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UF & UAB Phase I Demonstration Study: Older Driver Experiences with Autonomous Vehicle Technology

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ABSTRACT

Older adults (≥ 65 years) account for almost 20% of the population in the United States and prefer driving as their primary mode of transportation but are at greater risk for crash-related injuries and death, compared to younger drivers. Autonomous vehicles (AVs) may hold health and safety benefits for older drivers, if this segment of the population accepts and adopts this technology. To document older drivers' perceptions toward AVs, this study used a repeated measures crossover design, with random allocation of 104 older drivers who were exposed to (a) an autonomous shuttle (Society of Automotive Engineers Level 4) and (b) a simulator programmed to run in autonomous mode (Society of Automotive Engineers Level 4). Participants completed pre- and post-exposure surveys, to report their adoption preferences and perceptions on nine domains of an Autonomous Vehicle User Perception Survey. A two-way mixed ANOVA was used to analyze the time effect, group effect, and time by group interaction. No group effects were evident, but older drivers' perceptions of safety, trust, and perceived usefulness of AV technology increased after being exposed to the AV technology. The group by time interaction effects indicated the significance of older adult perceptions pertaining to intention to use, trust, perceived usefulness, control/driving efficacy, and safety. This study provides valuable contributions to the current body of knowledge regarding the determinants of older adult AV technology acceptance practices. Yet, it is recommended that repeated testing take place because different automated systems, levels of technology, contexts, policies, and local conditions may influence older drivers' perceptions of AV technology.

Keywords:

Autonomous Shuttle, Older Drivers, Perceived Safety, Trust in Automation, Intention to Use

EXECUTIVE SUMMARY

The purpose of this project was to assess older drivers' (≥ 65 years of age) perceptions of autonomous vehicles (AVs). Study participants completed an Autonomous Vehicle User Perception Survey before and after being exposed to (a) an autonomous shuttle, operating in a closed and fixed loop, and (b) an automated driving simulator scenario. The first step of this project was to develop a survey to measure older drivers' perceptions of AVs. The survey was validated using a focus group, subject-matter experts, and psychometric testing. Survey responses were gathered from two samples, older drivers at the baseline (i.e., prior to exposure to AVs) of our demonstration study (i.e., Task 3) and from participants via Amazon Mechanical Turk (MTurk) (i.e., Task 1). The survey was used to quantify older adults' perceptions of AVs and determine if any differences existed before and after exposure, by group, and by time. We also examined group by time interaction effects. We hypothesized that older adults would demonstrate an increase in safety, trust, and intention to use the technology—all important precursors of acceptance and adoption practices—after exposure to the technology. We also hypothesized that older drivers' perceptions would have the greatest magnitude of change after experiencing the autonomous shuttle (vs. simulator). Our findings generally supported the hypotheses, but also indicated that important group by time interaction effects existed for older adult perceptions pertaining to safety, trust, intention to use, perceived usefulness, and control/driving efficacy. Regarding order effects, older drivers' trust increased after experiencing the driving simulator but then decreased to baseline values after riding in the shuttle. For the other group of older drivers, their trust increased after the shuttle and this increase was maintained after riding in the simulator. Older drivers' perceived safety increased after being exposed to the simulator and shuttle, regardless of the order of exposure. Moreover, both the autonomous shuttle and the simulator programmed to run in autonomous mode, were feasible modes for collecting data in a valid and reliable way. The attrition rate for this study was 0%, with no participants dropping out as a result of simulator sickness. This is an important finding as simulator sickness is highly prevalent among older adults.

Given the novelty of this study, the research team had to overcome some challenges. The City of Gainesville and researchers needed to obtain a waiver from the National Highway Traffic Safety Administration to collect data with participants (1) riding the autonomous shuttle and (2) on public roads. The first condition did not occur until much later in the study, and, as such, the team had to deviate from the planned shuttle route in the downtown area—and the rides took place in a deserted bus depot. The simulator scenario was programmed based on the originally approved on-road shuttle route, and as such, congruence between the shuttle route and the simulator scenario was compromised—an unintended effect of the logistics of the study. Moreover, between March 2020 and September 2020, research was halted, as a result of the COVID-19

pandemic. Utilizing Center for Disease Control and Prevention guidelines, personal protective equipment, and restrictions in the number of passengers, the study team completed the study in December 2020.

To our knowledge, this was the first study to quantify older adults' perceptions of AVs, using a valid and reliable user perception survey, before and after real world experiences in two types of AV modes. The main finding suggests that older drivers' perceived safety, trust, and usefulness increased after being exposed to autonomous vehicle technology. The study also demonstrates that both the autonomous shuttle and simulator programmed to run in autonomous mode can be used to expose older adults to AVs. In conclusion, we surmise that older drivers need to be exposed to AVs if they are to accept and adopt this emerging technology.

1.0 INTRODUCTION

By 2020, approximately 40 million (18%) license holders in the United States (US) will be over the age of 65 (Murdock, Cline, Zey, Perez, & Jeanty, 2015). This figure represents a 50% increase in the number of older drivers in a mere two decades (Federal Highway Administration, 2002). Florida is leading the nation with almost 25% of the population being older adults. Unfortunately, 2016 crash statistics indicate that 71,247 older drivers were involved in crashes, 358 died and 20,395 were consequently injured (Federal Highway Administration, 2016). Strikingly, and despite older drivers' adherence to safe driving practices including using seat belts, driving under safe conditions, and avoiding driving under the influence of alcohol (National Highway Traffic Safety Administration & Author, 2017; Naumann, Dellinger, Zaloshnja, Lawrence, & Miller, 2010; Quinlan, Annett, Myers, Ryan, & Hill, 2004; U.S. Department of Transportation & National Highway Traffic Safety Administration, 2016), their increased risk of death or injury in motor vehicle crashes stems from increased frailty (i.e., decreased bone mineral density) and age-related declines in visual, cognitive and motor functions that impact their ability to drive safely (Owsley, 1999). Age-related factors impact older adults' driving performance, including the ability to control a vehicle while conforming to the rules of the road, declines in vision and reaction times, and decreased function in reasoning and recall (Centers for Disease Control and Prevention, 2017; Owsley, 1999; Transportation Research Board, 2016). These factors also include or may be exacerbated by comorbidities, and polypharmacy. As a result, older drivers face increased risk for crashes, crash-related injuries, and/or fatalities (Centers for Disease Control and Prevention, 2017; National Highway Traffic Safety Administration, 2015). In 2015 in the US alone, over 6,800 older drivers died and more than 260,000 were injured as a result of motor vehicle crashes. This number amounts to nearly 20 older drivers being killed and 712 injured every day (Centers for Disease Control and Prevention, 2013). In fact, older drivers are the second most prevalent group involved in motor vehicle collisions in the US (Centers for Disease Control and Prevention, 2017; National Highway Traffic Safety Administration, 2015).

Despite the toll from crashes discussed above, studies associate mobility afforded by driving with increased life satisfaction, quality of life, autonomy, and wellbeing for older drivers (Dickerson, Meuel, Ridenour, & Cooper, 2014; Dickerson, Molnar, Bedard, Eby, Berg-Weger, et al., 2017; Musselwhite, 2011). In contrast, driving cessation is associated with poor health trajectories, including increased rates of depression, limited life-space mobility, early nursing home admissions and premature death (Chihuri et al., 2016; Dickerson et al., 2014; Dickerson, Molnar, Bedard, Eby, Berg-Weger, et al., 2017; Dickerson, Molnar, Bedard, Eby, Classen, et al., 2017; Edwards, Lunsman, Perkins, Rebok, & Roth, 2009; Fonda, Wallace, & Herzog, 2001; Freeman, Gange, Munoz, & West, 2006; Marottoli et al., 2000; Musselwhite, 2011; Ragland, Satariano, & Macleod, 2005).

As the number of adults over 65 years of age increases in North America, *crash mitigation strategies* have emerged as a critical factor in preventing crashes and associated impacts on traffic congestion. Moreover such mitigation strategies—i.e. older driver screening, assessment, intervention (Classen, Dickerson, & Justiss, 2012; Classen, Monahan, Auten, & Yarney, 2014; Dickerson et al., 2014), enhanced vehicles with improved safety features (Bengler et al., 2014; Centers for Disease Control and Prevention, 2015; Charlton, Fildes, & Andrea, 2002; Koppel, Clark, Hoareau, Charlton, & Newstead, 2013; National Highway Transportation Safety Administration, 2007), enhanced infrastructure (Classen et al., 2009; Shechtman et al., 2008; Shechtman et al., 2007) and effective policies (Classen & Awadzi, 2008; Levy, 1995; Morrissey & Grabowski, 2005; Staplin & Freund, 2013) afford older drivers the opportunity to stay on the road longer and safer, while they reap the health-related benefits of being actively engaged in their communities and participating in societal events. Moreover, public health benefits are also evident as the risk for other motorists or road users being crash-involved with older drivers, are reduced. From a transportation engineering perspective, such outcomes will also lead reduced non-recurring congestion to improved operational efficiency of the transportation network.

Autonomous vehicles (AVs; SAE International, 2018), now becoming a reality, have the potential for enormous safety, societal and environmental benefits. Particularly, AVs can prevent older driver crashes occurring due to age-related declines in function resulting in human error, enhance lifelong mobility, while also reducing pollution and *non-recurrent congestion impacts* because of crash reduction (National Highway Traffic Safety Administration, 2013; NHTSA & USDOT, 2017). In 2016, a bill (HB 7061) was enacted in the Florida legislature that requires that Long Range Transportation Plans in the state include advanced technology such as AV. However, based on recent studies examining consumer preferences of AV, the results from older adults indicated that trust and hesitation exist around their comfort in adopting full vehicle automation (American Automobile Association, 2016; Hartford, 2015; Reimer, 2014). A clear weakness of such studies is that older drivers were *not exposed to “driving” an AV either in real-world format or via simulator technology*.

Lived experiences in such AV modes, in combination with surveys, may more accurately reveal the thoughts, beliefs, perceptions, and hesitations of older drivers before, during and after “driving” the autonomous simulator or the AV—and inform scientists and engineers of strategies to enhance adoption practices among older drivers. Information gained from such experiences will also help to identify opportunities and barriers to improve older drivers’ interaction with AV, facilitate their ease-of-use practices, and potentially empower them to adopt this technology.

Because Florida is a model state for older driver mobility issues (Classen & Awadzi, 2008), and Gainesville Florida is an emerging “smart city” (Gonzalez, 2018), it is critical that scientists study and understand these adoption patterns of older drivers pertaining to automated technology. Lessons learned from such work may result in strategies to further improve upon older driver adoption practices of AV, suggest practical hints to engineers for design elements that will serve the needs of older users, and provide information to shape city and state policies for regulatory purposes of AV deployment, adoption, and use.

The scientific premise of this proposal is: (1) The number of older adults is nearing 20% of the population across the US, and Florida is leading the nation with 25% of its population being older adults. However, older drivers are at-risk for crashes and deleterious crash-related effects. (2) Driving, a critical mode of transportation for older adults, yields many health, community and societal benefits, while driving cessation leads to poor health outcomes. (3) The deployment of autonomous vehicles is expected to have health and safety benefits for older drivers, positively impact the environment, and yield societal benefits-- such as crash prevention --that will result in lives saved and improved traffic flow. (4) The state of Florida is a leader in older driver safety practices, and the city of Gainesville is invested in becoming a smart city. (5) University of Florida (UF) and the University of Alabama-Birmingham (*UAB) have the expertise and infrastructure—i.e., scientists, a high-fidelity simulator, and an autonomous vehicle-- that can be deployed to engage older drivers in experiencing AV technology. Consequently, our team was ideally positioned to study older drivers’ perceptions, values, beliefs, and attitudes, pertaining to such AV technology, as a foundational step towards state-wide deployment and adoption among older drivers.

1.1 OBJECTIVE

This project’s objective was portioned into three tasks which included: a) Developing and validating an Autonomous Vehicle User Perception Survey (AVUPS) to assess users’ perceptions of AVs; b) Developing and validating a simulated driving scenario that corresponded to the on-road shuttle route; and c) Assessing older drivers’ perceptions at baseline, after being exposed to the automated shuttle, and after being exposed to the driving simulator in autonomous mode— using the AVUPS and routes developed in b) above. For a) this study utilized measurement theory to establish face and content validity; for b) this study utilized congruence validation using the feedback of national experts via a content validity index; and for c) this study used a randomized crossover design to randomize the order of exposure to autonomous vehicles and control for order effect.

