automated Driving Systems: A Vision for Safety 2.0* (NHTSA & USDOT, 2017) to guide best practices for deployment of AVs and prioritized safety design elements which include better understanding human machine interface, consumer education, and user training. The scientific community and industry partners expect that AV will have tremendous safety and health benefits for road users throughout the lifespan *if users accept and adopt these technologies* (AUVSI, 2018). Recent reviews (Becker & Axhausen, 2017; Gkartzonikas & Gkritza, 2019) suggest that *age* (Abraham et al., 2016; Bansal & Kockelman, 2017; Bansal et al., 2016; Haboucha et al., 2017; Hulse et al., 2018; J.D. Power and Associates, 2012; Madigan et al., 2016; Missel, 2014; Pakusch et al., 2018; Payre et al., 2014; Rodel et al., 2014; Schoettle & Sivak, 2014; Venkatesh et al., 2003), *gender* (Abraham et al., 2016; Anania et al., 2018; Bansal et al., 2016; Schoettle & Sivak, 2014), *technology readiness* (Parasuraman, 2000; Parasuraman & Colby, 2015), and *AV exposure* (J.D. Power and Associates, 2012; Xu et al., 2018) moderate users' acceptance and willingness to use AVs, as further described in the next section.

Currently, there is considerable geographic variation in the extent of AV exposure, due to wide variation in the regulations concerning the ability to operate AVs on public roads (Penmetsa et al., 2019). In June 2019, Governor Ron DeSantis signed House Bill 311 that paves the way for Florida to continue as an international leader in AV testing and innovation. Due to the potential of AVs to offer a multitude of advantages to road users, it is essential to monitor the public's opinion on this particular technological development. However, based on recent studies examining consumer preferences of AVs, road users indicated that *trust and hesitation* exist around their comfort in adopting full vehicle automation (Abraham et al., 2017; Hulse et al., 2018; Liu et al., 2019; Missel, 2014; Reimer, 2014, Rodel et al., 2014). Regional (i.e., city and state) differences within the U.S. may also exacerbate differential rates of vehicle automation adoption. For instance, 28.4% of Texans (45±16 years old) were not interested in using AVs regardless of price, compared to 19% of individuals (37±16 years old) living in Austin, Texas (Missel, 2014; Rodel et al., 2014). Additionally, demographic and built-environment variables (e.g., technology proficiency, socioeconomic status, land type) affect users' perceptions of AVs. Interestingly, social pressures or influences were similar between younger and older drivers with 50% of Texans preferring their friends and/or family to use AVs before they themselves adopt them. A weakness of these studies is that road users were only surveyed, and as such not exposed to riding actual AVs.

One type of AV of particular interest for this project is the autonomous shuttle (AS), which is represented in the family of automated shared ride services. Research indicates that exposure to AVs in combination with surveys, may more accurately reveal the perceptions and/or hesitations of drivers before, during, and after "driving" the autonomous simulator or the AS and thus inform scientists, manufacturers, and engineers of adjunctive strategies (i.e., guidelines, tips, techniques, tools) to enhance acceptance and adoption practices of AS among drivers. For example, findings from our work documented in the final report of the Phase I UF and UAB study indicated that in older drivers (≥65 years old), perceptions before and after exposure to AV technologies (i.e., SAE Level 4 simulator and AS) change favorably for some variables (e.g., trust and safety when exposed to both modes) or for their intention to use AV technology, when exposed to the simulator. As such, these findings can inform health care professionals, engineers, city managers and transportation officials of opportunities and barriers to improving drivers' interaction with AS and facilitate their ease-of-use practices and adoption of these technologies (Classen et al., 2021). It is critical that scientists understand the AS *acceptance* of drivers through the lifespan. In fact, findings from the work proposed here and from others may result in strategies to further improve upon acceptance and adoption practices of AS, suggest practical hints to engineers for refining design elements, and provide information to shape the city or state policies for regulatory purposes of AV deployment, adoption, and use.

The Scientific Premise of This Proposal – Every year, roughly 1.3 million younger, middle-age, and older drivers as well as other road users die in car crashes, worldwide. The deployment of AV, including AS, is expected to have tremendous health and safety benefits for all road users that may potentially save lives. The State of Florida is a pioneer for AS testing and the City of Gainesville is invested in becoming a smart city. The UF and UAB have successfully completed a demonstration study of older driver perceptions pertaining to AV technology. Building on this foundation, our expert group used the methodologies, equipment (a high-fidelity driving simulator and autonomous shuttle) and infrastructure (i.e., existing collaborating team of scientists, City of Gainesville, TransDev, and stakeholders) to study younger and middle-age drivers' perceptions, values, beliefs, and attitudes pertaining to AV technologies and to combine that with older drivers' data. Findings from this work will be a foundational step towards understanding strategies necessary for acceptance and deployment of AS. This work will also lay the foundation for AV technology (both modes: simulator and AS) use in those who are socially and/or medically disadvantaged, disabled, demented, or deskilled (e.g., elderly).

1.1 Objective

This project directly addresses the **STRIDE Strategic Area 2: Performance Measurement & Management Using Connected & Automated Vehicle Data.** Specifically, the study had two objectives: (1) Quantify the younger and middle-age drivers' (N=106, 80% power) perceptions, values, beliefs, and attitudes, before and after "driving" a simulator (Level 4, SAE Guidelines) and after riding in a highly autonomous shuttle (AS) (Level 4, SAE Guidelines); and (2) Build a predictive model of facilitators and barriers from the data collected in this Phase 2 proposed project, in combination with the older driver data (N=104, 80% power) collected via the Phase 1 (Project D2).

1.2 Scope

This research assessed younger and middle-age drivers' perceptions of AVs after direct exposure to AV technology and compared it to the older drivers' experiences obtained from Phase 1. This study employed a scientifically rigorous approach, i.e., collecting baseline data and a validated and reliable AV User Perception Survey (Mason et al., 2021) to assess perceptions of younger and middle-age drivers after exposure to both an autonomous shuttle and a driving simulator. The final outcome of the project is to understand the perceptions of drivers through the lifespan before and after exposure to the two types of AV modes.

2.0 LITERATURE REVIEW

2.1. AV Technology, including the Autonomous Shuttle and the Autonomous Driving Simulator

Autonomous vehicles are an emerging travel mode gaining attention mainly due to perceived safety and convenience. Considerable public and private investments in the AV industry are projected to total $7 trillion by 2050 (Intel, 2017). Still, uncertainty remains pertaining to travelers' trust and intention to use AVs. This literature review provides a synthesis of findings from earlier studies examining the perceptions and attitudes of travelers with respect to AV technologies, particularly AS, including the impacts of *age* and *gender* in preferences and other user perceptions.

Shared automated vehicle services, with the AS being one such mode, represent transformative technologies that may be revolutionizing existing transportation systems. Although SAV services were first conceptualized in the early 1990s in Europe, marketable deployment of these services is only now beginning to materialize (Parent & de La Fortelle, 2005). The literature indicates existence of different types of SAV systems, classified according to the operations involved (e.g., booking time, ability to share such systems) and the level of integration with other transportation modes (Narayanan et al., 2020). Full deployment of the SAV is questionable, as the current estimations of market penetration vary from 8%–84% in 2035 (Lyons & Babbar, 2017) to 50% of fleet composition predicted in 2050 (Litman, 2020). However, knowledge of the public's perceptions for successful and sustainable use of these systems in a scalable way, over the long-term, is paramount for successful deployment. Further, to avoid negative transportation network operational impacts (e.g., traffic congestion as a result of too many vehicles) and environmental consequences (e.g., light pollution, community severance, or safety hazards), these SAVs must be synchronously shared with high levels of acceptance and trust among the public (Paddeu, Parkhurst, & Shergold, 2020).

Automated driving simulators are used to assess user perceptions of AV technology. For example, Mok et al. (2017), used an immersive full car driving simulator to provide insight in drivers' trust as they experience SAE levels 2 and 3. The participants found the simulator more trustworthy over time. Likewise, Haghzare and colleagues (2021) conducted a study on 36 older adults in a fully automated high-fidelity driving simulator and found their acceptance of the AV technology was high, particularly if the simulator is operating in a style like their own vehicle. Also, preference for the use of AV technology increased after exposure; however, those 80+ years of age expressed significantly more negative attitudes regarding expected performance of the AV technology. In our own work, we have indicated that a high-fidelity simulator can adequately be used to assess the before and after perceptions of older drivers (65+

years old), and that the simulator exposure particularly increases intention to use, safety, and trust in the AV technology (Classen et al., 2020; Classen et al., 2021).

As such, from these early studies, it appears that AV technology, including AS and automated simulators, may be used as plausible modes to examine user perceptions on acceptance and adoptions patterns. Moreover, AV technology holds plausible opportunities for health and safety, and the automated simulator may be used as a suitable substitute for on-road exposures to determine the perceptions of adults on this automated technology.

2.2 Age as a Predictor of AV Technology Acceptance by Survey or Exposure to AV Technology

2.2.1. Exposure to Survey Only

Charness and colleagues (2018) surveyed 441 adults about their perceptions of AVs. They found that the type of AV exposure (i.e., SAE Level 4) did not show any significant relationship with participant's age. However, older adults showed more concern with AV technology than their younger counterparts. Likewise, Abraham and colleagues (2017) surveyed ~3000 drivers and found that comfort with AV technology decreased with age. About 40% of younger adults (25–34 years old), 23% of middle-age adults (45–54 years old), and 14% of older adults (65–74 years old) were comfortable with AVs. This finding was consistent with the review of Becker and Axhauser (2017) examining age as a predictor of AV acceptance. They reported that from the 10 studies reviewed, six indicated that younger adults were more accepting of AVs than older adults (Becker & Axhausen, 2017); one found a positive correlation between age and AV acceptance (Haboucha et al., 2017); whereas three found no significant differences between age groups (Krueger et al., 2016; Kyriakidis et al., 2015; Missel, 2014).

A U.S.-based survey conducted by Lee (2019) indicated that among 3505 adults (16–75+ years), older adults (i.e., 55+ years old) were less comfortable with higher levels of automation. However, other variables, such as a higher degree of education and income, also contributed to predicting acceptance. A survey study completed on 1088 Texans designed to gather attitudes of AV technology (SAE Level 4) showed attributes of Texans' adoption of and interest in AVs. Results suggested that older people had lower interest for all levels of automation (Bansal & Kockelman, 2017). Rovira et al. (2019) surveyed trust in AVs among 138 participants (86 younger and 52 older adults) and concluded that while trust in self-driving vehicles is dependent on multiple interacting variables, in general, there were few age differences in the measure of trust.