1.2 SCOPE

This is one of the first studies in the US to assess older drivers' perceptions of AVs after direct exposure to such technology. This demonstration study utilizes a scientifically rigorous approach (i.e., validated survey to assess perceptions of AVs, validated driving scenario, and a randomized crossover design) to better understand older drivers' initial impressions of AVs and assess changes in perceptions to AVs after real-world experiences in both an autonomous shuttle and a driving simulator programmed to run in autonomous mode.

2.0 LITERATURE REVIEW

2.1 OLDER DRIVERS

The number of older adults (≥ 65 years of age) is nearing 20% of the US population, and Florida is one of the leading States with 25% of its population being older adults (US Census Bureau, 2019). In 2018, there were almost 45 million licensed drivers aged 65 and older in the US, a 60% increase from 2000 (Federal Highway Administration, 2018). Driving is a significant mode of transportation for older adults, because it ensures mobility and independence and yields many health, community and societal benefits (Dickerson et al., 2014; Dickerson, Molnar, Bedard, Eby, Berg-Weger, et al., 2017). However, older drivers who continue to drive are also at an increased risk for crashes and deleterious crash-related effects (Dickerson et al., 2017). According to Li, Braver, and Chen (2003), because older drivers are more fragile, their fatality rates are 17 times higher than those between the ages of 25 to 64 years old. Thus, there is a need to identify effective strategies that could support the mobility and independence of older adults, while reducing their crash risk on the road. As such, AVs provide plausible opportunities for safe and lifelong mobility of older drivers.

2.2 AUTONOMOUS VEHICLES

Autonomous vehicles (Level 1-5; SAE International, 2018), represent a potentially transformative technology that allows users to travel without actively engaging in the driving task (Level 4-5), thus eliminating crash risks related to human factors. However, achieving such potential depends on the users' perceptions and adoption of the technology. Although user perceptions (alone) have been surveyed in the past (Deloitte, 2014; McDonald, Reyes, Roe, Friberg, & McGehee, 2016; Smith & Anderson, 2017), the actual litmus test is to expose users to AVs to validly assess their perceptions based on their lived experience. Older drivers' perceptions in combination with engagement with AVs have not widely been studied (Classen, Mason, Wersal, Sisiopiku, Rogers, et al., 2020). AVs can broadly

be classified as the personal autonomous vehicle—with the Society of Automotive Engineers International (SAE International, 2018) Level 1, 2, and 3 readily available in the current market—and shared autonomous vehicles (SAVs) currently undergoing pilot testing in many states (Abraham et al., 2016).

2.3 SHARED AUTONOMOUS VEHICLE SERVICES

SAV services represent transformative technology that may be revolutionizing transportation as we know it. SAV stems from a system combining car-sharing and AVs, and was first conceptualized in the early 1990s in Europe (Parent & De La Fortelle, 2005). Although the idea has been in development since the early 1990s, commercial deployment of such services in urban (and other) settings is only now beginning to materialize. The literature indicates the existence of different types of SAV systems and they are 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, Chaniotakis, & Antoniou, 2020). Based on booking time, SAV services can be divided into on-demand (the user reserves a vehicle in real time), reservation-based (the user reserves a vehicle in advance), or a combination of the latter two systems. 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).

Nordhoff and colleagues (2020) reported on passenger opinions related to safety in an autonomous shuttle. Passengers (N=119) rode in an autonomous shuttle with a 'hidden steward on board' in a mixed traffic environment. Researchers examined perceived safety, interactions with autonomous shuttles in crossing situations, and communication with autonomous shuttles. The authors concluded that riders associated their perceptions of *safety* with low speed, dynamic object and event identification (e.g., pedestrian crossing the path of the shuttle), longitudinal and lateral control, opportunity to press the emergency button inside the shuttle, *trust* in the technology, sharing the shuttle with fellow travelers, the operation of the shuttle in a controlled environment, and the behavior of other road users outside the shuttle.

Kaye and colleagues (2020) utilized the Theory of Planned Behavior to assess individuals' *intentions to use* fully autonomous shuttles, as well as their perceived *trust*. Participants ($N = 438$; 64% female) aged between 17 and 84 years ($M_{\text{age}} = 35.42$ years) completed a 15-minute online questionnaire. The findings revealed that attitudes, subjective norms, and perceived behavioral control were significant positive predictors of *intention to use* autonomous shuttles when they become publicly available, and that perceived *trust* was a significant positive predictor of participants' intentions to do so. However, study participants did not ride in the autonomous shuttle.

Because AVs are not yet widely deployed, some researchers have used driving simulators, programmed to drive in autonomous mode, in addition to surveys, to also assess the attitudes of transportation users related to adopting AV technology (Lee, Liu, Domeyer, & DinparastDjadid, 2019).

2.4 AUTONOMOUS DRIVING SIMULATORS

Driving simulators programmed to run in autonomous mode are used to assess user attitudes, perceptions and behaviors related to “driving” an AV (Classen et al., 2020; Lee et al., 2019; Molnar et al., 2018). For example, Lee and colleagues (2019) utilized an autonomous driving simulator to record participants driving styles (aggressive, moderate, and conservative) across four intersection types (i.e., with and without a stop sign and with and without crossing path traffic). Results indicated that recording brake and accelerator pedal responses provides an accurate display of drivers' *trust* of autonomous driving styles. Classen et al. (2020) used a high-fidelity driving simulator (SAE Level 4; SAE) to study the initial perceptions of older drivers of accepting such technology. An interim analysis ($N = 69$) compared older drivers' perceptions before and after exposure to the autonomous shuttle and autonomous driving simulator. After exposure to the autonomous driving simulator, older drivers' *safety*, *trust* as well as *perceived usefulness*, and perceptions related to *cost* of AVs improved compared to baseline (i.e., pre-exposure). The researchers concluded that exposing older adults to an autonomous simulator may promote older adults' acceptance and adoption of AVs. Likewise, Molnar and colleagues (2018) found that driving-specific control preferences were significantly related to *trust*, after experiencing a simulated driving scenario that required switching between manual and autonomous modes. As such, these studies related to AVs and driving simulators running in autonomous mode, show that researchers detected changes in drivers' perception related to acceptance of AV technology, specifically but not exclusively related to *safety*, *trust*, and *intention to use*—each next described.

2.5 SAFETY

Stakeholders in the field of AVs—from industry to the general public, and specifically older drivers—seek confidence in the *safety* of these systems in order to trust them and eventually adopt them as an acceptable mode of transportation. One question to examine is when AVs can be considered to be acceptably safe—that is, deemed adequately safe to operate on public roads without the oversight of a human driver. The Rand Corporation established a framework for understanding *safety*, and it is broadly categorized in three areas (i.e., safety as measurement, safety as a process, and safety as a threshold; Blumenthal et al., 2020). The first area pertains to the leading and lagging kinematic measures used by engineers (e.g., hard braking). Safety as a process addresses the technical standards, government regulation (e.g., policies and laws), and the safety culture of the society. Safety culture is defined as the culture “in a geographical area that can influence driver responses to perceptions of risk associated with system hazards and driver intentions to engage in risky behaviors” (Ward, Otto, & Linkenbach, 2014, p. 42). Of particular importance for this paper, is the third area of the safety framework—i.e., the safety threshold as predicated on the human driver, predicated on the automated driving system, and predicated on the “absolute” goal to be achieved. Unfortunately, no clear safety thresholds exist for AVs and these thresholds must be understood from a multi-dimensional perspective. This includes thresholds related to internal factors (e.g., the user knowledge, attitudes, and behaviors), external factors (e.g., the developer’s knowledge, engineering algorithms), dynamic factors (i.e., the safety threshold changes as the AV technology evolves), and contextual factors (i.e., the safety thresholds based on the environment characteristics, e.g., fog, snow, mountainous terrain, wherein the AV is operating). As such, all of the factors may be working simultaneously, and dynamically, to influence the threshold of safety.

Safety asymmetry, another complicating factor, occurs because the actual safety guidelines implemented in the operational design domain (ODD; SAE, 2018) of an AV are not known by the end-user or passenger. Moreover, users are not always informed, from a data driven perspective, about the actual safety measures underlying the ODD of the AV system. Finally, human drivers will make inevitable comparisons between their driving and that of the automated driving systems to judge how safe the system is. As such, the disparities between what the users know, what they do not know, and what other stakeholders (e.g., manufacturers, industry, engineers) know, continue to shape the politics of AV safety, and lead to gaps in fully understanding the extent of safety among the different stakeholders.

To overcome the safety asymmetry, researchers recommend that AV developers and the larger research community advance safety measures specifically as they pertain to the general public. Among a set of recommendations, *roadmanship* and *collaboration of AV developers* with their communities, stand out. Roadmanship is the ability to drive on the road safely without creating hazards and responding well to hazards created by others (Fraade-Blanar et al., 2018). The collaboration between developers and their communities brings opportunities for the user to experience how the AV operate.

As such, *safety* is a multidimensional construct that may influence the user experience from a variety of perspectives. However, user confidence, and perception of safety, may increase if users have knowledge about the AV, a positive experience pertaining to the AV's ODD, and an appreciation for the reaction capabilities of the AV to safely operate on the roadway.

2.6 TRUST

Trust has been defined as “a history-dependent attitude that an agent will help achieve an individual’s goal in a situation characterized by uncertainty and vulnerability” (Khastgir, Birrell, Dhadyalla, & Jennings, 2018, p.291). While a paucity in the extant literature exists to indicate the relationship between users’ *trust* and SAVs, *trust* is ubiquitously recognized as an important predictor of accepting and adopting AVs (Noy, Shinar, & Horrey, 2018; Parasuraman & Riley, 1997; Shariff, Bonnefon, & Rahwan, 2017; Siebert, Oehl, Höger, & Pfister, 2013). In particular, *trust* influences people’s beliefs in the automation and their *intention to use* it—two critical aspects of acceptance and adoption of AVs (Molnar et al., 2018; Zhang et al., 2019). *Trust* is an important enabler, or barrier, to humans in the process of adopting AV technology. Decision to trust is influenced by the personality of the individual, but also socio-cultural factors (e.g., influence of social interactions, media, and norms) in a given context (Lee & See, 2004). Paddeu et al. (2020) developed an eloquent model to identify the principal factors influencing user trust in AVs. Specifically, this model includes four main categories: dispositional trust (i.e., age, gender, culture, and personality; Hoff & Bashir, 2015); situational trust (i.e., type of system, task difficulty, perceived benefits and risks, self-confidence and mood; Hoff & Bashir, 2015); learned trust (i.e., pre-existing knowledge and trust during an interaction; Hoff & Bashir, 2015); and expectations (i.e., previous experience; (Gold, Körber, Hohenberger, Lechner, & Bengler, 2015). They added that in the context of SAVs, people’s beliefs about AVs, social norms, emotions toward human technology interactions, and personal disposition (Lee & See, 2004) all greatly impact trust. This is of particular interest as the complexity, risk, and limited opportunity for

control associated with “riding” in a SAV may lead to under trusting the automation; whereas, automation that assists drivers and requires them to remain responsible for aspects of the driving task (Level 1-3, SAE), may lead to over trusting the automation (Lee & Kolodge, 2020). Lack of trust in particular, may leave the user susceptible to dread risk—a heightened feeling of risk that is uncontrollable and not understandable. Therefore, increasing the level of knowledge, understanding, and experience with AVs may reduce the potential users’ anxiety, increase their trust, and demonstrate positive perceptions towards future use—or at least their intention to use AVs.

2.7 INTENTION TO USE

A conceptual framework for investigating the adoption and acceptance of AVs among drivers (Mason, Classen, Wersal, & Sisiopiku, 2020) suggests that *intention to use* may be a core construct as derived from the Technology Acceptance Model (Davis, 1989), Car Technology Acceptance Model (Osswald, Wurhofer, Trösterer, Beck, & Tscheligi, 2012), Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), Technology Acceptance Model extended framework (Panagiotopoulos & Dimitrakopoulos, 2018), and the Safety Critical Technology Acceptance Model (Nees, 2016). Specifically, *intention to use* is postulated to be moderated by the *perceived usefulness* of the technology, combined with the *perceived ease of use*. Several surveys indicated that *intention to use* is also affected by *trust* in the technology—and, in particular, that trust moderates perceived risk (Choi & Ji, 2015; Kaur & Rampersad, 2018), leaving users more willing to engage with the AVs. Moreover, Abraham and colleagues (2017) assert that *intention to use* the technology may be greatly influenced by the users not having a clear grasp of the complexity involved with various types of automation. Thus, for end-users to demonstrate an intention to use the AV technology, and to optimally benefit from the advantages of AVs, adequate technology training may be required (Horrey & Lee, 2020).

2.8 TECHNOLOGY ACCEPTANCE MODELS

A multitude of automotive manufacturers, technology companies, and institutions are developing AV technology to address transportation safety and equity for users across the lifespan and mobility spectrum. These developers must create technology that are safe and efficient, while also acceptable and adoptable by the intended users. Recent studies have suggested that AVs should be safer than human drivers in order for transportation users to adopt and accept this technology (Shladover & Nowakowski, 2019; Waycaster, Matsumura, Bilotkach, Haftka, & Kim, 2018). Furthermore, users increase their demand for safety when they entrust their safety to an automated system (Waycaster et al.,

2018). Specifically, Liu and colleagues (2019) found that AVs should be four to five times as safe (i.e., ~ 75% reduction in traffic fatalities) as human drivers, if they are to be adopted. Although safety is a critical predictor, several other factors (i.e., perceived usefulness, perceived ease of use, and trust) influence users' willingness to accept technology.

In order to understand adults' perceptions of AV technology, the Automated Vehicle User Perception Survey (AVUPS) was constructed to measure transportation users' perceptions of AVs. Conducting an extensive literature review was a required prerequisite to generating and modifying survey items. The following section provides an overview of models used for determining acceptance and adoption of technology.

The Technology Acceptance Model (TAM; Davis, 1989) proposes that the use of an information system is determined by the behavioral intention of a user, which is mediated by perceived usefulness (i.e., belief that the use of a system will improve performance) and perceived ease of use (i.e., belief that the use of a system will be free of effort). Technology that is perceived to be easier to *use* as well as *useful* is more likely to be accepted by users (Davis, 1989). The TAM consistently explains about 40% of the variance in individuals' intention to use vs. the actual usage of informational technology (Osswald et al., 2012; Venkatesh et al., 2003). Although the TAM provides a conceptual framework for determining *user ease* and *usefulness*, it has been criticized for its lack of predictive power and overlooked constructs (i.e., cost, cultural differences, social aspects of decision making; Bagozzi, 2007).

Venkatesh and colleagues (Venkatesh et al., 2003) integrated eight acceptance models into the Unified Theory of Acceptance and Use of Technology (UTAUT), designed to capture all of the factors impacting intention to use a particular technology. The UTAUT postulates that *performance expectancy*, *effort expectancy*, *social influence*, and *conditions* that facilitate technology acceptance are critical constructs. Although the UTAUT is encompassing, it presents a model with 41 independent variables for prediction of intentions and at least eight independent variables for predicting behaviour (Bagozzi, 2007). However, these constructs may be influenced by gender, age, experience, and voluntariness of use (Madigan, Louw, Wilbrink, Schieben, & Merat, 2017).

The Car Technology Acceptance Model (CTAM; Osswald et al., 2012) was developed by integrating the TAM and UTAUT. The modeling approach supports decision processes regarding In-Vehicle Information Systems (IVIS)

implementation in the automotive industry. IVIS provide contextual information (i.e., driving speed or position of the car) to deliver driving-related information and support to the driver. The CTAM incorporates the UTAUT model with the addition of perceived stress, safety, and anxiety. As such, the benefit of this model is the consideration of safety and anxiety as these perceptions may be affected by adding stimulus (i.e., information from IVIS) to driving, an already complex instrumental activity of daily living. The primary disadvantage to this model is the lack of empirical support as CTAM was developed in 2012 with 21 subjects that completed their questionnaire.

The 4P (i.e., podlike vehicles) Acceptance Model (Sina Nordhoff, van Arem, & Happee, 2016) was influenced by the UTAUT and pleasure-arousal-dominance framework (Mehrabian, 2007). The 4P Acceptance Model guided survey construction designed to elucidate user acceptance of SAE Level 4 vehicles or driverless pod-like vehicles without a steering wheel that operated within the constraints of dedicated infrastructure. The purpose of the 4P Acceptance Model is to prevent generalizability to AVs that will operate outside of a closed loop. The advantage of the 4P Acceptance Model is the holistic and comprehensive view of user acceptance (22 components) that goes beyond the attributes of AVs. For instance, components include vehicle characteristics, contextual characteristics, mobility characteristics, socio-demographics, willingness to pay, and arousal. Nordhoff and colleagues (2018) conducted interviews and subsequently developed a 94-item survey.

The Safety Critical Technology Acceptance Model (SCTAM; Hutchins & Hook, 2017) was developed from the TAM (Davis, 1989) but proposes additional focus on the psychology of control, acceptance, and trust that influence the use of a safety critical technology. Preliminary results suggest that authority (i.e., approval from a governing body) is the single greatest factor in the addition of the SCTAM (Hutchins & Hook, 2017). Likewise, the TAM-extended framework (Panagiotopoulos & Dimitrakopoulos, 2018), also developed from the TAM, indicated that four constructs (i.e., perceived usefulness, perceived ease of use, trust, and social influence) affect users' intention to use AVs. Perceived usefulness was the strongest predictor of behavioral intention of the user, suggesting that AVs must provide functional benefits (i.e., freeing up users' time and simplifying their lives) if users are to adopt this technology.

The findings from the Self-driving Car Acceptance Scale (SCAS; Nees, 2016) suggest that drivers must establish realistic expectations about the performance of automation before interacting with AVs to facilitate long-term acceptance. The 24-item scale was utilized in an experiment which found that people were

more accepting of AVs after reading a vignette featuring an idealized portrayal of perfect automation in self-driving cars as compared to a scenario that described a more realistic situation in which the human driver played a monitoring role and occasionally intervened during vehicle automation.

In summary, acceptance and adoption practices among end-users, and in particular older drivers, is a complex dynamic, influenced by a multitude of factors, as discussed above. If older drivers are to accept and adopt AVs that will yield health and safety benefits to them, researchers must understand their perceptions, before and after exposure to AVs.

3.0 TASK 1: SURVEY DEVELOPMENT AND VALIDATION

3.1 INTRODUCTION

The purpose of this task is to report on development, validation, and test-retest reliability of a survey to assess adults' perceptions of highly AVs (SAE Level 4). Numerous researchers have surveyed consumer perceptions about vehicle automation (Becker & Axhausen, 2017) using a variety of surveys (Kyriakidis, Happee, & Winter, 2015; Michael A. Nees, 2016; Osswald et al., 2012; Payne, Cestac, & Delhomme, 2014). However, a majority of these efforts were focused on potential consumers who may purchase this technology, which may not occur given the financial and/or ecological constraints of owning and maintaining an AV (Fagnant & Kockelman, 2014). Moreover, dynamic ridesharing and ridehailing schemes involving AVs may be implemented resulting in reduced private car ownership (Fagnant & Kockelman, 2015). Findings from previous research showed that the determinants of user perceptions on acceptance of AVs are largely unknown.

The primary objective of this task was to construct the AVUPS derived from the technology acceptance models discussed above, to assess perceptions of user acceptance of AV technology. Therefore, this task had three aims: a) generate and modify items for a survey to determine user perception of acceptance of AVs; b) establish face, content, and construct validity of the AVUPS; and c) assess test-retest reliability of the AVUPS.

3.2 METHODOLOGY

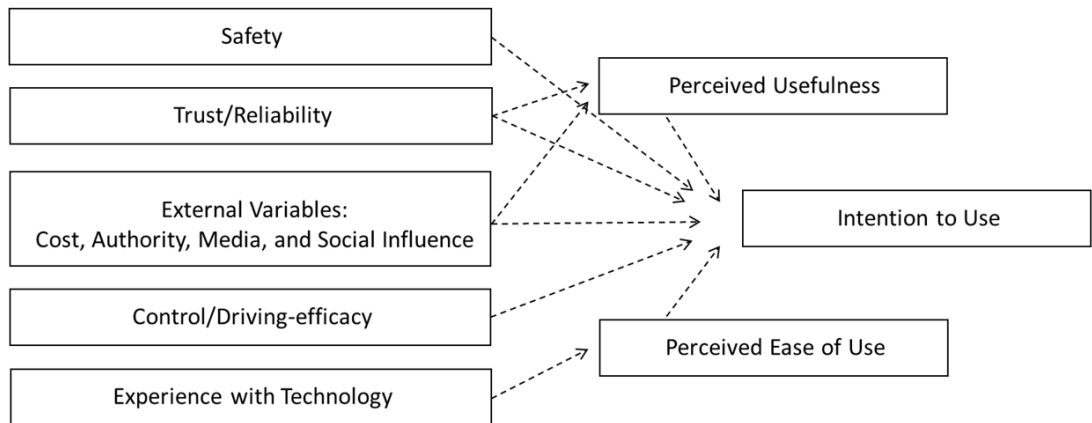
The Institutional Review Board (IRB) of the University of Florida approved this study (IRB201802574; IRB201801988; IRB201902699).

3.2.1 AIM 1: ITEM GENERATION AND MODIFICATION

The initial stage of instrument development was performed in three steps –i.e., identifying the content domain, generating sample items, and constructing the instrument (Zamanzadeh et al., 2015). Items were generated from seven acceptance models: 1) TAM; 2) SCTAM; 3) CTAM (Osswald et al., 2012); 4) UTAUT (Venkatesh et al., 2003); 5) TAM-extended framework (Ilias Panagiotopoulos & Dimitrakopoulos, 2018); 6) SCAS (Nees, 2016); and 7) 4P Acceptance Model (Nordhoff et al., 2016).

Survey items were written to reflect a conceptual model (see Figure 3-1) which contained eight potential sub-dimensions: (a) *intention to use*; (b) *perceived ease of use*; (c) *perceived usefulness*; (d) *safety*; (e) *trust and reliability*; (f) *experience*; (g) *control and driving-efficacy*; and (h) *external variables* (i.e., media, governing authority, social influence, and cost). Twenty-one of 35 items were generated by the authors whereas 14 items were modified from previous surveys (Cho, Park, Park, & Jung, 2017; Choi & Ji, 2015; Davis, 1989; Gold et al., 2015; Nees, 2016). Self-generated items and their potential domains were chosen to align with TAM, UTUAT, and extended models while also integrating additional themes that arose during subsequent qualitative studies (Buckley, Kaye, & Pradhan, 2018; Nordhoff, de Winter, Payre, van Arem, & Happee, 2019). The survey was designed to elicit users' perception of acceptance to fully automated vehicles (SAE Level 4 or 5).

FIGURE 3-1. CONCEPTUAL MODEL TO GUIDE SURVEY DEVELOPMENT.



At the beginning of the survey, participants were prompted by the statement:

“An automated vehicle (i.e., self-driving vehicle, driverless car, self-driving shuttle) is a vehicle that is capable of sensing its environment and navigating without human input. Full-time automation of all driving tasks on any road, under any conditions, and does not require a driver nor a steering wheel.”

The 36 visual analogue scale (VAS) items were developed with verbal anchors, ranging from disagree to agree. VAS is a continuous scale, typically with two descriptors (i.e., verbal anchors) on the extremes of a 100 mm horizontal line (Jensen, Chen, & Brugger, 2003). Respondents rated their perceptions by making a mark (i.e., vertical slash) corresponding to their level of agreement/disagreement. The distance between the marked point and the origin of the line was measured to quantify the magnitude of the response. Additionally, four open-ended items were developed to allow individuals to consider and provide their own ideas, thoughts, and feelings (Creswell & Clark, 2011).

3.2.2 AIM 2: ESTABLISH FACE, CONTENT, AND CONSTRUCT VALIDITY

First, *face validity* was established. Face validity is an initial judgment of whether a tool assesses the concept it purports to measure (Gravetter & Forzano, 2012) and refers to how items are to be interpreted by the

intended audience (i.e., layperson) who will complete the survey (Streiner & Norman, 1989). The 40-item survey was presented to the Institute of Mobility, Activity, and Participation (I-MAP) team (two quantitative researchers, one qualitative researcher, one clinician, five rehabilitation science or civil engineering doctoral students, and two undergraduate students) who provided input and recommendations on the wording, clarity, and comprehension of the items.