As such, and based on the studies above, age is a predictor of acceptance of AV technology, generally indicating that younger adults (vs. older adults) are more accepting of AV technology, without exposure, and when being surveyed (Bansal & Kockelman, 2017; Becker & Axhausen, 2017; Charness et al., 2018; Abraham et al., 2017; Haboucha et al., 2017; Lee et al., 2019). That being said, some studies find no predictive validity in age pertaining to acceptance. Acceptance of technology, however, is a complex construct that must be understood in terms of trust, safety, intention to use, and comfort with the technology as well (Rovira et al., 2019). Moreover, although age is an important predictor of AV acceptance, other variables such as gender, education, and socioeconomic factors must also be considered (Lee et al., 2019).

Kaye and colleagues (2020) solicited perceptions of participants (*N* = 438) on their trust and intention to use AS and found a positive relationship between age and perceived trust in AS, with age being a negative predictor of future intentions to use. Contrary to the findings of Kaye et al., a Berlin-based survey of the perceptions of individuals to AS (N=384), indicated that older adults were more positive when compared to younger adults. However, although these participants could visualize the AS a public transportation mode, they were not inclined to replace their current mode of primary transportation as a trade-off to the AS (Nordoff et al., 2018).

Interestingly, Liljamo and colleges concluded that although age has an impact on positive attitudes towards AVs, it was the middle-age participants (compared to the 18–24 years old and the 55–64 year old groups) in particular, who demonstrated the most positive attitudes (Liljamo et al., 2018). To further indicate heterogeneity in findings pertaining to age and AV acceptance, Texas A&M Transportation Institute (2016) conducted an online survey (N=3097) and found no correlation with age and acceptance or intent to use AVs. In fact, psychosocial variables proved more influential when compared to demographic variables, as these researchers found that individuals with a travel-restrictive disability were the most likely to indicate use of AVs. Finally, and most consistently with the mainstream thinking in AV studies, Schoettle and Sivak (2016) found from a public opinion survey (N=1533) conducted over two consecutive years (2015–2016) that as age increased, the *acceptance* and preference level in AV decreased.

Based on the studies above, a wide variance in acceptance is observed. Some studies suggest that old age is a negative predictor of acceptance for AS (Kaye et al., 2020; Schoettle & Sivak, 2016), and another indicates that middle-age adults (compared to younger and older adults) have greater acceptance towards AVs (Liljamo et al., 2018). Yet, another indicates that older adults had the greatest level of acceptance for AVs, even if they will not trade their primary mode of transportation (Nordoff et al., 2018). Finally, the review indicates that age alone is not the determining factor in acceptance, especially when different demographics and individuals with disabilities are factored into the analysis as well (Lee et al., 2019; Texas A&M Transportation Institute, 2016).

2.2.2. Exposure to AV Technology

Interestingly, in a study among Chinese undergraduate students, Xu and colleagues (2018) found that AV exposure increased trust, perceived usefulness, and perceived ease of use of AVs. However, findings cannot be generalized across cultures and nationalities. For example, Anania and colleagues (2018) found that younger to middle-age adults' willingness to ride in an AV differed across nationality and gender after being exposed to various AV newspaper headlines. As such, age may vary in predicting AV *acceptance*, based on nationality, culture, and gender.

2.2.3. Exposure to the Autonomous Shuttle

In Europe, Madigan and colleagues (2016) exposed 349 adults (16–74 years old) to the EZ10 AS and found that age was no longer a factor in predicting acceptance after direct exposure to the AS. Likewise, Classen and colleagues (2020; 2021) conducted a repeated measures crossover design, with random allocation of 104 older drivers who were exposed to an automated shuttle and a driving simulator in automated mode (SAE Level 4). Although all the participants were above 65 years of age, no age cohort effects were observable in the AS acceptance, but older drivers' perceptions of safety, trust, and perceived usefulness of AS increased after exposure. As such, studies indicate that age are no longer a strong predictor of acceptance after participants have been exposed to an AS (Madigan et al., 2016; Classen et al., 2020; 2021). However, older adults are improving in their acceptance, specifically related to perceptions of safety, trust, and perceived usefulness of AS after being exposed to the use of such technology (Classen et al, 2020; 2021).

2.2.4. Exposure to Autonomous Driving Simulator

Hartwich et al. (2019) examined the development of drivers' trust and acceptance of an autonomous driving simulator by exposing 20 younger (25–45 years old) and 20 older (65–85 years old) adults. Both age groups showed slightly positive a priori trust and acceptance ratings, which significantly increased after the initial experience and remained stable afterwards. However, compared to younger drivers, older drivers reported more positive attitudes (Hartwich et al., 2019).

In a simulator study utilizing 72 participants, Molnar et al. (2018) considered the impact of age, gender, and simulator realism. Age effects were found for variables related to driving performance and perceptions about automated technology. Specifically, middle-age drivers were the least likely to express outright trust in automated driving, while the older age group was more likely to be comfortable with someone else driving the vehicle.

In summary, although age influences AV acceptance, generalizations are challenging because several limitations, such as unbalanced age groups, varying levels of psychometric rigor in surveys, able vs. disabled persons, and cultural or national contexts exist and may further influence the estimates of the results. However, what is clear is that in general, older and younger adults are more positive towards AV technology (autonomous simulator and/or AS) after exposure and that older adults generally, at least in the U.S., demonstrate the largest positive shift in perspective when compared to younger adults.

2.3 Gender as a Predictor of AV Technology Acceptance

According to U.S. Census data, women are outnumbering men in the U.S. adult population by 2.5% (roughly over 7 million) (United States Demographic Statistics, 2017). It is well known that men and women show different driving behaviors that affect their attitudes, safety, and perceived risk (The Social Issues Research Center, 2004). With known differences in driving behavior and the potential for women to have a great influence in the transportation system, gender may reveal interesting acceptance and adoption practices of AV technology.

2.3.1. Survey Exposure

Charness surveyed acceptance in 441 adults (M_{age}=37.14; *SD*=12.79; age range=18–73; 61.4% women) towards AVs and found that gender played a significant role in attitudes towards concern of AVs, eagerness to adopt AVs, and willingness to relinquish driving control (Charness et al., 2018). Specifically, eagerness to adopt was lower in women whereas willingness to relinquish driving control was more prevalent among men. Abraham and colleagues (2017) surveyed ~3000 drivers and found that men (vs. women) are more comfortable with AV technology. Likewise, Becker and Axhausen (2017) concluded that younger adults in urban environments, men (vs. women), and those currently owning a vehicle with AV technologies tend to be the most positive about using AV technology.

Additionally, from the study by Liljamo and colleagues (2018), men (vs. women) had more positive attitudes, and the assumption was made that men will adopt new technology sooner than women. But, in a public opinion survey (aligned with census characteristics in 2010), Schoettle and Sivak (2016) found no significant differences in gender pertaining to AV preferences when comparing men to women. However, Hohenberger and colleagues (2016) utilized responses (N=1603) to analyze the effect of age and sex (M_{age}= 48.51; *SD*=15.64; female=51.3%) on AV acceptance and willingness to use practices. Responses showed that men (vs. women) were more likely to associate positive emotions with AVs. Moreover, they found that younger women and older men have more anxiety associated with willingness to use AVs.

2.3.2. Autonomous Shuttle Exposure

Studies are starting to emerge to examine gender differences in the AS literature. For example, Nordoff et al. (2018) exposed individuals (N=384) in Berlin, Germany, to an AS and found that gender did not have a significant effect on intention to use the AS. Likewise, Classen and colleagues (2020; 2021) found no gender differences in acceptance and adoption practices among older drivers who have been exposed to the AS.

2.3.3. Autonomous Driving Simulator Exposure

Molnar et al. (2018) examined responses of participants (N=72) to automated simulation realism in a driving simulator. Although age, gender, and simulator realism were included as control variables, their model did not show significance in variance for age or gender in trusting the automation ($F(3, 56)=0.47$; $p=0.71$). Likewise, Classen and colleagues (2020; 2021) found no gender differences in acceptance and adoption practices among older drivers who have been exposed to the driving simulator running in automated mode. Loeb et al. (2019), however, did find age and gender differences in emergency takeover from automated mode to manual driving mode in the driving simulator. Specifically, 60 participants (male=48%; teens aged 16–19=32%; adults aged 35–54=37%; seniors aged 65+=32%) were exposed to the driving simulator running in autopilot, and the results indicated that the men crashed less than women and that the middle-age group crashed less than the other age groups. A gender effect was also observed by Sheng et al. (2019) who tested 19 participants ($M_{age}=22.57$; $SD=3.76$; 63% female) in a high-fidelity driving simulator in fully autonomous mode. The findings indicated that a significant main effect exists for gender (F (1, 302) =10.62; $p=0.001$; $\eta^2=0.47$) with men (vs. women) showing higher trust in the automation.

In summary, among adults, mixed results exist for gender as an ubiquitous predictor of acceptance of AV technology. Overall, it seems that men (vs. women) are more positive towards adopting AVs and surrendering control (Becker et al., 2017; Charness et al., 2018; Liljamo et al., 2018; Abraham et al., 2017) when being surveyed. However, with exposure to the AV technology, mixed results exist as no gender differences are reported in the extant literature (Classen et al., 2020; 2021; Molnar et al., 2018; Nordhoff et al., 2018; Schoettle & Sivak 2016;) pertaining to older drivers. Yet, gender differences do exist where different age cohorts are exposed to AV technology (Loeb et al., 2019; Sheng et al., 2019). As such, gender differences in the context of AV technology perceptions vary by age, and the gender-age phenomenon must be examined in follow-up studies to better understand its role in predicting AV acceptance.

3.0 TASK 1: YOUNGER AND MIDDLE-AGE DRIVERS' PERCEPTIONS BEFORE AND AFTER EXPOSURE TO AUTONOMOUS VEHICLES

3.1 Introduction

Although the deployment of autonomous vehicles may hold health and safety benefits for younger and middle-age drivers, not much is known about their perceptions when they are being exposed to AV technology, such as a driving simulator running in automated mode or the AS. Lived experiences via exposure to "driving" a simulator in autonomous mode and an AS, in combination with surveys, may provide more accurate insights into the perceptions of younger and middle-age drivers before and after "driving" the autonomous simulator or the AS.

3.1.1. Objectives

This study sought to:

(1) Quantify the younger and middle-age drivers' (N=106, 80% power) perceptions, values, beliefs, and attitudes before and after "driving" a simulator (SAE Level 4) and after riding in an AS (SAE Level 4); and

(2) Build a predictive model (N=210) of facilitators and barriers from the data collected in this project, in combination with the Phase 1 older driver data (N=104) collected via UF & UAB's Demonstration Study: Older Driver Experiences with AV Technology, 15 Aug 2018-28 Feb 2020, STRIDE D2.

3.2 Methodology

The Institutional Review Board (IRB) of the University of Florida approved this study (IRB202000464).

3.2.1. Design

Experimental repeated measures crossover design with *baseline survey*, exposure to the autonomous driving simulator and AS, *post-visit survey 1*, crossover to simulator or AS, and *post-visit survey 2*. These prospective data were analyzed with the data obtained from Phase 1 to provide a predictive model quantifying experiences of drivers from all *age* groups (young, middle-age, and old) with AV (simulator and AS) technology.

3.2.2. Recruitment

We recruited participants through the infrastructure and support of the UF Student Government, UF HealthStreet, UF Health Study Listings (StudyConnect), Rotary Clubs of Gainesville, UF's Institute for Mobility, Activity and Participation recruitment pool, ResearchMatch, The Village Senior Living Community, FDOT's Safe Mobility for Life Coalition, and local community organizations (e.g., libraries, churches, recreation centers). Recruitment presentations and/or postings were provided to audiences at these locations. We posted notices on social media sites (e.g., UF Studies). All strategies were IRB approved. Participants received $25.00 for participation.

3.2.3. Participants

We included 106 licensed community-dwelling younger (N=53, 18–39 years old) and middle-age (N=53, 40–64 years old) drivers of both genders and racial representation from North Central Florida, who had driven in the last 6 months, could travel to the site of testing in Gainesville, and could participate across 2–3 visits in four 15-minute surveys, a 15-minute simulated drive, and a 15-minute AS drive. We excluded participants who did not communicate in English, were transportation dependent, and showed cognitive impairment, i.e., scored <18 on the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005).

3.2.4 Equipment

The Autonomous Shuttle (AS) – We used the same autonomous shuttle (EasyMile EZ10) provided by Transdev as used in the STRIDE D2 project. The EZ10 AS can transport up to 12 passengers, is fully electric, and has embedded automated driving capabilities that allow it to integrate into an automated road transport system for public transportation in private areas or cities at a speed reaching 28 mph. Participants rode in this AS in a low speed (≤15 mph) environment (see Route Description). A Transdev engineer developed the mission file, which specified the desired goal points, as the system autonomously generates a route, and then executes the path. The AS uses lidar, cameras, and GPS to survey the environment and decide upon the best motion behaviour at each instant. The EZ10 can operate in two driving modes: (1) the automated mode, in which the vehicle is self-driven and follows its programs and missions; and (2) the manual mode, in which an operator drives the EZ10 manually with a remote control. The operator may shift the shuttle into manual mode if hazards (i.e., roadblock, construction, etc.) arise that impact autonomy. Additionally, the operator is onboard to aid passengers that require mobility assistance, inspect and provide vehicle maintenance, and control the shuttle's climate.

Figure 3-1. EasyMile EZ10 autonomous shuttle

Participants were exposed to a 20-minute AS ride at low speed (≤15 mph). The initial AS ride started in a downtown parking garage (220 SE 2nd Ave., Gainesville, FL), exited the parking garage and travelled south on 2nd Ave., turned right on SW 2nd Ave., and continued to the roundabout at 10th St., where it looped around and returned to the parking garage. This environment poses ambient traffic and included the AS encountering pedestrians, cyclists, and other road users.

Figure 3-2. Road Course for the Autonomous Shuttle in Downtown Gainesville, FL

The shuttle route was extended beginning June 1, 2021, adding one more roundabout, two stops, four right turns, and one left turn. This route extension increased the shuttle ride from 20 minutes to 30 minutes.

Figure 3-3. Extended road course for the autonomous shuttle in downtown Gainesville, FL

The Driving Simulator – The Realtime Technologies Inc. (RTI; Royal Oak, MI) simulator, a high-fidelity and multi-sensory simulator configured on a computerized platform, customizable and scalable, was used in this study (Figure 3-4). The simulator is integrated into a full car cab with seven HD visual channels and three forward channels creating a 180° field of view, with additional visual display channels, high-fidelity graphic resolution, component modeling, steering feedback, spatialized audio with realistic engine, transmission, wind and tire noises, and an autopilot feature to turn the simulator into AV mode. The visual display operates at a 60-Hz refresh rate to support smooth graphics projected on three flat screens with high intensity projectors. Behind-car views are accomplished with one rear screen (seen through the rearview mirror), two built-in LCD side mirrors, and one virtual dash display (LCD panel) within the car. The system allows for drives with changing environmental conditions, video recording of the driver's simulator session, and incorporation of rural, urban, and highway driving. Data are collected in real-time and can be plotted for immediate feedback (e.g., displaying lane offset, time headway or number of lane crossings) or saved for post-analysis. The simulator operating system drives include a combination of ambient and scripted traffic that interacts realistically with other vehicles based on human behavior or decision models and real-time physics-based vehicle dynamics calculations. The scenario for this study utilized the autopilot feature for a 10-minute automated drive, built to replicate the AS on-road experience (see Route Description). The scenario includes low to moderate speed (15–30 mph, city area) with realistic road infrastructure, buildings, ambient traffic. The system handles all aspects of the designated driving task. A control area situated at the rear of the vehicle overlooks the driver, vehicle, and screens and allows the operator to control and monitor all aspects of the experiment.

Figure 3-4. RTI high-fidelity simulator

3.2.5 Procedure

We quantified the perceptions of younger drivers (N=69, 18–39 years old) and middle-age drivers (N=37, 40–64 years old), who have been exposed to “driving” the autonomous simulator and riding in the AS. Each participant completed a baseline survey, matched for *age* (±2 years) and gender, and then randomly assigned to complete drives either in the simulator (N=53; at the Smart House) or the AS (N=53; in downtown Gainesville) on two separate occasions. Each participant completed post-visit survey 1 (same content as baseline survey), then crossed over to “drive” the modality not initially driven and completed post-visit survey 2 (same content as baseline survey). Thus, each participant was exposed to both the simulator and the AS, so we were able to make meaningful comparisons across the four surveys. Participants driving the simulator and/or the AS may be prone to developing simulator sickness. As such, we implemented our tested and standardized Simulator Sickness Protocol (Brooks et al., 2010; Classen et al., 2011; Stern et al., 2017) to prevent, reduce, or mitigate the occurrence of simulator sickness. Protocol measures included dietary recommendations prior to the drive, utilizing an acclimation protocol, employing a simulator sickness questionnaire, increasing the correspondence between the various sensory, i.e., visual, kinesthetic and vestibular cues, supplying environmental adaptations (5-minute acclimation drive; 10-minute simulator drive; cool comfortable conditions at 72°F, air circulating via fan, avoidance of complex sensory scenes), and determining and managing the simulator sickness symptoms. These methods had proven to be successful in our previous older adult studies (Classen et al., 2011; Shechtman et al., 2007, 2008). We maximized our strategies (per IRB protocol) to protect against risk and optimize participant comfort and safety. Also, we followed the COVID-19 guidelines from the Centers for Disease Control and Prevention, from the National Highway Traffic Safety Administration, City of Gainesville, and Transdev. Moreover, these protocols were approved by the UF's Office of Research and the IRB.

The implementation of this research was halted due to the COVID-19 pandemic. On March 9, 2020, Governor Ron DeSantis issued Executive Order 20-52, proclaiming a State of Emergency for COVID-19. Accordingly, recruitment and data collection were on hold until June 26, 2020. The College of Medicine's Associate Dean for Research approved the research activity on June 26, 2020, acknowledging the Research Resumption Plan reflecting COVID-19 guidelines. The study required screening, baseline surveys, and exposure to the AS and the driving simulator. The AS ride was limited to two participants per ride, while maintaining social distancing and the safety operators using sanitizer wipes to disinfect high-touch surfaces before and after each ride. Researchers, research participants, and safety operators from Transdev were issued personal protective equipment and kept their face masks on during the drive. The driving simulator exposure took place at the UF Smart House in the Oak Hammock Retirement Community. Before entering UF Smart House, temperature checks were performed for all the participants and hand sanitizers were placed throughout the Smart House. The researchers sanitized the driving simulator before and after each ride. The COVID-19 protocol was rigorously followed, resulting in no reported cases during or after data collection.

3.2.6 Measures

Data collection occurred via capturing participants' demographic and medical information and survey responses. Trained project staff performed data collection and entry. The researchers collected demographics and medical information such as *age*, gender, ethnicity, education, marriage, employment status, and health conditions (U.S. Department of Health & Human Services, 2019). The Trail Making Test, Parts A and B, (TMT A, TMT B), Automated Vehicle User Perception Survey (AVUPS), Technology Readiness Index 2.0 (TRI), Technology Acceptance Model (TAM), Life Space Questionnaire (LSQ), and Driving Habits Questionnaire (DHQ) were administered for the baseline surveys.

The TMT A & B are paper-based neurological tests used for screening and assessing cognitive function, specifically set shifting and aspects of executive functioning (Avers & Wong, 2019). The TMT has two parts, TMT A measures visual scanning and visuomotor speed, and TMT B additionally involves executive functions. In each test, the participant is asked to draw a line between 24 circles that are randomly printed on a piece of paper. For part A, the circles have only the numbers, whereas for part B, half of the circles are numbers, and the other half are alphabet letters. Participants are asked to connect the circles in an ascending order, which makes the part B more difficult task. The test is timed until completion, and the completion time (in seconds) is the final score of the test (Avers & Wong, 2019).

The AVUPS (Mason et al., 2021, Appendix B) is a visual analog scale for the purpose of assessing individuals' perceptions of AVs. AVUPS consists of 28 items that the participant ranks from 0=disagree to 100=agree and an additional four open-ended items. AVUPS could measure nine subdomains (*intention to use*, trust, perceived usefulness, *perceived ease of use*, perceived safety, control and driving efficacy, cost, authority, and social influence) categorized into three subscales, i.e., *intention to use, barriers, well-being* and the *total acceptance score of* AV technology.

The TRI 2.0 (Parasuraman, 2000; Parasuraman & Colby, 2015) and TAM (Davis, 1989) indicate the prior exposure to technologies and *acceptance* of technology. The TRI examines individual's readiness to use technology across four categories (*optimism*, innovativeness, discomfort, and insecurity) and includes 16 items (scored from 1=strongly disagree to 5=strongly agree). For this analysis, we have only used the *optimism* category with four items: i.e., the autonomous vehicle "contributes to better quality of life" (item #1), "gives more freedom of mobility" (item #2), "gives people more control over their daily lives" (item #3), and "makes me more productive in my personal life" (item #4).

The TAM consists of 26 items (scored from 1=strongly disagree to 7=strongly agree). For this analysis, we have used four items in the TAM, indicative of *perceived ease of use*. These items included the autonomous vehicle is "clear and understandable" (item #7), "does not require a lot of my mental effort" (item #8), "easy to use" (item #9), and "easy to get the AV to do what I want it to do" (item #10) (Davis, 1989).

The Life Space Questionnaire (LSQ) shows the baseline information on current mobility status (Stalvey et al., 1999). The LSQ consists of nine yes-or-no items assessing the mobility and is scored (1=yes; 0=no) by summing the item scores.