Content validity measures the degree to which elements of the measurement instrument are relevant, representative, and comprehensive of the construct for a particular assessment purpose (Haynes, Richard, & Kubany, 1995). Three or more raters (i.e., subject-matter experts) are needed to provide a rigorous rating (Lynn, 1986) and raters should have expertise in the content area under investigation (Grant & Davis, 1997). Content validity index (CVI) results are used to refine the items and the CVI process is repeated until an acceptance level of content validity is reached (i.e., Scale CVI > .90) (Waltz, Strickland, & Lenz, 2010).

Seven subject-matter experts rated the content validity of the survey and were selected to represent relevant domains which included one expert in cognitive psychology (20 years of experience), one expert in measurement and survey design (45 years of experience), three experts in transportation engineering (combined 70 years of experience), and two experts in human factors (combined 45 years of experience). The experts provided their feedback via a Qualtrics survey by rating the relevance of each item on a 4-point Likert scale (1 = not relevant, 2 = relevant with major revisions, 3 = relevant with minor revisions, and 4 = very relevant). They also provided qualitative feedback on item accuracy, organization, clarity, appearance, purpose, understandability, and adequacy (Grant & Davis, 1997).

3.2.3 AIM 3: ASSESS TEST-RETEST RELIABILITY

Test-retest reliability: Participants provided their written consent or waived consent to participate in the study. The AVUPS was distributed online using Amazon Mechanical Turk (MTurk). Amazon MTurk provided access to a virtual community of workers from different regions of the country with varying backgrounds, who are willing to complete human intelligence tasks (HITs). The researchers of this study submitted a HIT and interested MTurk workers responded using the survey link which

directed them to Qualtrics. The requirements for the MTurk respondents were that they had to be living in the US and have attempted at least 1000 HITs with a successful completion of at least 95% of their attempted HITs (i.e., Master Workers). The first HIT was completed by 137 participants and they were asked to complete the survey again in two weeks. After two weeks, 84 participants (61% response rate) completed the survey again. The follow-up responses (i.e., after two weeks) for the 84 participants were used to assess test-retest reliability.

Construct validity: A third batch of 65 respondents completed the survey to provide the research team with an adequate total sample for factor analysis (i.e., >250 responses; Watson *et al.*, 2018). MTurk survey responses from the first and third batch (n = 202) were aggregated with baseline survey responses (n = 110) from participants participating (i.e., ≥ 65 years old; valid driver's license; no signs of cognitive impairment via the Montreal Cognitive Assessment) in the current AV Demonstration Study (Classen *et al.*, 2020), resulting in a final sample of 312 participants.

The measurement model was constructed utilizing a two-stage approach consisting of an exploratory factor analysis (EFA) and Mokken Scaling Analysis (MSA). The main outcomes of survey validation are discussed below but in-depth information (i.e., details and outcomes) of these analyses are detailed in an open-source publication (Mason, Classen, Wersal, & Sisiopiku, 2021).

3.2.4 ANALYSIS

Data processing was carried out in RStudio (RStudio, Boston, MA) with R version 4.0.2 (R Core Team, 2020), using the psych and Mokken packages.

Face validity: To establish face validity, the I-MAP team provided feedback on items' order and clarity, and how items are to be interpreted by the intended audience who will complete the survey (Streiner & Norman, 1989). Items were discussed and revised during a meeting to incorporate feedback.

Content validity: included calculation of both an item-level CVI (I-CVI) and the scale CVI (S-CVI). Using CVI procedures (Lynn, 1986), rater scores were collapsed with an item-level score of 3 or 4, indicating acceptable item relevance, and a score of 1 or 2, indicating need for a major revision

or low item relevance. Item-level CVIs of 0.86 or 1.00 were acceptable (0.86 = the item was rated as relevant by six raters; 1.00 = the item was rated as relevant by seven raters), whereas scores of 0.71 or below (0.71 = the item was rated as relevant by five raters) were unacceptable. After the analysis, items with a low item CVI (= 0.71) were revised by the research team, whereas items with scores 0.57 or below (0.57 = the item was rated as relevant by four raters) were removed from the survey. The CVI process and item refinement were repeated until an acceptable level of content validity was reached (average CVI \geq 0.80; (House, House, & Campbell, 1981). Items were ordered thematically regarding the domain they are intended to represent as it has been shown to enhance internal consistency reliability (Lam, Green, & Bordignon, 2002; Melnick, 1993).

Test-retest reliability: of AVUPS was assessed using intra-class correlation (ICC) and paired sample correlation (Sackett, Haynes, & Tugwell, 1985).

Construct validity: An EFA was employed to extract the fundamental dimensions of users' perceptions of AVs and compared those to the conceptual model (see Figure 3-1). Items comprising factors that emerged from the EFA were entered as separate Mokken scales as well as inputting all items into the MSA. Due to negative loading, nine items were reverse scored using the *paste0* function in R. A MSA was conducted to explore whether there were hierarchical properties in users' perceptions and of the AVUPS.

3.3 RESULTS

Face validity: The I-MAP team provided critiques and suggestions to make the survey understandable to the layperson across the lifespan. Feedback from the I-MAP team was used to assess face validity of the survey. Out of the 40 items generated from the literature review, 30 (75%) items were approved without edits, nine (22.5%) items were revised and subsequently accepted, and one item (2.5%) was removed. These items were rephrased to avoid leading questions, reduce ambiguity, limit jargon and technical terms, and be relevant to adults of all ages.

Content validity: After establishing face validity, seven subject-matter experts provided relevance ratings and extensive feedback for the survey. The first round of content validity consisted of 39 items with an overall scale CVI of 84% (mean relevance for all items), with 28 of 39 (71.8%) items rated greater than or equal to 0.86 (six of seven experts rated the item as relevant). Six items were removed

from the survey with an item rating of 43% (three of seven experts rated the item as relevant). Five items with an item rating of 71% (five of seven experts rated the item as relevant) were amended and sent back to the experts for further evaluation. All seven experts provided relevance ratings and feedback for the five revised items. In the second round of content validity, four of five items had a CVI greater than or equal to 0.86 (at least six of seven experts rated the item as relevant) and were thus accepted without changes. The other item was removed from the survey as it had a CVI below 70%. The final survey (Table 3-1) consisted of 32 items (28 VAS and four open-ended), with a scale CVI of 96% (Mean CVI of all items) and 32 out of 32 items (100%) rated greater than or equal to 0.86. Both scale CVI values indicate acceptable content validity (Polit & Beck, 2006).

TABLE 3-1. ITEMS AND EXPECTED DIMENSIONS

Dimension	Item	#	Source for modification
Experience with technology	I use technology to make tasks easier for me	1	Nees, 2016
	I use technology in my vehicle to make tasks easier for me	2	Self-developed
	I have had bad experiences when I try to use new technology instead of doing things "the old-fashioned way"	3	Nees, 2016
Intention to Use	I am open to the idea of using automated vehicles	4	Self-developed
	I would use an automated vehicle on a daily basis	15	Davis, 1989
	I would rarely use an automated vehicle	16	Self-developed
Trust/Reliability	I am suspicious of automated vehicles	5	Gold <i>et al.</i> , 2015
	I can trust automated vehicles	6	Choi & Ji, 2015
	I will engage in other tasks while riding in an automated vehicle	7	Gold <i>et al.</i> , 2015
	I feel hesitant about using an automated vehicle	28	Cho <i>et al.</i> , 2017
Perceived Usefulness	Automated vehicles will reduce traffic congestion	8	Self-developed
	Automated vehicles will assist with parking	9	Self-developed
	Automated vehicles will allow me to stay active	10	Self-developed
	Automated vehicles will allow me to stay involved in my community	11	Self-developed
Perceived Ease of Use	Automated vehicles will enhance my quality of life/well-being	12	Self-developed
	Automated vehicles will be easy to use	13	Nees, 2016
	A lot of effort is required to figure out how to use an automated vehicle	14	Nees, 2016
Safety	When I'm riding in an automated vehicle, other road users will be safe	25	Self-developed

	Automated vehicles will increase the number of crashes	26	Gold <i>et al.</i> , 2015
	I feel safe riding in an automated vehicle	27	Nees, 2016
Control/ Driving-efficacy	Even if I had access to an automated vehicle, I would still want to drive myself	17	Nees, 2016
	I prefer the option to drive myself by turning off the automated system	18	Nees, 2016
	My driving abilities will decline due to relying on an automated vehicle	19	Self-developed
External Variables			
<i>Cost</i>	I will be willing to pay more for an automated vehicle compared to what I would pay for a traditional car	20	Nees, 2016
	If cost was not an issue, I would use an automated vehicle	21	Self-developed
<i>Authority</i>	I would use an automated vehicle if National Highway Traffic Safety Administration (NHTSA) deems them as being safe	22	Self-developed
<i>Media</i>	Media portrays automated vehicles in a positive way	23	Self-developed
<i>Social Influence</i>	My family and friends will encourage/support me when I use an automated vehicle	24	Self-developed
Open-ended	Describe influences that may promote your willingness to use automated vehicles	29	Self-developed
	Describe influences that may deter you from using automated vehicles	30	Self-developed
	Describe potential benefits of automated vehicles	31	Self-developed
	Describe potential disadvantages of automated vehicles	32	Self-developed

Test-retest reliability: A subsample of 84 MTurk Workers was used to estimate the test-retest reliability of the AVUPS. Participants completed the AVUPS again, 2 weeks after the first AVUPS. Spearman's rho (ρ) and intraclass correlation coefficients ($ICC_{2,1}$) were computed to assess the test-retest reliability at the subscale level. A perfect Spearman correlation of -1 or +1 occurs when the variables are a perfect monotone function of one another. ICC reliability values can range from 0 to 1 and can be interpreted as poor (< .4), fair (.4 - .6), good (.6 - .75), and excellent (> .75; Fleiss, Levin, & Paik, 2013). The total AVUPS scores for test and retest reliability in these 84 participants were significantly and strongly correlated with excellent reliability ($\rho = .76, p < .001, ICC = .95$). The separate Mokken scale (i.e., factors) scores for test-retest were also significantly and strongly correlated with excellent reliability: *Intention to use* ($\rho = .80, p < .001, ICC = .93$), *perceived barriers* ($\rho = .73, p < .001, ICC = .87$), and *well-being* ($\rho = .72, p < .001, ICC = .84$).

Construct validity: Survey responses from 312 adults ($M_{age} = 47.84, SD_{age} = 18.77$; 59% male; 21% non-Caucasian; 2% Hispanic/Latinx) living in the US were used to

assess the factor structure and psychometric properties of the AVUPS. An EFA was performed on all 28 AVUPS items to compare the factor structure of the empirical data against the conceptual model (11 Factors; See Figure 3-1). The factor structure did not match the conceptual model. Thus, a parallel analysis was performed to determine the number of factors to keep in the EFA. A factor structure with four factors was established. Two items (Items 18 and 23) did not load on to the four-factor structure and were excluded from the subscales (i.e., factors). The four-factor structure with 26 items, explaining 57.35% of the variance, conceptually represented *intention to use* (13 items), *perceived barriers* (seven items), *well-being* (four items), and *experience with technology* (two items). The factor labels were determined by assessing item content, commonalities, and Loevinger's coefficient of homogeneity (Fabrigar et al., 1999). The fourth factor, *experience with technology*, contained two items which was insufficient for MSA. All 13 items met assumptions for MSA and were retained in the first subscale, *intention to use*. For the second subscale, *perceived barriers*, six of the seven items had adequate scalability coefficients, resulting in the removal of Item 3. All four items for the subscale, *well-being*, displayed no violations and were thus retained.

The MSA was performed on all 28 items to determine if the scale is unidimensional. This resulted in the removal of six items (Items 1, 2, 3, 14, 19, and 23). Assumptions were violated which resulted in the removal of two items (Items 11 and 26) from the scale.

3.4 CONCLUSION

The approach adopted in this study and the initial survey development (Mason et al., 2020) ensured that the survey instrument design included items that were relevant, concise, and clear. Specifically, the conceptual model guided item generation from the extant literature, followed by an assessment to determine face validity, and two rounds of reviews from subject-matter experts to establish content validity. The validation of the AVUPS and three separate Mokken subscales enables researchers to utilize the entire AVUPS or any combination of separate Mokken subscales to quantify users' perceptions of AVs. Future research may be performed to establish criterion validity, replicate the dimensionality, and to determine whether similar items demonstrate invariant item ordering. Currently, the survey may be utilized to assess road users' acceptance of AVs and potentially predict their intention to use this innovative technology. Furthermore, this instrument holds potential for informing city managers and transportation planners of the public's opinion on fully AVs.