The DHQ provides information on driving history and habits (Owsley et al., 1999). The DHQ consists of 34 items obtaining driving information from six domains during the past year. Specifically, we used *driving exposure* (number of self-reported miles driven in the past year) and *driving difficulty*, eight items ranging from 1 ("so difficult I no longer drive in the situation") to 5 ("no difficulty") on a 100-point scale. The mean score of the eight items is reduced by 1.0 and multiplied by 25. A score below 90 suggests driving difficulty.

The Motion Sickness Assessment Questionnaire (MSAQ) consists of four items assessing sweatiness, queasiness, dizziness, and nauseousness and the scored (from 0=not at all to 10=severely) on a visual analogue scale (Brooks et al., 2010). The MSAQ was administered before and after the exposure to both the autonomous shuttle and the driving simulator.

3.2.7 Data Analysis

Descriptive statistics for participant demographics and driving habits were displayed as frequency (*F* in %), mean (*M*) and standard deviation (*SD*). Data analyzed using nonparametric tests were displayed as median and interquartile range (IQR). Data analysis assumptions were assessed via box plot methods (outlier), Shapiro-Wilk test & QQ plot (normality), Levene's test (homogeneity of variance), and Box's M Test (homogeneity of covariances). Violated assumptions were detailed in the results, and non-parametric tests were used such as the Wilcoxon test and Kruskal-Wallis test. The fractional numbers of the degrees of freedom in ANOVA results come from the Greenhouse-Geisser correction to the violation of sphericity assumption.

A series of t-tests were used to check for baseline differences in the four AVUPS scores (i.e., *intention to use*, *barriers*, *well-being*, and *acceptance*). A series of two-way mixed analysis of variance (ANOVA) were performed to evaluate main effects (group and time) and whether there was an interaction between group and time affecting the four AVUPS scores. Post-hoc tests were deployed to explore the main effects for time or the group by time interactions. Data were stored using Research Electronic Data Capture (REDCap; Harris et al., 2019) and collated and analyzed in RStudios (RStudio Team, 2020) using R version 4.0.2 (RStudio Team, 2020), the tidyverse ecosystem (Wickham et al., 2019), and rstatix package (Kassambara, 2021). An alpha level of 0.05 was set a priori, and p-values were adjusted to control for multiple comparisons using the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995).

3.3 RESULTS

Task 1: Quantify the younger and middle-age drivers' (N=106) perceptions, values, beliefs, and attitudes, before and after "driving" a simulator (Level 4, SAE Guidelines) and after riding in a highly autonomous shuttle (AS) (Level 4, SAE Guidelines)

3.3.1 Descriptive Results

A total of 106 participants (M_{age}=36.22; *SD*=15.04; 48 males; 58 females) were screened and enrolled into the study. Younger drivers (n=69; 18–39 years old) and middle-age drivers (n=37; 40–64 years old) were randomly assigned to two groups (n=53 each): one group being exposed to the AS first (ASF) and the other to the simulator first (SF); the order was reversed for the next visit.

The descriptive statistics for the demographic data are displayed in Table 3-1. Overall, we had slightly more women than men in the study; they were of varying ethnicity, yet about a third were Asian or Pacific Islander and a third were White. About three quarters of the group held a degree and, as such, the participants were well-educated. A majority of participants were single, and almost all of the participants were working or in school, with only the minority (14%) being retired, unable to work, or unemployed.

Table 3-1. Demographic data for younger and middle-age drivers (N=106)

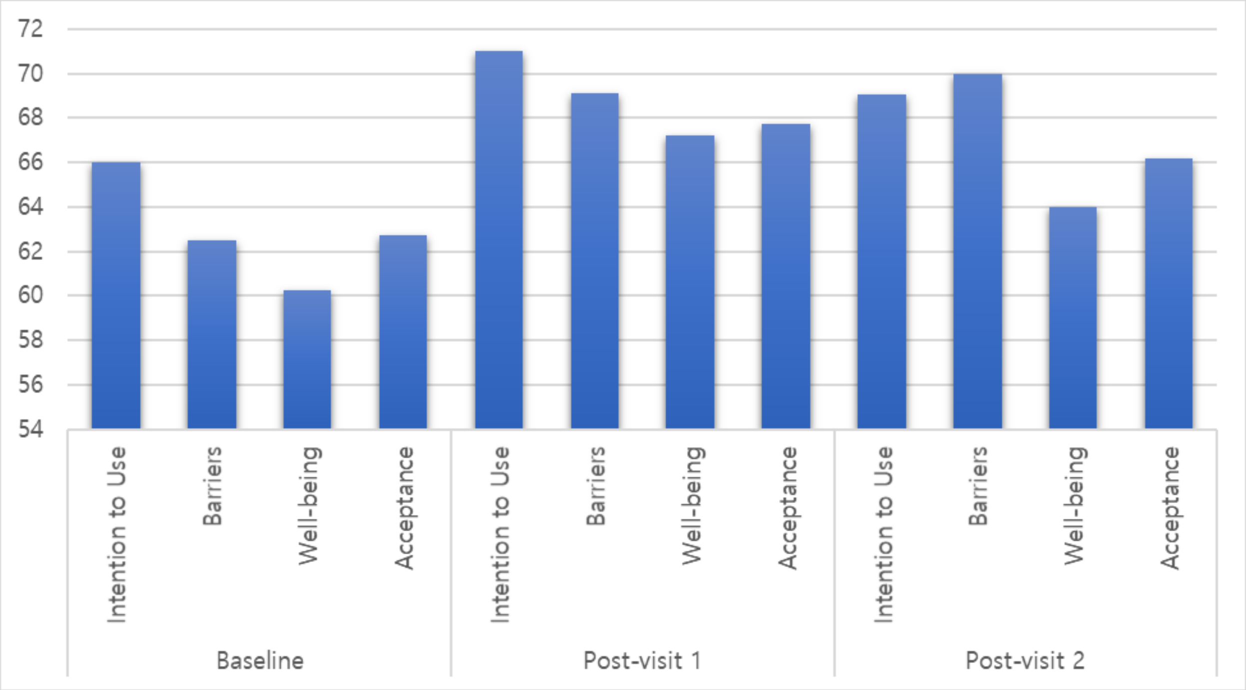
Factor	Value	Frequency (%)
Sex	Male	48 (45%)
	Female	58 (55%)
Ethnicity	African-American or Black	12 (12%)
	Asian or Pacific Islander	38 (36%)
	Caucasian or White	37 (35%)
	Hispanic or Latino	14 (13%)
	Multiracial	2 (2%)
	Other	3 (2%)
Education	High school graduate or equivalent	9 (8%)
	Some college credits	5 (5%)
	Trade, Technical, Vocational training	2 (2%)
	Associate’s degree	32 (30%)
	Bachelor’s degree	29 (28%)
	Master’s degree	9 (8%)
	Doctorate, Professional degree	20 (19%)
Marital Status	Single, never married	63 (59%)
	Married or domestic partnership	34 (32%)
	Widowed	1 (1%)
	Divorced	8 (8%)
Employment	Part-time	11 (10%)
	Full-time	29 (27%)
	Retired	9 (9%)
	Homemaker	4 (4%)
	Student	48 (45%)
	Unable to work	4 (4%)
	Unemployed	1 (1%)

3.3.2 Within-Group Differences

A series of t-tests was used to assess baseline differences between group 1 (simulator first; SF) and group 2 (autonomous shuttle first; ASF) for four AVUPS scores (*intention to use, barriers, well-being,* and *acceptance*). Appendix B indicates the AVUPS with each of the four domain scales and the items pertaining to those domains for easy reference.

Descriptive statistics are displayed in Table 3.1. At baseline, there were no differences between group 1 SF and group 2 ASF for *intention to use*, *barriers*, *well-being*, or *acceptance* (p range=0.267–0.455). Figure 3-5 below indicates the descriptive summary for the four AVUPS score differences, before and after the AV exposure among baseline, visit 1, and visit 2. Compared to baseline, all the scores increased for post-visit 1, and for post-visit 2. However, when comparing post-visit 2 to post-visit 1, intention to use, well=being and acceptance slightly decreased with perceived barriers increasing which indicates a more favorable perception towards barriers.

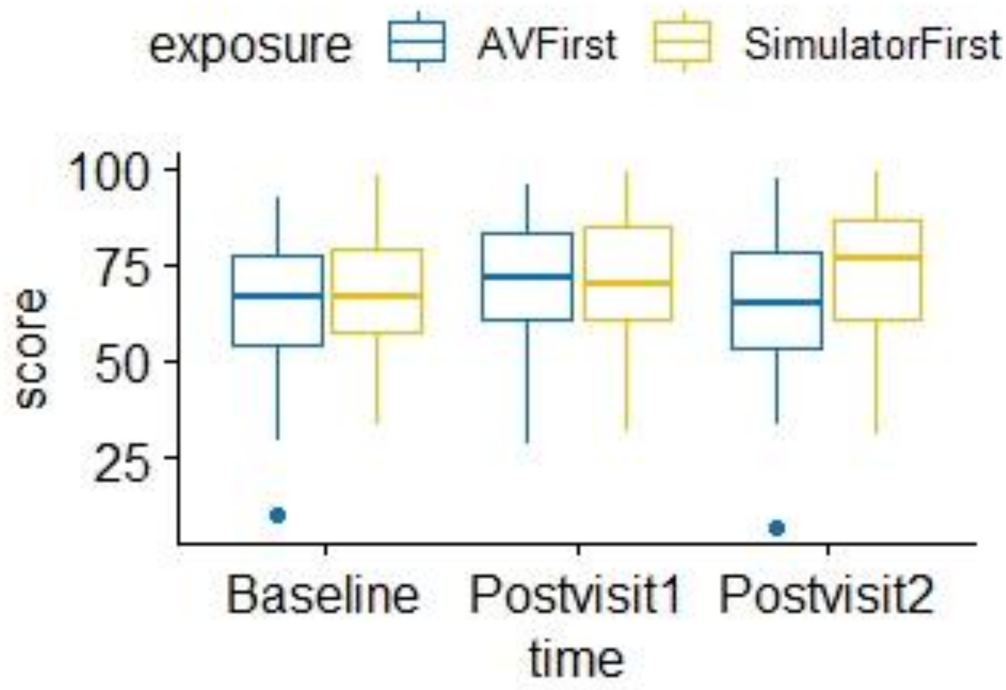
Figure 3-5. Four AVUPS score differences before and after the AV exposure



A series of two-way mixed ANOVAs were deployed to test the main effects of group (group1 SF and group 2 ASF) and time (baseline, post-visit 1, and post-visit 2) and group × by time interaction on the four AVUPS scores.