4.0 TASK 2: DEVELOP CONGRUENT DRIVING ROUTES

4.1 INTRODUCTION

To our knowledge, and from the studies reviewed, little is known about the influences of environmental components on users' perceptions in either an autonomous simulator or automated shuttle. There is value in understanding environmental components such as the drain on batteries in the shuttle (i.e., heat/air conditioning, speed, grade) but researchers know little as to how it can impact users' experience in AVs. Additionally, autonomous simulator research revealed that environmental components such as experience, weather, and road conditions can influence users' expectation (Koglbauer, Holzinger, Eichberger, & Lex, 2018; Payre, Cestac, & Delhomme, 2016). Furthermore, it is critical to understand environmental components as the environment can impact, positively or negatively, the person, their task (i.e., occupation), or engagement with AV (i.e., performance; Baum, Christiansen, & Bass, 2015).

Limited research exists on the congruence between the modes (i.e., simulation or on-road) of vehicle automation to assess users' perceptions with surveys. This task aims at establishing face and content validity between an AV simulation scenario and an on-road course. The main objective is to ensure consistency between these two scenarios that were intended to be used to exposed older adults that participated in the study to AVs.

4.2 METHODOLOGY

Development of an autonomous simulation scenario was an iterative team-based approach integrating an extensive range of data from video, audio, observation, and online/city tools. The development of a congruent scenario took approximately 3 months with weekly meetings between the simulation developer and an occupational therapist. Additionally, progress was presented, through video, to the remaining team members in bi-monthly meetings to acquire input for refinement and congruence. The five team members had experience within transportation, simulators, occupational therapy, engineering, driving rehabilitation, computer science, and exercise physiology. In addition to the meetings, data collected prior to simulation scenario development were utilized to ensure congruency between expected AV on-road route and the simulation scenario being developed.

The following data were assessed and incorporated throughout the process: a) Consultation with traffic operations and other city stakeholders; b) AV Stakeholders such as shuttle engineers and operators from TransDev; c)

Collaborated with the developers for the AV (EasyMile EZ10 Vehicle) & AV Simulator (RTI High-Fidelity Simulator) to retrieve and clarify specifications and manuals; d) Google maps utilized to preview projected route outlined by the City of Gainesville Phase 1 deployment route; e) Video recording obtained during standard traffic patterns of projected route and time of operation; f) Non-recorded observations conducted in the morning to observe any major differences between the PM/AM; and g) images/video recording broken into environmental components by a researcher (i.e., occupational therapist) trained to perform this task.

The next stage in the development of the simulation scenario required face validity. This process is important to understand if individuals outside of the team would consider the AV on-road route and AV simulation scenario congruent.

4.2.1 AUTONOMOUS SIMULATOR AND SHUTTLE ROUTE

The experiment took place in Gainesville, FL. The autonomous shuttle route was planned to begin in a parking garage making a right on SW 2nd St. continuing to a two-way stop intersection (cross traffic vehicles traveling ~ 25 mph). Based on the route plans, the shuttle takes a right onto SW 2nd Ave heading in the west direction. The shuttle maintains this route until it encounters the second roundabout at SW 10th St and loops around to head east bound on SW 2nd Ave. The shuttle continues straight until it reaches the left turn only lane for SW 2nd St., which has an unprotected left turn. The shuttle continues straight on SW 2nd St. until making a left back into the parking garage. The entire SW 2nd Ave. corridor is lined with cyclist lanes on both east/west bound directions. Additionally, this is a bus route road with vehicle parking lined on the west bound direction and a minimal pickup/drop-off location on the east bound side of SW 2nd Ave. Moderate amounts of pedestrians/cyclist/scooters utilize crosswalks and sidewalks along this route. There are two unique time-based hazards along this route. The first is construction of a new building on westbound near SW 8th St. and the second is time of day influence on solar glare. The route includes seven crosswalks, four primary intersections (two merge yields, one yielded left turn, and one stop), 15 streets that intersect the route (see Figure 4-1).

FIGURE 4-1. AUTONOMOUS SHUTTLE ROUTE



The simulation development used the same environment type (e.g., suburban) with similar components of behind the wheel recording (e.g., types of buildings, intersections, crosswalks, etc.). The behind the wheel video ([Autonomous Road Course](#)) and simulation development video ([Autonomous Vehicle Simulation Scenario](#)) can be retrieved and observed from their respective link.

4.2.2 PROCEDURE FOR ASSESSING FACE VALIDITY

The AV on-road route and AV simulation scenario were presented via Microsoft® PowerPoint® with supporting information on the mode of transportation (EasyMile EZ10 Vehicle and RTI High-Fidelity Simulator). The members were instructed that the two recordings are not intended to be 100% alike but rather a realistic representation of that type of environment (e.g., suburban). A qualitative researcher, who was not directly associated with this study, conducted a semi-structured discussion group with seven members (four students, one clinician, and two researchers) of the Institute for Mobility, Activity, and Participation (I-MAP) to elicit feedback. Specifically, the members discussed the following: a) Traffic conditions (e.g., # of cars on road / common congested areas, such as intersections, crosswalk, or signage); b) Physical environment (e.g., suburbia, parking lots, building styles, vehicle type or presence); c) Hazard perception (e.g., pedestrian crossing abruptly, car pulling out, work zone); d) Fidelity (e.g., sense of believability of the realism of riding in an AV in both conditions); and e) Modifications (e.g., recommendations for improving how to make the two rides similar). The input acquired was incorporated for further refinement and development of the simulation scenario.

4.2.3 PROCEDURE FOR ASSESSING CONTENT VALIDITY

Following the recommendations presented in literature (Lynn, 1986), the team developed a content validity index (CVI) survey on a 3-point Likert scale (1-mildly alike, 2-moderately alike, and 3-mostly alike). This survey was given to seven subject-matter experts in the fields of human factors, transportation, rehabilitation science, driving, traffic safety, engineering and simulation. Each potential expert received an e-mail outlining the research study, anticipated time commitment, and deadline for response. Upon accepting, experts were provided with an instructional e-mail with a link to a Qualtrics survey and a PowerPoint presentation on the specification of the AV on-road route and an AV simulation scenario. The chosen experts provided feedback by completing a Qualtrics survey where they rated the level of congruence using the 3-point Likert scale with the opportunity to provide qualitative feedback on their rating for components of the physical environments between the AV on-road route and the AV simulation scenario.

4.2.4 ANALYSIS

Face validity: was assessed through a focus group which provided feedback on five indices pertaining to environmental congruence. The notes that were taken during the semi-structured meeting were analyzed and reviewed with the qualitative researcher, senior author, and simulator lab manager. These findings were coded, through team discussion and consensus, to represent what the team could or could not address within the simulation scenario. Specifically, areas that could not be addressed had to be discussed (e.g., simulator limitations such as adding a median, changing the size of the roundabout, and improving graphical detail). The aforementioned limitations are of great value. However, median and the size of the roundabout were limitations with the version of software the team had while using the new autonomous mode feature. In addition, improving graphical detail (e.g., higher resolution and texture maps) to be more realistic would cause video rendering issues.

Content validity: The subject-matter experts' feedback was analyzed at both the item level CVI (I-CVI) and scale CVI (S-CVI). The I-CVI score is calculated by studying the proportion of the seven raters who scored the item as congruent (e.g., 3-mostly alike). In accordance with CVI guidelines (Polit & Beck, 2006), acceptable I-CVI levels were considered between .8 – 1.0. A score of .86 signified that six out of the seven raters scored that environmental component as 3-mostly alike. However, a score of .71 or

below signified that five or fewer raters scores the item as 3-mostly alike. S-CVI was the percentage of I-CVIs that were acceptable (i.e., I-CVI \geq .86). Data were collated and analyzed in Microsoft® Excel®.

4.3 RESULTS

Face validity: The information gained from the seven participants from the I-MAP team addressed five indices (traffic conditions, environment, hazard perceptions, fidelity, and desired modifications). Overall, the feedback consisted of both comments of congruence and incongruence; see Table 4-1 Face Validity Feedback. Two points were well discussed through member cross talk: 1) foliage/vegetation in simulation scenario and 2) building height. Specifically, there was a debate if it was representative of a suburban setting with members debating their point of view.

After discussing face validity findings with the research team, six of the seven (86%) recommendations were used. One out of the seven, “less cars in roundabout,” was not addressed as the team felt this was an actual representation of a suburban environment, despite the on-road recording not having as much traffic in the moment of that recording. However, during other observations, dense traffic was recorded in the roundabouts. No member discussed the mountain range in the background which could be due to understanding that the simulation scenario was intended to be a representation of suburban environment and not 100% similar. Having a distinction between background and foreground assists with the reduction of simulator sickness symptoms (e.g., dizziness, nauseous, sweatiness, and queasiness; Lin, Abi-Rached, Kim, Parker, & Furness, 2002). Ultimately, the team gained a better understanding of how to improve congruence between an AV on-road route and an AV simulation scenario.

TABLE 4-1. FACE VALIDITY FEEDBACK FOR SCENARIO DEVELOPMENT.

Indices	Comments
Traffic conditions	<ul style="list-style-type: none"> • Traffic lights missing (phase 1 deployment) • Timing of cars/pedestrians/cyclists/distances similar • Crosswalk was really off – (red instead of white lines) • A lot more cars in simulation but not enough people • Cyclists presence was similar between the two recordings
Environment	<ul style="list-style-type: none"> • More traffic in simulation than in the video • Simulation did not have as much as vegetation as the recording • Buildings were similar with real world environment and construction zone • Simulator seemed more urban/city like and road course seemed more residential • In simulator “I could see things a lot easier” as compared to the real-world recording • Vehicle entering roundabout was accurate depiction of real-world
Hazard Perceptions	<ul style="list-style-type: none"> • Illegal street crossing (jaywalking) was not present • Multiple pedestrians crossings would be beneficial • Cars not yielding / pulling out was accurate
Fidelity	<ul style="list-style-type: none"> • Difficulty answering this question • AV Sim – stops were really fast as compared to AV on-road • Recommended obtaining video footage from AV shuttle
Modifications	<ul style="list-style-type: none"> • White crosswalks* (brick/white) • More foliage* (locations/specific) • Building height adjustment* • Less cars in roundabouts in simulation • Turn signal of vehicles entering roundabout* • More pedestrians present* • Diversifying pedestrian models* • Upcoming warning pedestrian crosswalk signs*

Note. * refers to areas that were addressed in simulation scenario

Content validity: The subject-matter experts rated 17 components of the physical environment on the level of congruence (1-mildly alike, 2-moderately alike, and 3-mostly alike) and were encouraged to provide qualitative feedback on anything rated below a three. The qualitative feedback was used to improve the congruence by addressing the experts’ concern for how the variable was represented in the AV simulation scenario. Any item representing an environmental component with a CVI score below .71 was modified. Specifically,

the item was modified or amended to include the expert's feedback. The team discussed a strategy for addressing any item that scored .57 or below which signified that four out of the seven experts rated the item less than a 3 (mostly alike). The S-CVI = .83, met acceptable congruence ($\geq .80$). If a variable was unable to be addressed adequately due to a limitation (e.g., simulator-based constraint) it was removed and explained to address experts' feedback. A detailed discussion of the participants' feedback is published (Classen, Mason Wersal, Sisiopiku & Rogers, 2020)

The item ratings range and mean scores along with experts' feedback were discussed with the senior author, simulator lab manager, and remainder of the team. Specifically, the 17 item I-CVI ranged from .57 to 1.0 with an S-CVI of .83. Since the majority of recommendations were in congruence with the findings of the face validity meeting, no additional modifications were required. The recommendation for having the autonomous shuttle drive only in one direction is not possible due to the vehicle using a narrow mobility lane for most of the route, diverting only when mobility lane is not present (e.g., roundabouts). The autonomous shuttle is required to abide by the plan outlined and approval by the NHTSA.

4.4 CONCLUSION

AVs will cause a paradigm shift in the transportation industry, which will require ongoing research to understand their impact on humans. However, little is known about how environmental components that may influence individuals' experiences and perceptions—that will also affect their desire to participate in the use of this emerging technology. Development of AV simulator scenarios with high congruence to the on-road routes provide higher levels of fidelity and strengthen the internal validity of studies using dual modes (autonomous shuttles and driving simulators) to assess participants' perceptions of AVs.

5.0 TASK 3: OLDER DRIVERS' PERCEPTIONS BEFORE AND AFTER EXPOSURE TO AUTOMATED VEHICLES

5.1 INTRODUCTION

In the US, 36,096 deaths were reported in 2019 as a result of traffic fatalities—and the older drivers have the largest percent increases in being involved in fatal crashes (NHTSA, 2020). In 2018, 6,907 people 65 and older were killed in traffic crashes, accounting for 19% of all US traffic fatalities (NHTSA, 2018). That being said, Cox and Cicchino (2021) reported, "for the first time (since 1990s) that drivers in their 70s are doing better than drivers ages 35-54 on some measures (fatal crash involvements per licensed driver, and police-reported crash

involvements per mile traveled). Moreover, over the past decade, fatal crash involvement rates increased for middle-aged drivers but remained stable for older drivers.” However, to address traffic safety concerns, NHTSA has adopted a Road Safety Management Blueprint with three important safety strategies: proactive vehicle safety, long-term planning for the road to zero fatalities, and deployment of autonomous vehicle (AV) technology (NHTSA, 2016). The deployment of AVs may reduce traffic fatalities by 94% (NHTSA, 2017), potentially benefitting the health and safety of older drivers in a way not possible before the use AVs. However, the acceptance and adoption of AV technology are dependent on the end-user’s perspective of their *safety* while being engaged with the AV, the *trust* that they have in the system, and their *intention* or willingness to use such systems. Thus, a need exists to gain an understanding of the end-user perceptions related to *safety*, *trust*, and *intention to use* which will have significant impacts on AV deployment and/or large-scale adoption of such technology.

The UF Institutional Review Board approved the study after a full board review. All participants provided informed consent for their enrollment into the study. This study used an experimental-repeated measures crossover design with a *pre-visit survey*, *intake surveys*, exposure to the autonomous shuttle or the autonomous mode driving simulator, *post-visit survey 1*, *crossover to simulator or autonomous shuttle*, and *post-visit survey 2*. Participants were recruited through the infrastructure and support of Oak Hammock and other residential communities in Gainesville, FL, the older adult recruitment pool of UF’s Institute for Mobility, Activity and Participation, and through UF’s Institute on Aging. Participants received \$25.00 for participation in the study.

Community dwelling drivers (N=104), 65 years of age or older, from North Central Florida, who had a valid driver’s license and reported driving within the last 6 months were included in this study. Participants were excluded if they did not communicate in English or showed signs of cognitive impairment, i.e., scoring < 18 on the Montreal Cognitive Assessment (MoCA). Participant intake and assessment were conducted in the living areas of the Smart House in the Oak Hammock Residential Community (5100 S.W. 25th Blvd., Gainesville, FL), which provided a comfortable setting for participants and research personnel. The simulated driving assessments occurred in the simulator laboratory, located in the garage of the Smart House. The on-road experience in the autonomous shuttle occurred at a formerly used bus depot in Gainesville, FL.

5.2 METHODOLOGY

5.2.1 EQUIPMENT

The study used an EasyMile EZ10 autonomous shuttle provided by Transdev. This SAE Level 4 autonomous shuttle (see Figure 5-1) uses vision sensors, light detection, GPS tracking system, and ranging LIDAR to map its environment and to decide upon the best motion behavior at each instant. The EZ10 shuttle can drive autonomously on certain pre-mapped routes but is not yet able to drive on any road, at any time. The shuttle does not have a steering wheel or other primary controls and can only be manually operated by a safety operator via a joystick remote control. The maximum speed of the vehicle is 25 miles per hour. The shuttle has six seats and six standing positions and can transport up to twelve passengers.

FIGURE 5-1. EASYMILE EZ10 AUTOMATED SHUTTLE.



The shuttle route (see Figure 5-2) lasted about 10 minutes and took place in a deserted bus depot due to restrictions in operating an AV in mixed traffic at the time of the study. During testing, participants remained seated while the shuttle operated at a low speed (\approx 10 miles per hour) without the presence of ambient traffic or road users. During segments of the route, the safety operator explained vehicle capabilities and features to the participants. The number of participants in the shuttle, during testing, ranged from two to six participants. During the COVID-19 pandemic, shuttle capacity was restricted to two participants.

FIGURE 5-2. AUTOMATED SHUTTLE ROUTE AT THE BUS DEPOT.



The RTI driving simulator used in this study is integrated in a full car cab with seven high-definition visual channels, including three forward channels creating a 180° field of view, three backward channels with behind-car views 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 RTI system has a 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 autonomous driving mode (see Figure 5-3). The *visual display* operates at a 60Hz refresh rate to support smooth graphics projected on three flat screens with high intensity projectors. The system allows for experimental drives with changing environmental conditions, video recording of the driver's simulator session, and incorporation of rural, urban, and highway driving. The simulator operating system drives are created with a combination of ambient and scripted traffic that interacts realistically with other vehicles based on human behavior/decision models and real-time physics-based vehicle dynamics calculations.

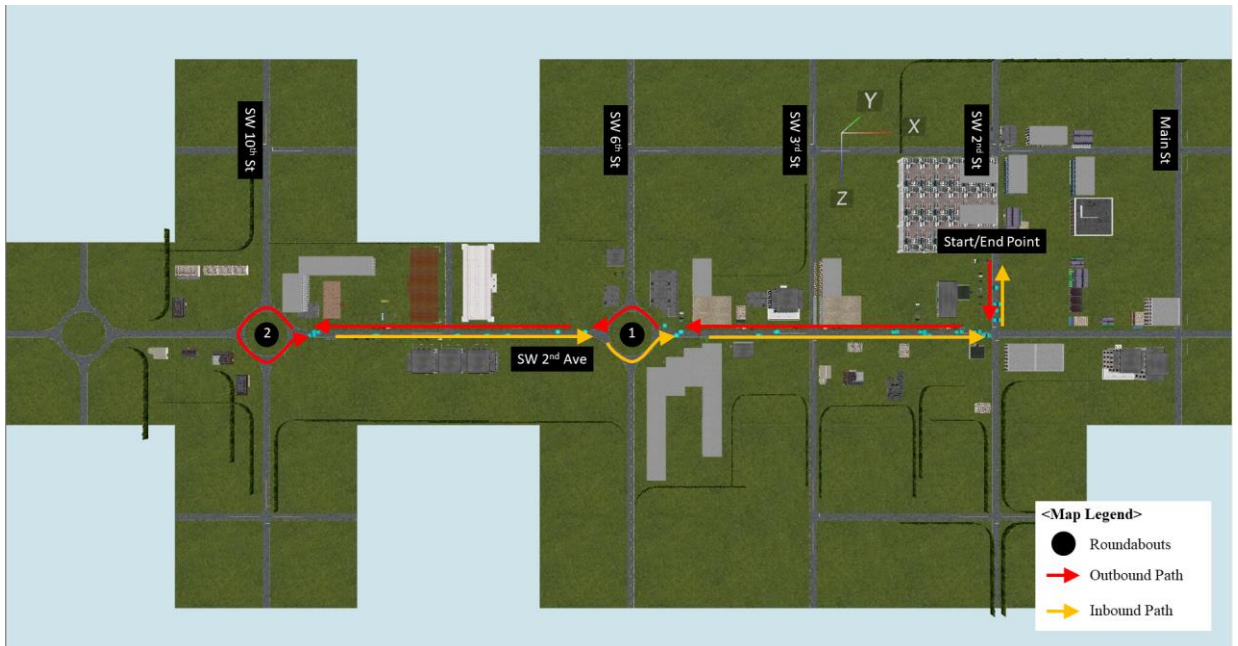
The scenario for this study utilized a 5-minute acclimation drive, with half of the participants randomized to “drive” the adaption scenario and half not—for the simulator only. The acclimation drive helps to enhance the comfort of the participants as they acclimate to the driving simulation environment. We utilized the simulator sickness questionnaire (Brooks et al., 2010) to determine pre- and post-drive experiences related to simulator sickness. The 10-minute autonomous drive (SAE Level 4) occurred in a low to moderate speed (15-35 mph) residential and suburban area with realistic road infrastructure, buildings, and ambient traffic with the system handling all aspects of the designated driving task (see Figure 5-4). A control area situated at the rear of the vehicle overlooks the driver, vehicle and screens (see Figure 5-3) allowing the

operator to control and monitor all aspects of the experiment. During the simulated scenario, a researcher assessed simulator sickness via the motion sickness assessment questionnaire (MSAQ; Brooks et al., 2010).

FIGURE 5-3. FULL-CAB DRIVING SIMULATOR AND CONTROL AREA.



FIGURE 5-3. TOPOGRAPHICAL MAP OF THE SIMULATOR SCENARIO.



5.2.2 PROCEDURE

Each participant provided written informed consent, was screened for cognitive impairment using the MoCA (Nasreddine et al., 2005), and then completed the pencil-and-paper surveys consisting of a demographic and medical history form, driving habits questionnaire (Owsley, Stalvey, Wells, & Sloane, 1999), technology acceptance model (Davis, 1989), technology readiness index 2.0 (Parasuraman & Colby, 2015), an autonomous vehicle user perception survey (AVUPS; Mason et al., 2020). During participant intake, researchers explained that both the shuttle and simulator can drive autonomous pre-mapped routes but neither vehicle was able to drive on any road at any time. To minimize the effects of social interaction, participants were asked to remain silent while riding in the shuttle and in the driving simulator and to save their questions for after the experiment. Each participant (N = 104), was randomly assigned to complete the autonomous shuttle (n = 54) or the simulator (n = 50) drive, complete the AVUPS, cross-over to “drive” the modality not initially driven, and complete the AVUPS again. After riding in the shuttle or simulator, each participant completed the *Motion Sickness Assessment Questionnaire*, used for detecting both motion (EZ10 shuttle) and simulator sickness (MSAQ; Brooks et al., 2010).

Participants driving the simulator may be prone to developing simulator sickness. We implemented a simulator sickness protocol to mitigate the occurrence of simulator sickness (Brooks et al., 2010; Classen, Bewernitz, & Shechtman, 2011). These measures include: offering dietary recommendations prior to the drive; utilizing an acclimation protocol; employing a simulator sickness questionnaire; reducing the sensory incongruence between the visual, kinesthetic and vestibular systems by removing visual clutter in the peripheral field, including engine sounds, and vibrations for vestibular sensation; supplying environmental adaptations (5 minute acclimation drive, 10 minute simulator drive, cool comfortable conditions at 72 degrees Fahrenheit, air circulating via fan; avoidance of complex sensory scenes (i.e., introduced “calmer” traffic scenes with some vehicles, a few pedestrians, a few parked vehicle alongside the road, and only necessary infrastructure); and determining/ managing the extent of simulator sickness symptoms (Stern, Akinwuntan, & Hirsch, 2017). These strategies have been shown to be successful in driving simulation studies with older adults (Classen et al., 2011; Shechtman et al., 2007).

A COVID-19 protocol was used for the shuttle, which aligned with the Centers for Disease Control and Prevention guidance and was agreed upon

by the NHTSA, Transdev, and the City of Gainesville, and approved by UF's Office of Research and the IRB. The research team and Transdev operators provided older drivers with Personal Protective Equipment (PPE) and restricted shuttle capacity to two participants at any given time. Participants were seated across from one another to ensure social distancing of six feet. All study personnel wore N-95 masks. The shuttle was sanitized before and after use via disinfectant wipes. The protocol was followed rigorously, and no COVID-19 infections were acquired or reported during or after testing.

During the beginning of the pandemic, data collection was halted until a research resumption plan was developed and approved by UF's Office of Research and the IRB. The research resumption plan and *COVID-19 protocol for older drivers' visits to the simulator lab* at the Smart House aligned with Centers for Disease Control and Prevention guidelines. Participants were screened for common symptoms prior to entering the gated community of Oak Hammock where the Smart House is located, and temperature checks were performed on each participant prior to entering the simulator lab. Participants were informed to bring personal protective equipment (i.e., facemask). Based on their preference and the COVID-19 protocol, participants were provided with additional personal protective equipment (i.e., disposable gloves, cloth masks, face shield) and hand hygiene products. Social distancing was maintained throughout the study visits. The driving simulator and other research equipment were sanitized before and after use and disposable seat covers covered the driver's seat in the driving simulator car cab. An infectious disease risk assessment manager assessed the driving simulation lab and provided recommendations to the team. Beyond those already mentioned above, other protocols included maintaining physical distancing, permitting only one person in the driving simulator cab, providing good air ventilation, turning the fan of the cab on high, and opening the side door of the garage where the simulator was housed to allow for outside air exchange. All study personnel wore N-95 masks. The team also published a video on the lab's website to inform all participants of the protocol. Moreover, the protocol was followed rigorously, and no COVID-19 infections were acquired or reported during or after data collection.