3.3.2.1. Intention To Use – The two-way mixed ANOVA for *intention to use* revealed a time effect: $F(2,208)=12.703$; $p<0.0001$; $\eta_g^2=0.016$; and group × time interaction, $F(2,208)=12.106$; $p<0.0001$; $\eta_g^2=0.015$. However, a group effect was not detected: $F(1,104)=1.806$; $p=0.182$; $\eta_g^2=0.015$. Figure 3-6 below displays the *intention to use* score differences before and after exposure to the driving simulator and autonomous shuttle.

Figure 3-6. Intention to use score differences before and after exposure

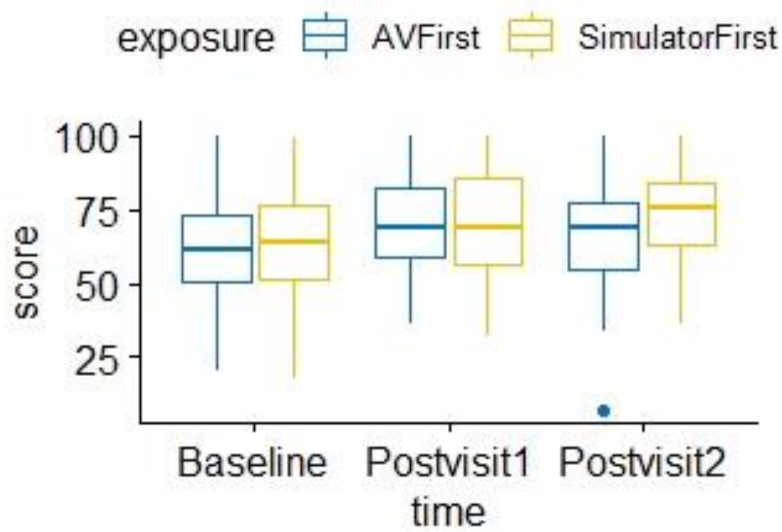


Post-hocs revealed *intention to use* was significantly greater for group 1 (SF) compared to group 2 (ASF; p=0.0067) at post-visit 2, but not baseline (p=0.267) or at post-visit 1 (p=0.823).

Post-hocs for group 1 (SF) displayed that *intention to use* was significantly greater at post-visit 1 than at baseline (p =0.048), greater at post-visit 2 than at baseline (p =0.003) and greater at post-visit 2 than at post-visit 1 (p=0.009). For group 2, ASF *intention to use* was significantly greater at post-visit 1 than at baseline (p <0.0001) and greater at post-visit 1 than at post-visit 2 (p <0.0001) but there is no significant difference between baseline and post-visit 2 (p=0.791).

3.3.2.2 Barriers – The two-way mixed ANOVA for *barriers* revealed a time effect (F(2,208)=19.151; p<0.0001; η_g^2=0.037) and group × time interaction (F(2,208)=4.329; p=0.014; η_g^2=0.009). However, no group effect was detected (F(1,104)=0.851; p=0.358; η_g^2=0.006). Figure 3-7 displays *barriers* score differences before and after exposure.

Figure 3-7. barriers score differences before and after exposure

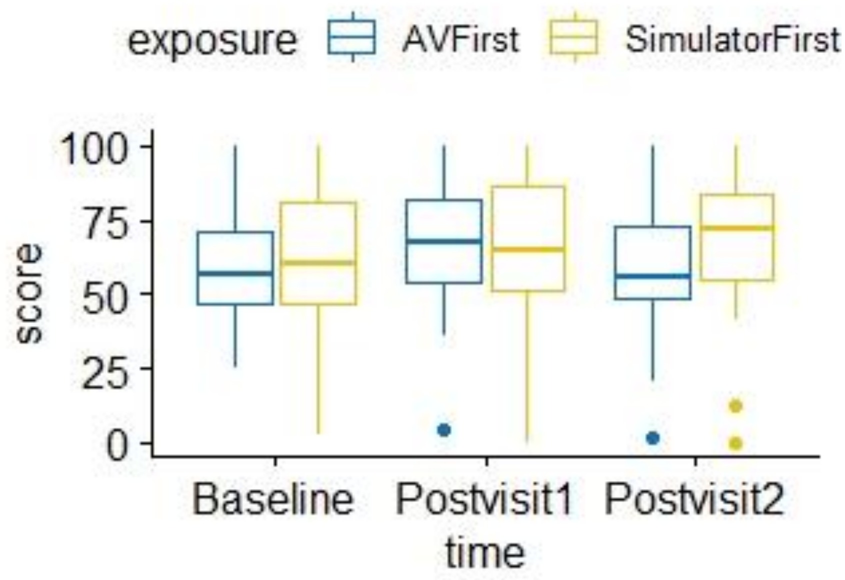


Post-hoc tests revealed that group 1 (SF) and group 2 (ASF) demonstrated no differences in their perceptions on the *barriers* at baseline and post-visit 1. However, at post-visit 2, *barriers* had significantly greater scores for group 1 (SF) compared to group 2 (ASF; p =0.041).

Post-hoc tests displayed that for group 1 (SF), *barriers* was significantly greater at post-visit 1 (p =0.036) and post-visit 2 (p <0.0001), compared to baseline, and greater at post-visit 2 compared to post-visit 1 ($p \leq .0001$). For group 2 (ASF), *barriers* was also significantly greater at post-visit 1 ($p \leq 0.001$) and post-visit 2 (p=0.004) than at baseline. No difference was seen between post-visit 1 and post-visit 2 (p=0.148).

3.3.2.3 Well-Being – The two-way mixed ANOVA for *well-being* revealed a group effect (F(1,104)=0.977; p=0.325; η_g^2=0.007), a time effect (F(1.81,187.96)=9.4; p=0.00022; η_g^2=0.018), and group × time interaction (F(1.81,187.96)=7.173; p=0.001; η_g^2=0.014). Figure 3-8 displays *well-being* score differences before and after exposure to the driving simulator and the AS.

Figure 3-8. Well-being score differences before and after exposure



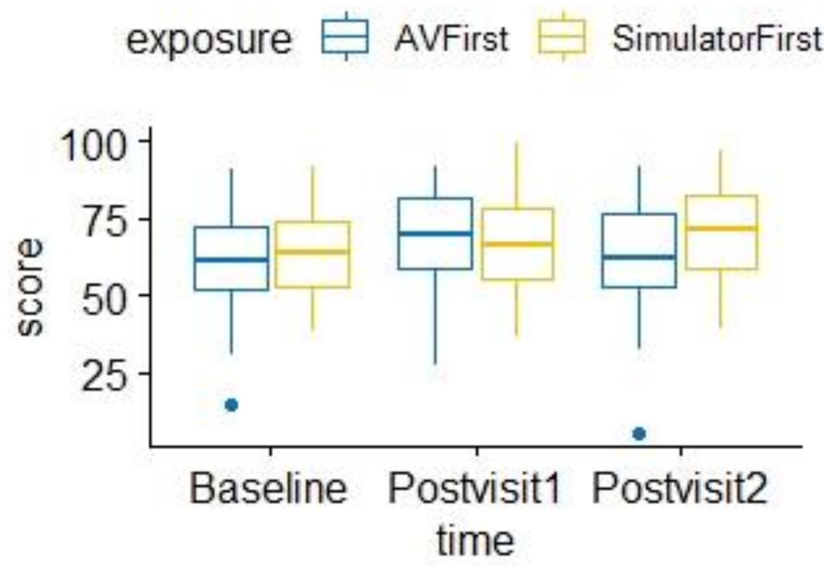
Post-hoc tests for group 1 (SF) and group 2 (ASF) demonstrated no differences in their perceptions on the *well-being* at baseline and post-visit 1. However, at post-visit 2, *well-being* was significantly greater for group 1 (SF) as compared to group 2 (ASF) (p=0.0158).

Post-hoc tests showed that for group 1 (SF), *well-being* was significantly greater at post-visit 2 than at baseline (p =0.041), but there were no significant differences between post-visit 1 and baseline (p =0.147), and between post-visit 2 and post-visit 1 (p=0.147).

For group 2 (ASF), *well-being* was significantly greater at post-visit 1 than at baseline (p<0.0001), and greater at post-visit 1 than at post-visit 2 (p<0.001). However, no significant difference was observed between baseline and post-visit 2 (p =0.853).

3.3.2.4. Acceptance – The two-way mixed ANOVA for *acceptance* revealed a group effect ($F(1,104)=1.371$; $p=0.244$; $\eta_g^2=0.011$), a time effect ($F(2,208)=15.246$; $p<0.0001$; $\eta_g^2=0.018$), and group × time interaction ($F(2,208)=17.014$; $p<0.0001$; $\eta_g^2=0.02$). Figure 3-9 depicts *acceptance* score differences before and after exposure.

Figure 3-9. Acceptance score differences before and after exposure



Post-hoc tests revealed that Group SF and Group ASF demonstrated no differences in their perceptions on *acceptance* at baseline and post-visit 1. However, at post-visit 2, *acceptance* was significantly greater for Group SF compared to Group ASF (p =0.00417).

Post-hoc tests displayed that for Group SF, *acceptance* was significantly greater at post-visit 2 than at baseline (p =0.00022), and greater at post-visit 1 than at baseline (p =0.00029), but there was no significant difference between post-visit 1 and post-visit 2 (p =0.061). For Group ASF, *acceptance* was significantly greater at post-visit 1 than at baseline (p<0.0001), and greater at post-visit 1 than at post-visit 2 (p<0.0001), but there was no significant difference between baseline and post-visit 2 (p=0.067).

3.3.3 Age Group Differences

We also considered the impact of *age* group differences (N=210; young vs. middle-age vs. older adult group). We tested the percentage of score change between baseline and post-visit 2 for *intention to use*, *barriers, well-being*, and *acceptance* among different age groups: young (n=69) vs. middle-age (n=37) vs old (n=104).

Data normality assumptions were violated for all four AVUPS scores. Shapiro Wilks test displayed violations for *intention to use* (p=0.1238), *barriers* (p=0.1866), *well-being* (p=0.8558), and *acceptance* (p=0.1649). A series of a Kruskal-Wallis tests displayed no differences between the *age* groups for *intention to use* ($\chi^2(2)$=4.666; p=0.097), *barriers* ($\chi^2(2)$=3.840; p=0.097), *well-being* ($\chi^2(2)$=0.143; p=0.097), or *acceptance* ($\chi^2(2)$=3.407; p=0.182). The findings suggest that there are no differences in a score change between baseline and post-visit 2 for *intention to use*, *barriers*, *well-being*, and *acceptance* among young (n=69), middle-age (n=37) and elderly (n=104).

4.0 TASK 2: BUILDING A PREDICTIVE MODEL OF FACILITATOR & BARRIER

Build a predictive model of facilitators and barriers from the data collected in this Phase 2 proposed project (N=106), in combination with the Phase 1 older driver data (N=104) collected via the Phase 1 (Project D2).