5.2.3 MEASURES

The demographic and medical history form was modified from the National Institute on Aging Clinical Research Toolbox and used to collect

age, gender, race, education, relationship status, and employment data (US Department of Health & Human Services, 2019).

The AVUPS (i.e., developed during Task 1) was used to measure older drivers' perceptions of AVs at baseline and after each exposure (simulator and autonomous shuttle). For the purpose of this study, we analyzed nine domains from the AVUPS—i.e., *intention to use, trust, perceived usefulness, perceived ease of use, safety, control/driving efficacy, cost, authority, and social influence*—consistent with our interim analysis, and telling of older adult acceptance and adoption practices pertaining to AVs (Classen, Mason, Wersal, Sisiopiku, & Rogers, 2020). Item responses were averaged into their respective dimensions which produced dimension scores ranging from 0 (negative perceptions of AVs) to 100 (positive perceptions of AVs). The AVUPS internal consistency was excellent ($\alpha = .91$) in this study.

The MSAQ questionnaire consisted of four domains (sweaty, queasy, dizzy, nauseous) ranging from 0 (not at all) to 10 (severely). The survey was developed and validated to assess simulator sickness symptoms. The analysis focused on the demographic information, data on simulator acclimation exposure, and the nine domains from the AVUPS measured with a visual analogue scale.

5.2.3 DATA ANALYSIS

Descriptive statistics were conducted on participants' age, race, education, marital status, and employment status. Continuous data were presented as mean (*M*) and standard deviation (*SD*) whereas categorical data were presented as count (*n*) and percent (%). The motion sickness scores and nine domains of the AVUPS were assessed for normality via visual examination (i.e., probability plots, histograms, stem and leaf plots) and statistical tests (i.e., Fisher's skewness, kurtosis, and Shapiro-Wilk test). A series of one-way ANOVAs were performed on older drivers' perceptions to assess differences between the groups at baseline. A Kruskal-Wallis H test was used to determine group differences for MSAQ difference scores (MSAQ scores after the simulated automated drive – baseline MSAQ scores) between older drivers that did and did not receive the acclimation scenario. A two-way mixed ANOVA with group (Group 1 exposed to the simulator first; Group 2 exposed to the shuttle first) and time (baseline vs. post-exposure 1 vs. post-exposure 2) was conducted to assess differences between older drivers' perceptions at baseline, after

exposure to the autonomous shuttle, and after exposure to the simulator. Post-hoc tests were performed if ANOVAs reached significance ($p < .05$).

Data were stored using Research Electronic Data Capture (REDCap; Harris et al., 2019) and collated and managed in R Studios (RStudio Team, 2020) using R version 4.0.2 (R Core Team, 2020) and the tidyverse ecosystem (Wickham et al., 2019). An alpha level of .05 was set *a priori* and *p*-values were adjusted to control for multiple comparisons using the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995). Fractional degrees of freedom were used in cases where Levene's test indicated unequal variance.

5.3 RESULTS

From the 141 participants screened, we enrolled 104 participants ($M_{age} = 74.30$, $SD = 5.95$), consisting of 47 males ($mean\ age = 76.1$, $SD = 5.64$) and 57 females ($mean\ age = 72.80$, $SD = 5.81$) into the study. Some older drivers ($n = 54$; 27 females) were first exposed to the shuttle, whereas the remaining older drivers ($n = 50$; 30 females) were first exposed to the simulator. The racial distribution indicated that participants were self-identifying as White ($n = 93$, 89%), Black, ($n = 7$, 7%) and Other ($n = 4$, 4%). The older drivers demonstrated a high level of education and reported having either a doctorate (23%), master's (30%) or bachelor's degree (20%), whereas 23% had an associate, some college, or a technical school certification, and 4% had either a GED or high school education. Participants reported their current employment status as retired ($n = 83$, 80%), working part-time ($n = 14$, 13.5%), working full-time ($n = 5$, 5%), with 1 homemaker, and 1 unemployed. Lastly, older adults reported marital status as being married (71%), divorced (12%), single (6%), or widowed (11%).

All participants completed their rides in the autonomous shuttle and driving simulator without provocation of motion or simulator sickness. The detailed motion and simulator sickness data before and after the main drives are displayed in a journal paper currently under review. Generally, older drivers who were exposed to the simulator displayed significant increases in simulator sickness symptoms—across the four domains (sweaty, queasy, dizzy, nauseous), compared to the same group being tested in the shuttle. The Shapiro-Wilk test was used for checking the normality, and normality was violated ($p < .05$), thus a non-parametric test (i.e., Kruskal-Wallis H test) was used. The between group (acclimation, $n = 54$; no acclimation, $n = 50$) differences for simulator sickness before and after the automated driving scenario are displayed in Table 5-1. The

results indicate that distributions of MSAQ scores were similar for the two groups. Median MSAQ scores in all four domains were not statistically significantly different between two groups of participants in exposure to the driving simulator.

TABLE 5-1. BETWEEN GROUP DIFFERENCES FOR SIMULATOR SICKNESS BEFORE AND AFTER THE DRIVING SIMULATOR ACCLIMATION DRIVE.

MSAQ Domains	Acclimation group (N=54)	No Acclimation group (N=50)	Test Statistics
	Median (SD)	Median (SD)	
Sweatiness	.00 (1.55)	.00 (1.55)	$\chi^2(1) = .037, p = .848$
Queasiness	.00 (1.63)	.00 (1.73)	$\chi^2(1) = .323, p = .760$
Dizziness	.00 (1.55)	.00 (1.84)	$\chi^2(1) = 2.184, p = .556$
Nauseousness	.00 (1.24)	.00 (1.36)	$\chi^2(1) = 1.145, p = .570$

Note. Benjamini-Hochberg adjusted *p* values are presented; Test statistics were reported for the Kruskal-Wallis H test

5.3.1 GROUP EFFECT

The Shapiro Wilk test revealed normality violations for older drivers' perceptions in both groups and at most time points (see Appendix D). All AVUPS domain scores were violated other than *control/driving efficacy*. Skewness and Kurtosis values are also displayed in Appendix D but were not violated. ANOVAs are fairly robust to deviations from normality and were used to analyze older drivers' perceptions of AVs (Blanca et al., 2017). A series of one-way ANOVAs revealed no differences between the groups at baseline (Range: *p* = .210 - .846). The two-way mixed ANOVA revealed no group effect (Range: *p* = .280 - .927) for older drivers' perceptions of AVs (Table 5-2).

TABLE 5-2. OLDER DRIVERS' PERCEPTIONS OF AVs AT BASELINE AND GROUP EFFECT TEST STATISTICS.

Dimensions	Baseline			Group Effect Test Statistics
	Group 1	Group 2	Test Statistics at Baseline	
Intention to Use	76 (20)	77 (18)	$F(1,102) = .172, p = .680$	$F(1,102) = .009, p = .927$
Trust	62 (19)	67 (19)	$F(1,102) = 1.590, p = .210$	$F(1,102) = .171, p = .680$
Perceived Usefulness	76 (17)	77 (18)	$F(1,102) = .038, p = .846$	$F(1,102) = .122, p = .728$
Perceived Ease of Use	75 (21)	76 (18)	$F(1,102) = .113, p = .737$	$F(1,102) = 1.181, p = .280$
Safety	70 (19)	73 (17)	$F(1,102) = .567, p = .453$	$F(1,102) = .859, p = .356$
Control/Driving Efficacy	48 (18)	46 (20)	$F(1,102) = .243, p = .623$	$F(1,102) = .053, p = .818$

Cost	65 (23)	69 (20)	$F(1,102) = .690, p = .408$	$F(1,102) = .679, p = .412$
Authority	78 (26)	80 (20)	$F(1,102) = .276, p = .600$	$F(1,102) = .009, p = .923$
Social Influence	70 (26)	71 (23)	$F(1,102) = .069, p = .793$	$F(1,102) = .081, p = .777$

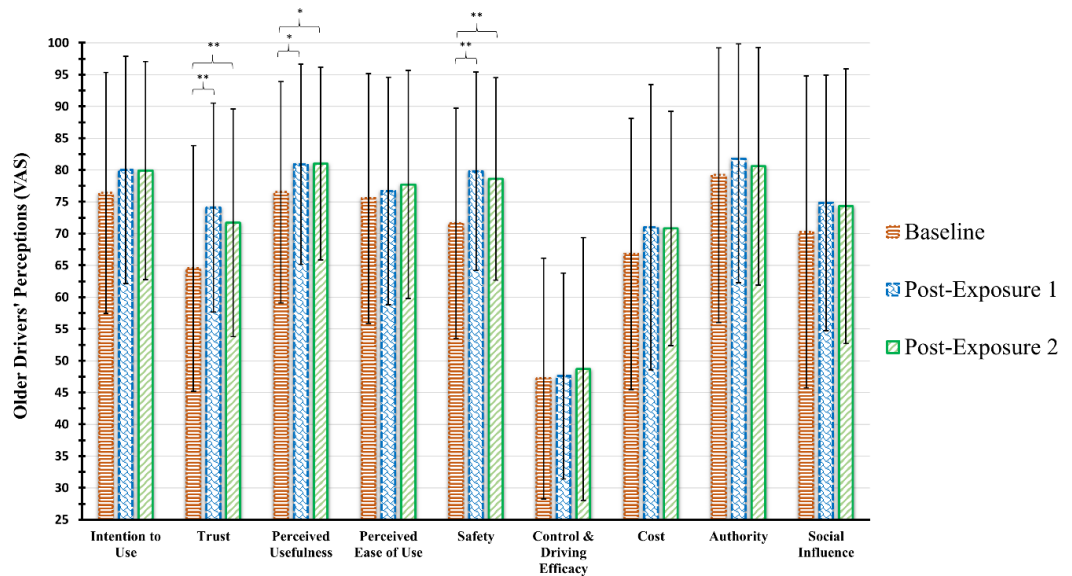
Note. Group 1 was exposed to the simulator first and Group 2 was exposed to the shuttle first.

5.3.2 TIME EFFECT

The two-way mixed ANOVA revealed a time effect (i.e., exposure to AV technology) for drivers' *intention to use*, $F(2,204) = 3.582, p = .030, \eta_p^2 = .034$, *trust*, $F(2,204) = 22.210, p < .001, \eta_p^2 = .179$, *perceived usefulness*, $F(1.83,738.21) = 7.124, p = .001, \eta_p^2 = .065$, *perceived safety*, $F(2,204) = 19.075, p < .001, \eta_p^2 = .158$, and *cost*, $F(2,204) = 4.122, p = .018, \eta_p^2 = .039$. The two-way mixed ANOVA revealed no time effect for older drivers' *perceived ease of use*, $F(2,204) = .591, p = .554, \eta_p^2 = .006$, *authority*, $F(2,204) = 1.111, p = .331, \eta_p^2 = .011, p = .174, \eta_p^2 = .025$, *social influences*, $F(2,204) = 2.554, p = .080, \eta_p^2 = .024$, and *control and driving efficacy*, $F(2,204) = .347, p = .707, \eta_p^2 = .003$.

The bar graphs (Figure 5-5) display descriptive trends for the AVUPS domains at baseline, after the shuttle, and after the simulator—and indicate the statistically significant differences observed. After controlling for multiple comparisons via the Benjamini-Hochberg procedure, post-hoc analysis revealed older drivers' *intention to use* was not statistically significant after their first exposure ($p = .091$) or second exposure ($p = .058$) compared to baseline. Older drivers' *trust* was enhanced after their first exposure ($p < .001$) and second exposure ($p < .001$) compared to baseline. Older drivers' *perceived usefulness* was enhanced after the first exposure ($p = .027$) and second exposure ($p = .006$) compared to baseline. Older drivers' *perceived safety* was enhanced after their first exposure ($p < .001$) and second exposure ($p < .001$) compared to baseline. Older drivers' *cost* did not change after their first exposure ($p = .059$) and second exposure ($p = .054$) compared to baseline.