4.1 Data Analysis

A series of four multiple linear regressions were conducted to investigate the effects of the independent variables: *optimism* (TRI domain), perceived *ease of use* (TAM domain), *life space* (LSQ total score), annual *driving exposure* (DHQ Item 14), *driving difficulty* (continuous), *age* (continuous), *gender* (binary), *employment* (full or part-time vs. other), *education* (high school diploma, trade school, some college credit, associate's degree, bachelor's degree, master's degree, and doctorate), *marital status* (married vs. other), and *race or ethnicity* (White vs. others) on the AVUPS scores (dependent variable) after cumulative exposure to the driving simulator and autonomous shuttle (post-visit 2).

Driving exposure was converted from miles driven per week to miles driven per year. The exposure type (driving simulator or autonomous shuttle), employment, *race/ethnicity*, gender, and marital status were categorized as dummy variables, and relabeled as shown in Table 4-1 below. The modeling process was conducted in R Studios (RStudio Team, 2020) using R version 4.0.2 (R Core Team, 2020). The packages "MASS" (Ripley et al., 2021) and "CAR" (Fox et al., 2021) were used to perform the forward and backward selection of independent variables and the removal of multicollinearity. The selection of the best model fit was based on the lowest Akaike Information Criteria (AIC) value.

Table 4-1. Variables (exposure, employment, race, ethnicity, sex, marital status) relabelled for the regression analyses

Variables	Original	Relabeled
Exposure Type	1 (simulator first; SF)	1
	2 (autonomous shuttle first; ASF)	0
Employment	Full-time and Part-time	1
	Other types	0
Race/ethnicity	Caucasian or White	1
	Other types	0
Sex	Male	1
	Female	0
Marital status	Married or domestic partnership	1
	Other types	0

Education was recategorized from 1 to 7 based on the level of educational attainment with 1 denoting High school graduate or equivalent and 7 denoting Doctorate/Professional degree as shown in Table 4-2.

Table 4-2. Education recategorized based on the level of educational attainment

Original	Relabeled
High school graduate or equivalent (GED)	1
Trade, technical or vocational training	2
Some college credits	3
Associates degree	4
Bachelor’s degree	5
Master’s degree	6
Doctorate or professional degree	7

The models were fitted to the combined datasets of STRIDE UF & UAB Demonstration Study – Phase 1 (older adult group; N=104) and Phase 2 (young and middle-age group; N=106). The missing values (5 out of 210) were removed before the modeling process.

4.2 Results

4.2.1. Demographics

The descriptive statistics for the variables are displayed in Table 4-3 and demographic data for all study participants combined (younger, middle-age, and elderly drivers; N=206) are summarized in Table 4-4.

Table 4-3. Descriptive statistics for the variables to be entered in the regression model

Variable	N	Mean	Std	Median	Min	Max
Age	206	55.18	22.35	65.00	19.00	91.00
Optimism	206	4.37	0.55	4.00	3.00	5.00
Perceived ease of use	206	4.99	1.09	5.00	2.00	7.00

Variable		N	Mean	Std	Median	Min	Max
Life space		206	5.50	1.16	5.00	0.00	9.00
Miles driven per year		206	7115.38	11,448.00	4264.00	208.00	104,104.00
Driving difficulty		206	80.65	16.80	83.91	0.00	100.00
AVUPS Baseline	*Acceptance*	206	66.30	14.57	66.80	14.85	95.45
	Intention to use	206	68.46	14.47	69.23	16.00	97.77
	Barriers	206	66.52	17.73	66.83	17.67	100.00
	Well-being	206	68.44	20.95	71.25	3.00	100.00
AVUPS Post-visit 2	*Acceptance*	206	70.59	14.49	71.65	24.25	100.00
	Intention to use	206	72.42	15.24	73.00	25.85	100.00
	Barriers	206	73.14	15.27	75.00	22.50	100.00
	Well-being	206	72.60	19.85	76.00	0.00	100.00

Table 4-4. Demographic data for all study participants combined (younger, middle age, and elderly drivers, N=206)

Factor	Value	Number	Percentage
Sex	Male	93	45.15%
	Female	113	54.85%
Education	High school graduate or equivalent	8	3.88%
	Some college credits	3	1.46%
	Trade, technical, vocational training	29	14.08%
	Associate’s degree	21	10.19%
	Bachelor’s degree	53	25.73%
	Master’s degree	60	29.13%
	Doctorate or professional degree	32	15.53%
Race/Ethnicity	Caucasian or White	129	62.62%
	Other	77	37.38%
Marital Status	Married or domestic partnership	105	50.97%
	Other	101	49.03%
Employment	Full-time or part-time	57	27.67%
	Other	149	72.33%
Exposure Type	Type 1 (simulation first, SF)	101	49.03%
	Type 2 (autonomous shuttle first, ASF)	105	50.97%

4.2.2 Intention to Use

The fitted regression model explained 29.5% of the variance (R^2=0.295; $R_{Adjusted}^2$=0.2774; F(5,200)=16.74; p<0.001). As indicated in Table 4-5 below, *optimism* (β=9.18; p<0.001); *perceived ease of use* (β=4.92; p<0.001), and *race/ethnicity* (White: yes; β=5.06; p=0.038) were statistically significant predictors of *intention to use*.

Table 4-5. Regression model to identify predictor variables of intention to use

Variables	Coefficient	SE	*t* value	*p*
(Intercept)	−1.72327	8.588666	−0.20065	0.84118
Age	0.080815	0.052326	1.544457	0.124058

Optimism	9.182381	1.734087	5.295225	3.12E-07 ***
Perceived ease of use	4.922493	0.910582	5.405874	1.83E-07 ***
Race or Ethnicity (White: yes)	5.058215	2.423865	2.086838	0.03817 *
Exposure (Simulator first: yes)	3.335821	1.899167	1.756465	0.080539

Note: Significance codes: 0 '***'.001 '**'.01 '*'.05. The variables were not scaled to control for the level of measurement and as such no interpretations can be made in comparing coefficients to one another. However, each coefficient can be interpreted in its contribution to the R^2 value.

4.2.3 Barriers

The fitted regression model explained 22.45% of the variance (R^2=0.2245; $R_{Adjusted}^2$=0.2091; F(4,201)=14.55; p<0.001). Table 4-6 indicates that *optimism* (β=6.58; p<0.001), *perceived ease of use* (β=4.26; p<0.001), *driving difficulty* (β=0.14; p=0.018) and *race/ethnicity* (White: yes; β=7.13; p=0.001) predictor variables for *barriers* were statistically significant.

Table 4-6. Regression model to identify predictor variables of barriers

Variables	**Coefficient**	**SE**	***t* value**	***p***
(Intercept)	6.7815	9.407325	0.720874	0.471824
Optimism	6.583701	1.809461	3.638488	0.000349 ***
Perceived ease of use	4.258355	0.957778	4.446078	1.45E-05 ***
Driving difficulty	0.144232	0.060565	2.381452	0.018178 *
Race or ethnicity (White: yes)	7.138326	2.145497	3.32712	0.001043 **

Note: Significance codes: 0 '***'.001 '**'.01 '*'.05. The variables were not scaled to control for the level of measurement and as such no interpretations can be made in comparing coefficients to one another. However, each coefficient can be interpreted in its contribution to the R^2 value.

4.2.4 Well-being

The fitted regression model explained 36.36% of the variance (R^2=0.3636; $R_{Adjusted}^2$=0.3477; F(5,200)=22.86; p<0.001). Table 4-7 indicates that *age* (β=0.35; p<0.001), *optimism* (β=14.23; p<0.001), *perceived ease of use* (β=4.41; p<0.001), and *miles driven per year* (β= −0.00033; p=0.0015) are statistically significant predictor variables for *well-being*.

Table 4-7. Regression model to identify predictor variables of well-being

Variables	**Coefficient**	**SE**	***t* value**	***p***
(Intercept)	−26.8599	10.46539	−2.56655	0.011003 *
Age	0.348692	0.052899	6.591619	0.378 ***
Optimism	14.23477	2.142064	6.645355	0.281 ***
Perceived ease of use	4.407468	1.133594	3.888049	0.000137 ***
Miles driven per year	−0.00033	0.000102	−3.22056	0.001493 **
Gender (male: yes)	−3.98935	2.380938	−1.67554	0.095392

Note: Significance codes: 0 '***'.001 '**'.01 '*'.05. The variables were not scaled to control for the level of measurement and as such no interpretations can be made in comparing coefficients to one another. However, each coefficient can be interpreted in its contribution to the R^2 value.

4.2.5 Acceptance

The fitted regression model explained 33.59% of the variance (R^2=0.3359; $R_{Adjusted}^2$=0.3159; *F*(6,199)=16.78; *p*<0.001). Table 4-8 indicates that *age* (β=0.12; *p*=0.012), *optimism* (β=9.29; *p*<0.001), *perceived ease of use* (β=4.75; *p*<0.001), and *race/ethnicity* (White: yes; β=4.99; *p*=0.028) significantly predicted *acceptance*.

Table 4-8. Regression model to identify predictor variables of acceptance

Variables	**Coefficient**	**SE**	***t* value**	***p***
(Intercept)	−4.29834	7.989262	−0.53801	0.591168
Age	0.122988	0.048603	2.53048	0.012165 *
Optimism	9.290495	1.640781	5.66224	5.17E-08 ***
Perceived ease of use	4.749713	0.846946	5.608045	6.78E-08 ***
Miles driven per year	−0.00012	7.86E-05	−1.5703	0.117933
Race or ethnicity (White: yes)	4.99493	2.253808	2.216218	0.02781*
Exposure (simulator first: yes)	2.758943	1.776307	1.553191	0.121967

Note: Significance codes: 0 '***'.001 '**'.01 '*'.05. The variables were not scaled to control for the level of measurement and as such no interpretations can be made in comparing coefficients to one another. However, each coefficient can be interpreted in its contribution to the R^2 value.

5.0 CONCLUSION

Using a validated AVUPS, we studied the perceptions of 210 younger, middle-age, and older drivers before and after being exposed to an autonomous shuttle and a driving simulator running in autonomous mode.

Task 1: Quantify the younger and middle-age drivers' (N=106) perceptions, values, beliefs, and attitudes, before and after "driving" a simulator (Level 4, SAE Guidelines) and after riding in a highly autonomous shuttle (AS) (Level 4, SAE Guidelines)

Demographics – The sample of younger and middle-age drivers (n=106) is generally representative, except for education, of the demographic groups enrolled for North-Central Florida. Gainesville is a college town, and therefore, we were not too surprised by the increased level of education among our participants. However, this factor may influence the estimates; we know from the literature that a higher degree of education (and income) contributes to predicting *acceptance* (Bansal & Kockelman, 2017).

The Four AVUPS Scores – The four AVUPS scores (see examples of all the items under each of the domains on p. 42), before and after the AV technology exposure (both modes), indicate that all scores increased after the first exposure (both SF & ASF) and maintained the increase, with a slight drop in *well-being*, after the second exposure (both SF and ASF). These results suggest that regardless of group, scores on the AVUPS increase after exposures 1 and 2 for the SF and ASF groups.

Intention to Use – The SF group demonstrated significant differences when compared to the ASF group after the 2nd exposure, suggesting that this group may be more prone to see the actual behind-the-wheel benefits of driving an AV. This experience might have more significantly altered the SF group's perceptions pertaining to driving an AV, when compared to the shuttle, where the participants were passengers in the AS vs. a driver in the simulator. Interestingly, Horrey & Lee (2020) indicate how the shift in role– from driver to operator in the simulator or from driver to passenger in the shuttle— varies with the level of automation (Level 0–5) and within each type of system. In this case, and based on Horrey & Lee's argument, it may be possible that drivers could more realistically perceive how the AV technology in the simulator could benefit their role as a driver, and as such, their *intention to use* became more realistic in the simulator vs. the AS. The *intention to use* items (see Appendix B: AVUPS with each of the four domains and the items) provide good indications of how such perceptions were influenced positively. For example, some of these items include "open to the idea of using AVs" (item #4), "I can trust AVs" (item #6) and "AVs will be easy to use" (item #13), to name just a few.

Barriers – The SF group demonstrated significant and lasting differences in *barriers* scores, meaning that they had fewer *perceived barriers* to accepting the autonomous simulator after each one of the visits and when compared over time. Likewise, even though no differences existed for the ASF group between the two post-visits, this group also showed that they had fewer *perceived barriers* over time and as compared to their baseline scores in accepting the AS. This finding has important implications for stakeholders of the AV industry, as they can make a significant contribution to reducing *barriers* for younger and middle-age drivers pertaining to AV technology. Focusing on the items (see Appendix B: AVUPS, with each of the four domains and the items) that were included in the *barriers* domain, e.g., item #28 "I feel hesitant about using AV," may be a very good indication for industry partners, policy makers and mobility managers of where to start to address *barriers*, for enhancing the *acceptance,* and eventually adoption practices of these drivers towards AV technologies.

Well-being – Over time and for the last exposure (post-visit 2), the SF group had a significant increase, compared to the ASF, in their *well-being* scores; and for the SF group, *well-being* was significantly greater at post-visit 2 than at baseline. Likewise, for the ASF group, *well-being* was significantly greater at post-visit 1 (compared to baseline) and greater at post-visit 1 (compared to post-visit 2). Overall, we are very optimistic about this finding because the *well-being* items suggest that drivers of the simulator and riders of the AS have an increased expectation, after exposure, that the AVs will "be easy to use" (item # 10) and "be used on a daily basis" (item #12) and that they feel "less hesitant" (item # 24) about using an AV. Of course, the time effects must be taken into consideration, but overall, the *well-being* domain holds promise for AV technology *acceptance* in this group of younger and middle-age drivers.

Acceptance – Over time and for the last exposure only, the SF group (compared to the ASF) had a significant increase in their *acceptance* of AV technology. Moreover, the SF group and the ASF group also had a greater increase in post-visit 1 and post-visit 2 as compared to baseline. This is an interesting finding and suggests that in both groups, SF and ASF, benefits are derived from exposure to, and acceptance of, AV technology. *Acceptance* is a complex construct, and the literature indicates that multiple factors may influence adults' *acceptance* pertaining to AV technology (Bagozzi, 2007; Davis, 1989; Mason et al., 2021; Osswald et al., 2012; Parasuraman, 2000). Some of these factors include *intention to use* the technology and *perceived barriers*, as articulated in the AVUPS, but there are others, such as *technology readiness* and *perceived ease of use*. Nevertheless, *acceptance* of AV technology by the SF and ASF groups is an excellent indicator, barring time effects, of eventual adoption practices (Bagozzi, 2007; Davis, 1989; Osswald et al., 2012; Parasuraman, 2000).

Age Group Differences – Our findings revealed no significant differences between baseline and post-visit 2 for *intention to use, barriers, well-being,* and *acceptance* among the young (n=69), middle-age (n=37) and older driver groups (n=104). Based on the literature, a wide variance in *acceptance* is observed for drivers through the lifespan. Some studies suggest that old *age* is a negative predictor of *acceptance* for AS (Kaye et al., 2020; Schoettle & Sivak, 2016), which was not the case in our study. Liljamo et al. (2018) found that middle-age adults have greater *acceptance* towards AVs when compared to other *age* groups (younger and older drivers), which again was not supported by our findings. However, what is clear is that in general, older and younger adults are more positive of AV technology (autonomous simulator and/or AS) after exposure. Of course, *age* alone is not the determining factor in *acceptance*, especially when different demographics are factored into the analysis (Lee, 2019; Texas A&M Transportation Institute, 2016).

Task 2: Build a predictive model of facilitators and barriers from the data collected in this Phase 2 proposed project (N=106), in combination with the Phase 1 older driver data (N=104) collected via the Phase 1 (Project D2).

Demographics – The sample of all drivers (N=206 younger, middle-age, and older drivers; M_{age}=55.18; *SD*=22.35) had slightly more women (55%), was educated (~80%), and majorly of the White *race* (63%). About half of the group was *married*, and only a quarter was full-time or part-time employed. The *miles driven per year* by the group ranged from 208 to 104,000+ miles. The AVUPS baseline scores for the subscales (*intention to use, barriers*, *and well-being*) and the total *acceptance* scale ranged from 66 to 68 (out of 100), and for post-visit 2, these scores increased and ranged from 70 to 73 (out of 100).

Four Multiple Linear Regressions – Four multiple linear regression models were conducted to predict the AVUPS subscales (i.e., *intention to use, perceived barriers,* and *well-being*) and the *total acceptance* score. The four regression models have R^2 values ranging from 0.22 (*perceived barriers)* to 0.36 (*well-being*).

The results of the regression analyses indicated that *optimism* and *ease of use* positively predicted *intention to use, perceived barriers, well-being,* and the *total acceptance* score.

Not surprising, these findings indicate a positive relationship between those who are optimistic and see the *ease of use* of the technology in relation to their *intention to use*, overcoming *barriers* (e.g., overcoming hesitation towards AV technology, item #28 AVUPS), their increased *well-being* (e.g., “use of AV on a daily basis”, item #12 AVUPS), and their overall *acceptance* to the AV technology. Specifically, the items in the *optimism* domain indicate that new technology “contributes to better quality of life” (item 1), “gives more freedom of mobility” (item 2), “gives people more control over their daily lives” (item 3), and “makes me more productive in my personal life” (item 4) (Parasuraman et al., 2015). Likewise, the items in the *ease of use* scale indicate interaction with the autonomous vehicle is “clear and understandable” (item #7), “does not require a lot of my mental effort” (item #8), “easy to use”, (item #9) and “easy to get the AV to do what I want it to do” (item #10) (Davis, 1989). These items may be operationalized as intervention strategies for potential “riders of the AVs to set the stage for planners, policy makers, and industry partners to create opportunities for adults to experience the benefits of the current AS technologies (Classen et al., 2020; 2021).

Driving difficulty significantly and positively predicted *perceived barriers.* Specifically, less *driving difficulty* (meaning an increase in the total *driving difficulty* score) is an indication of perceiving fewer barriers in the use of AV technology. This is a positive finding given that the *driving difficulty* score (*M*=80.65; *SD*=16.80) for this total group of drivers (*N*=206) was slightly below the criterion of 90, suggesting that some may have experienced a decline in fitness-to-drive abilities. Because the older driver group had the most participants (n=104), it is likely that the driving difficulties mainly resided within this group. Older drivers will make up a substantially larger proportion of drivers involved in crashes in the coming years (Lyman et al., 2002), and therefore, targeted AV exposure may be optimally beneficial to them while they are still driving. As such, mobility managers, policy makers and industry partners need to consider this finding and develop interventions for AV technology use so that this approach can serve both as a crash avoidance strategy and a facilitator of community mobility.

Miles driven (lower mileage) negatively predicted *well-being.* Driving fewer *miles per year* is a proxy variable for declining physical and/or visual and cognitive abilities, which is more common among older drivers (Baldock et al., 2006). The authors surmise that this finding is not surprising given that if one drives a lower number of *miles per year*, then it is negatively associated with *well-being*. Specifically, the well-being items in the AVUPS included items such as "expecting that AVs will be easy to use" (item#10) or "using an AV on a daily basis" (item #12). Thus, if the lower mileage is a proxy for declining abilities, one may postulate that the drivers will be less positive about using new technology, such as used in this study.

Finally, the regression analysis results indicated that positive predictors of user *acceptance* of AV technology included *optimism, ease of use*, *race* (White), and *age* (increased *age*). In fact, these predictor variables accounted for 33.6% of the variance in *acceptance.* The racial data needs to be interpreted cautiously as an oversampling of participants from the White *race* were included in the study. However, increased *age* as a predictor of the overall *acceptance* of AVs holds plausible opportunities for targeting and exposing those who are older to the AV technology. This can be done in a variety of ways, including demonstration rides, show-and-tell rides, workshops, roundtable discussions with drivers who had (vs. not had) exposure to the AV technology, and neighborhood trail rides.

6.0 RECOMMENDATIONS

6.1 Limitations

Although the demographics in this study were consistent for a college town in North-Central Florida, the oversampling (e.g., White *race*), outliers (e.g., highly educated group), or self-report of variables (e.g., miles driven per year) may have influenced the estimates of this study. The variables used in the regression models were not scaled to control for the level of measurement (e.g., nominal, ordinal or numerical), and as such, no interpretations can be made in comparing coefficients to one another. However, each coefficient can be interpreted in its contribution to the final R^2 value. This study was also conducted in the midst of the pandemic, and the rigorous protocols implemented in the study, although protective, could have deterred some from participating. Likewise, others who would have enrolled may have abstained as a result of fear of exposure. An extension of the autonomous shuttle route occurred on June 1, 2021, (adding four more right turns, one left turn, and one stop) and the team did not control for this route extension in the analysis. As such, this study has inherent biases, such as a self-selection bias and spectrum bias. Even though we have tried to cast the recruitment net far and wide, we can at best describe the sample as a convenience sample. Therefore, this study’s findings, although they provide foundational knowledge for the AV technology industry, are only generalizable to study participants and settings that fit the demographic profile and context of this study. The findings do not speak to those urban individuals who choose not to drive and who would consider driving fewer miles a sign of a higher quality of life. As such, the study findings may be more applicable to those who drive less due to physical or cognitive limitations. Moreover, while city planners strive for a safer transportation system, they are also concerned that AVs will disrupt their efforts to transition our society toward a less auto-centric country, and many may remain skeptical about the safety benefits of AVs. Therefore, we may receive better adoption of our findings from mobility members and industry partners. Finally, the AV technology landscape is changing quite rapidly. Results may not be the same if testing is done in a vehicle traveling at highway speeds, and as such models may need to be adjusted over time to control for this phenomenon.

6.2 Strengths

The study included 210 drivers representing three different age cohorts, i.e., younger, middle-age and older, allowing between-subject comparisons to be made. The study findings reveal important foundational information about driver *acceptance*, *intention to use* AVs, *barriers* to AV technology, and *well-being* related to AV technology. Particularly, we have generated knowledge telling how *demographics, optimism, ease of use, life space, driving exposure,* and *driving difficulty*—not previously examined to this extent in the AV and driver literature—informs the field of the predictors of AV *acceptance*. This study was conducted on the principles of team science, including a collaboration between UF and UAB, the City of Gainesville, the University of Florida's Transportation Institute, I-STREET, industry partners, TransDev personnel and staff, and a high-tech simulator lab facility with an experienced lab manager. The team members, although varied in educational and experience level made a substantive contribution to the successful execution of the study—even in the midst of a pandemic. We have provided strategies that may inform mobility managers, policy makers, and industry partners alike in improving upon deployment practices of AV technology (autonomous simulator and the AS) for the near future.

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APPENDIX A – ACRONYMS AND ABBREVIATIONS

AS	Autonomous Shuttle
AS	Autonomous Shuttle first
AV	Autonomous Vehicle
Ave.	Avenue
AVUPS	Autonomous Vehicle User Perception Survey
CDC	Centers for Disease Control
DHQ	Driving Habits Questionnaire
DOT	Department of Transportation
HD	High-Definition
I-MAP	Institute for Mobility, Activity, and Participation
IRB	Institutional Review Board
LCD	Liquid Crystal Display
LSQ	Life Space Questionnaire
MoCA	Montreal Cognitive Assessment
MSAQ	Motion Sickness Assessment Questionnaire
MTurk	Mechanical Turk
NHTSA	National Highway Transportation Safety Administration
RTI	Realtime Technologies Inc.
SAE	Society of Automotive Engineers
SAV	Shared Autonomous Vehicles
SF	Simulator first
St.	Street
SE	Southeast
SW	Southwest
TAM	Technology Acceptance Model
TMT	Trail Making Test
TREND	Transportation Engineering and Development
TRI	Technology Readiness Index
UAB	The University of Alabama at Birmingham
UTAUT	Unified Theory of Acceptance and Use of Technology
VAS	Visual Analogue Scale

APPENDIX B – AVUPS AND ITEMS

AVUPS Scales	Items	Total Acceptance Score
Intention to Use		
AVUPS 4	I am open to the idea of using automated vehicles	Yes
AVUPS 6	I believe I can trust automated vehicles	Yes
AVUPS 7	I will engage in other tasks while riding in an automated vehicle	Yes
AVUPS 8	I believe automated vehicles will reduce traffic congestion	Yes
AVUPS 9	I believe automated vehicles will assist with parking	Yes
AVUPS 13	I expect that automated vehicles will be easy to use	Yes
AVUPS 15	I would use an automated vehicle on a daily basis	Yes
AVUPS 17	Even if I had access to an automated vehicle, I would still want to drive myself	Yes
AVUPS 20	I will be willing to pay more for an automated vehicle compared to what I would pay for a traditional car	Yes
AVUPS 21	If cost was not an issue, I would use an automated vehicle	Yes
AVUPS 22	I would use an automated vehicle if National Highway Traffic Safety Administration (NHTSA) deems them as being safe	Yes
AVUPS 25	When I'm riding in an automated vehicle, other road users will be safe	Yes
AVUPS 27	I feel safe riding in an automated vehicle	Yes
Perceived Barriers		
AVUPS 5	I am suspicious of automated vehicles	Yes
AVUPS 14	It will require a lot of effort to figure out how to use an automated vehicle	–
AVUPS 16	I would rarely use an automated vehicle	Yes
AVUPS 19	My driving abilities will decline due to relying on an automated vehicle	–
AVUPS 26	I believe that automated vehicles will increase the number of crashes	–
AVUPS 28	I feel hesitant about using an automated vehicle barriers	Yes

AVUPS Scales	Items	Total Acceptance Score
Well-being		
AVUPS 10	I expect that automated vehicles will be easy to use	Yes
AVUPS 11	It will require a lot of effort to figure out how to use an automated vehicle	—
AVUPS 12	I would use an automated vehicle on a daily basis	Yes
AVUPS 24	I feel hesitant about using an automated vehicle	Yes

APPENDIX C – SUMMARY OF ACCOMPLISHMENTS

Date	Type of Accomplishment	Detailed Description
6/2/20	Conference Presentation	Submitted: Classen, S., Mason, J., Wersal, J., Jeghers, M., & Hwangbo, S-W. *Assessment of automated vehicle technology integration for public transportation in Gainesville, Florida*. Short course to be presented at the American Occupational Therapy Association, San Diego, CA, April 8-11, 2021
9/9/20	Published Abstract	Mason, J., Classen, S., Wersal, J., & Sisiopiku, V. (2020). Survey design on the perceptions of automated vehicles: Face and content validity. American Journal of Occupational Therapy, 74, (4_Supplement_1). https://doi.org/10.5014/ajot.2020.74S1-PO3607
9/25/20	Other	UF Occupational Therapy Doctoral Student Works on Study to Understand Younger and Middle-aged Driver Perceptions on AV Technology at the University of Florida Transportation Institute newsletter
10/16/20	Other	Keynote address: Classen, S. Autonomous Vehicle Technology and Older Adults: A Primer for Health Care Professionals and Engineers. *Technology in Transportation. FAMU-FSU College of Engineering, Tallahassee, Florida. October 16, 2020. 10:00 AM – 3:00 PM.* Hosted by the Florida State University: Center for Accessibility and Safety for an Aging Population
12/15/20	Publication	Classen, S., Wersal, J., Mason, J., Rogers, J., & Sisiopiku, V. (2020). Face and content validity of an automated vehicle road course and a corresponding simulation scenario. Frontiers in Future Transportation. https://www.frontiersin.org/articles/10.3389/ffutr.2020.596620.
1/07/21	Publication	Mason, J., Classen, S., Wersal, J., Sisiopiku, V. (2021). Construct validity and test-retest reliability of the automated vehicle user perception survey. Frontiers in Psychology: Quantitative Psychology and Measurement. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.626791/abstract

Date	Type of Accomplishment	Detailed Description
1/11/21	Conference Presentation	Classen, S. Invited Guest Speaker: ROAM: The New Frontier: Older Adults' Perceptions of Level 4 Automated Vehicle Technology, Virtual presentation, 11 January, 2021.
3/10/21	Conference Presentation	Mason, J. Guest Speaker: Tools to Support adoption of Vehicle Automation. Virtually presented at the Human Factors Research at UFTI: Current Research and Future Directions Webinar on March 10, 2021.
4/02/21	Publication	Classen, S., Hwangbo, S. W., Mason, J., Wersal, J., Rogers, J., & Sisiopiku, V. P. (2021). Older drivers' motion and simulator sickness before and after automated vehicle exposure. Safety. https://doi.org/10.3390/safety7020026%20
5/27/21	Conference Presentation	Submitted: Classen, S., Sisiopiku, V., Mason, J., McKinney B., Hwangbo, S. W., & Yang, W. Users' Perceptions and Attitudes toward Autonomous Vehicle Technologies after Simulation Exposure – A Study across the Lifespan. RSS2022 (Road Safety and Simulation) on June 8-10, 2022, Athens, Greece.
6/12/21	Publication	Classen, S., Mason, J., Hwangbo, S. W., Wersal, J., Rogers, J., & Sisiopiku, V. P. (2021). Older drivers' experience with automated vehicle technology. Journal of Transport and Health, 22, 101107. https://doi.org/10.1016/j.jth.2021.101107
6/24/21	Conference Presentation	Hwangbo, S. W., Classen, S., Mason, J., Wersal, J., Rogers, J., Sisiopiku, V. *Older Drivers' Motion Sickness and Simulator Sickness After Automated Vehicle Exposure.* The Virtual Occupational Therapy Summit of Scholars on June 23-25, 2021.
7/13/21	Conference Presentation	Mason, J., & Classen, S. *Automated Shuttles and Buses for All Users (Session B210): Older Drivers and Persons with Disabilities Experiences with Automated Shuttles*. Virtually presented at the TRB: Automated Road Transportation Symposium (ARTS) on July 13, 2021.
7/15/21	Conference Presentation	Accepted: Hwangbo, S. W., Classen, S., Mason, J., Wersal, J., Rogers, J., Sisiopiku, V. *Older Adults' Motion Sickness and Simulator Sickness after Riding in an On-road Automated Shuttle and Simulated Drive in Autonomous Mode.* Florida Occupational Therapy Association's Virtual Live Conference on November 13-14, 2021.

Date	Type of Accomplishment	Detailed Description
7/22/21	Other	Mason, J. presented: Transportation survey and FL shuttle deployments. Presented at the Safe Mobility for Life Transitioning from Driving Team Meeting on July 22, 2021.
8/25/21	Other	I-MAP Works to Ensure Independence & Mobility for Drivers across the Lifespan at the University of Florida Transportation Institute newsletter
9/2/21	Media (article, etc.)	Kimberly, B. (2021, September 2). *Exposing older adults to self-driving technology improves perceptions on safety, usefulness: study.* McKnight's Senior Living. https://www.mcknightsseniorliving.com/home/news/exposing-older-adults-to-self-driving-technology-improves-perceptions-on-safety-usefulness-study/
9/15/21	Conference Presentation	Accepted: Classen, S., Sisiopiku, V., Mason, J., McKinney, B., Hwangbo, S. W., Yang, W. Users' Perceptions and Attitudes toward Autonomous Vehicle Technologies after Simulation Exposure – A Study across the Lifespan. 8th Road Safety and Simulation – RSS 2022 Conference at Athens, Greece, June 8-10, 2022.
9/28/21	Conference Presentation	Accepted (9/28/21): Manjunatha, P., Mason, J., Classen, S., Elefteriadou, L., & Srinivasan, S. Public Perception and Lessons Learned from Autonomous Shuttle Demonstration Studies. Transportation Research Board (TRB), Washington D.C., January 9-13, 2022.
10/1/21	Publication	Accepted (10/1/21): Manjunatha, P., Mason, J., Classen, S., Elefteriadou, L., & Srinivasan, S. Public Perception and Lessons Learned from Autonomous Shuttle Demonstration Studies. Transportation Research Records.

APPENDIX D – ASSOCIATED WEBSITES, DATA, AND OTHER PRODUCTS

Project data of the older drivers have been uploaded to Zenodo; see doi:10.5281/zenodo.4776758.

The younger and middle-age driver data will be uploaded in similar fashion to Zenodo.