FIGURE 5-4. OLDER DRIVERS' PERCEPTIONS OF AVs AT BASELINE, POST-EXPOSURE 1, AND POST-EXPOSURE 2



5.3.3 GROUP BY TIME INTERACTION

The two-way mixed ANOVA revealed a significant group by time interaction for older drivers' *intention to use*, $F(2,204) = 3.224, p = .042$, *trust*, $F(2,204) = 4.295, p = .015$, *perceived usefulness*, $F(2,204) = 3.002, p = .048$, *safety*, $F(2,204) = 3.942, p = .026$, and *control/driving efficacy* $F(2,204) = 4.542, p = .012$. However, there was no significant group by time interaction for older drivers' *perceived ease of use*, *cost*, *authority*, or *social influence*. Test statistics for time by group interaction are displayed in Table 5-3.

TABLE 5-3. OLDER DRIVERS' PERCEPTIONS OF AVs BEFORE AND AFTER AV EXPOSURE.

Dimensions	Group 1			Group 2			Test Statistics <i>Time x Group Interaction</i>
	Baseline	Simulator	Shuttle	Baseline	Shuttle	Simulator	
Intention to Use	77 (19)	78 (17)	82 (18)	76 (19)	82 (17)*	78 (18)	$F(2,204) = 3.224, p = .042$
Trust	67 (19)	75 (17)**	70 (17) ⁺	62 (19)	73 (17)**	74 (17)**	$F(2,204) = 4.295, p = .015$
Perceived Usefulness	77 (18)	82 (16)*	81 (15)	76 (18)	80 (16)	81 (15)*	$F(2,204) = 3.002, p = .048$
Perceived Ease of Use	76 (20)	78 (18)	80 (18)	75 (20)	75 (18)	75 (18)	$F(2,204) = .511, p = .601$
Safety	73 (18)	81 (15)**	79 (16)*	70 (18)	78 (15)**	78 (16)**	$F(2,204) = 3.942, p = .026$

Control/ Driving Efficacy	46 (19)	51 (17)	47 (19)	48 (19)	44 (17) ⁺	50 (19)	F(2,204) = 4.542, p = .012
Cost	69 (21)	72 (20)	72 (21)	65 (21)	70 (20)	69 (21)	F(2,204) = .033 p = .967
Authority	80 (23)	83 (20)	79 (18)	78 (23)	81 (20)	82 (18)	F(2,204) = 1.427, p = .242
Social Influence	71 (25)	75 (22)	72 (19)	70 (25)	75 (22)	77 (19)	F(2,204) = .921, p = .400

Note. *p<.05 compared to baseline. **p<.01 compared to baseline. ⁺p<.05 compared to simulator; Benjamini-Hochberg adjusted p values are presented.

After controlling for multiple comparisons, post-hoc analysis revealed older drivers' *intention to use* was significantly increased after experiencing the shuttle compared to baseline, for those in Group 2 ($p = .023$) but not Group 1 ($p = .079$). For Group 1, older drivers' *trust* increased after experiencing the simulator compared to their trust at baseline ($p < .001$) or after riding in the shuttle ($p = .023$). For Group 2, older drivers' *trust* increased after riding in the simulator ($p < .001$) and shuttle ($p < .001$) compared to baseline. In Group 1 ($p = .049$) and Group 2 ($p = .024$), older drivers' *perceived usefulness* was enhanced after experiencing the driving simulator compared to baseline. However, there were no significant differences in older drivers' *perceived usefulness* after experiencing the shuttle. In both groups, older drivers' *perceived safety* was enhanced after riding in the shuttle and driving simulator compared to baseline. In Group 2, older drivers' *control/driving efficacy* increased after experiencing the simulator compared to after being exposed to the shuttle ($p = .050$).

5.4 CONCLUSION

This study examined the perceptions of older drivers before and after being exposed to the Transdev manufactured EasyMile EZ10 autonomous shuttle and the RTI driving simulator replicating an AV experience; and examined the group effects, the time effects, and the group by time interaction effects.

5.4.1 Simulator sickness

Neither of the domains of the MSAQ (sweaty, queasy, dizzy, nauseous) were statistically significantly different between groups. This finding suggests that an acclimation scenario may not be necessary before exposing older drivers to the driving scenario in an automated driving simulator (SAE Level 4). However, it is important to note that our driving

scenario was relatively short (i.e., 10 minutes) and only consisted of two turns and three roundabouts, which may have limited the provocation of simulator sickness.

5.4.2 Group effect

No group effect was observed at baseline. Specifically, the groups (Group 1 exposed to the simulator first; Group 2 exposed to the shuttle first) demonstrated no differences in their perceptions on the AVUPS at baseline. This finding suggests that there was no difference between the groups regardless of time (i.e., all scores averaged throughout the three time points).

5.4.3 Time effect

As expected, and consistently with our first hypothesis, we observed a significant time effect for older drivers as they were exposed to AV technology. Specifically, significant differences were observed for *safety*, *trust*, and *intention to use*; but surprisingly, and not articulated in our hypothesis, we observed that *perceived usefulness* and *cost* were also reported in a positive and significant direction, after their first exposure to AV technology. However, after correction for the multiple comparisons, the remaining significant domains (for time exposure) were only *safety*, *trust* and *perceived usefulness*. These domains (*safety*, *trust* and *perceived usefulness*) are supported in the current autonomous shuttle (Choi & Ji, 2015; Kaur & Rampersad, 2018; Nordhoff et al., 2020; Salonen & Haavisto, 2019) and autonomous simulator literature (Classen et al., 2020; Molnar et al., 2018; Lee et al., 2019). Noteworthy is that *perceived usefulness*, coupled with *ease of use* of the AV technology, are both conceptually designated to be moderators of *intention to use* (Mason, et al., 2020). As such, the non-statistically significant difference for *ease of use*, may have reduced the combined (with *perceived usefulness*) variance that impacted *intention to use*. However, this explanation must empirically be tested with a structural equation model, or comparable analysis. Nevertheless, our study findings add to the temporal plausibility of AV technology studies, by suggesting that acceptance and adoption practices of older drivers, in particular, may be dependent on their perceptions related to *safety*, *trust* and *perceived usefulness* of AV technology.

5.4.4 Group by Time Interaction

Intention to use. In terms of *intention to use* (i.e., participants in Group 2, not Group 1, had a significant increase after experiencing the shuttle compared to baseline)—one may deduce that older drivers, who had to be more engaged with the simulator (i.e., manipulate some controls especially in the beginning of the drive) compared to the shuttle (where they were passive passengers) could better perceive how the level 4 automation may be applied to their personal car-driving experience as well. Interestingly, Horrey and 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 each level of automation and with each type of system. In this case, and based on Horrey and Lee’s argument, it may be possible that older drivers could more realistically see how the AV technology in the simulator could prolong their role as a driver—and as such *intention to use* became more realistic in the simulator vs. the shuttle.

Trust. Consistent with the literature, *trust* increased after the participants, in both the simulator and the shuttle groups, were exposed to the AV technology. Abraham et al. (2017) suggest that older drivers experience some hesitation pertaining to trusting full automation, but that more than 50% of them are comfortable with the idea that technological innovations will help the driver. It seems that *trust* increased after exposure to the technology, and potentially influenced their perceptions on how this technology may enhance their continued mobility.

Perceived usefulness. Given that driving is a highly valued activity for older drivers and a powerful facilitator of independence, autonomy and community participation (Dickerson et al., 2014; 2017), older drivers’ *perceived usefulness* pertaining to the simulator (for Group 1 and Group 2), but not for the shuttle, was significant. Specifically, the driving simulator simulated the autonomous vehicle (SAE Level 4), wherein the driver had an interactive experience with the vehicle, while observing and experiencing it’s autonomous features, and ability to “drive itself” in a downtown environment.

Control/driving efficacy. This experience of drivers described in the previous paragraph may also help to explain why *control/driving efficacy* increased after exposure to the simulator, compared to after being exposed to the shuttle, for Group 2 only. Conversely, due to the

government restrictions that we have experienced, the shuttle could not run on public roads—and as such the relatively mundane route in the deserted bus depot where the shuttle did run, might have also contributed to a non-significant experience in the participants' perceptions of *control/driving* efficacy.

Safety. The Rand Corporation's safety framework (Blumenthal et al., 2020), particularly the "safety threshold" may be used as a rationale for understanding the significance of *safety* perception, in both groups, and when exposed to either mode of AV, and when compared to baseline. Clearly *safety* as predicated on the "human driver", the "autonomous driving system", and as an "absolute" goal to be achieved— materialized as a valid argument in this study. Each of the older drivers was adequately informed on what they could experience (i.e., providing them before exposure with knowledge and information), the AV technology functioned as intended (e.g., both the shuttle and simulator operations were seamless), and everyone safely arrived back at their destinations without any incidents. That being said, safety perceptions may vary with the kind of AV technology used, the context in which they occur, the developers engaged, and the policies underlying them (Ward et al., 2014). Since we have only examined two modes (shuttle and simulator) both programmed at the SAE Level 4, *safety* perceptions must be considered as an important construct to be tested in a variety of circumstances, environments, and contexts in future studies —before generalization can occur.

6.0 CONCLUSION

Using a validated AVUPS, we studied the perceptions of 104 older drivers before and after being exposed to an autonomous shuttle and a driving simulator running in autonomous mode. For simulator sickness, neither of the four domains of MSAQ scores showed a statistically significant difference between groups. For between group differences after exposure to the automated shuttle or the driving simulator, no group effects were evident, but time effects indicated the significance of *safety*, *trust* and *perceived usefulness* of AV technology in the acceptance practices of older drivers. The group by time interaction effects indicated the significance of older adult perceptions pertaining to *intention to use*, *trust*, *perceived usefulness*, *control/driving efficacy*, and *safety*. Despite study limitations, and given the strengths of the study, the results are telling of the determinants of older adult AV technology acceptance practices. Certainly, future studies may want to build on the empirically validated perceptions in this study—but also need to reckon with different levels of vehicle automation, varying circumstances, environmental characteristics, and different political contexts to achieve an enhanced understanding of older driver acceptance practices pertaining to AV technology.

7.0 RECOMMENDATIONS

7.1 Limitations

Spectrum bias (highly educated and mainly white cohort) and self-selection bias (with enrollment likely influenced by the pandemic) may have impacted the findings of this study. Therefore, this study's findings are only generalizable to a group with a similar demographic profile as described in our study. Due to NHTSA restrictions at the time of the data collection, we could not test participants on a route that corresponded to the simulator route (downtown area with ambient traffic, buildings, construction zone, pedestrians, cyclists, parked cars, intersections, traffic circles, and bus stops). Again, the estimates, particularly pertaining to the participants' shuttle perceptions, may be an underestimate of their experience. Future studies must be conducted in such a way to overcome the limitations discussed above.

The scope of this study was limited to older adults. Thus, it is important to obtain and analyze information on the perceptions of younger and middle-aged drivers pertaining to accepting AV technology and compare data among different age groups. The authors were successful in obtaining funding from the USDOT through STRIDE Project A3 to conduct UF & UAB's Phase 2 Demonstration Study. The aim of the STRIDE A3 Project is to develop a model to support transportation system decisions considering the experiences of drivers of all age groups with AV technology. Specifically, via statistical methods we will shed light on the barriers (e.g., discomfort or insecurities) and the facilitators (e.g., readiness or willingness) of each group in adopting the AV technology.

7.2 Strengths

This study analyzed the perceptions of a large sample (N=104), with a valid and reliable AVUPS. Moreover, the participants were randomly allocated to the AV mode, to control for order effects. The participants demonstrated an equitable age and gender distribution. The team experienced no attrition as a result of driving simulation exposure and simulator sickness. Based on the rigorous COVID-19 protection protocol implemented for the participants, as well as the study personnel, no one reported being infected during or after this study. The composition of the study team, the collaboration with many agents of the aging network, including the City of Gainesville, Transdev, and the assistance from community facilities that helped the team with successful recruitment—all facilitated the outcomes presented here. Researchers undertaking future studies may benefit from also implementing the AVUPS, and follow the methods and procedures proven to have strengthened the design of this study. AV developers can benefit from understanding older drivers' needs as determinants of AV

adoption practices and customize their design and marketing practices to address such needs. Finally, the findings from this study help transportation planners and decision makers gain a better understanding of the factors that influence adoption of AVs and guide their efforts to develop plans and policies in support AV deployment across the southeastern US and beyond.

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9.0 APPENDICES

9.1 Appendix A – Acronyms, abbreviations, etc.

AAA – American Automobile Association
AV – Autonomous Vehicle
Ave. – Avenue
AVUPS – Autonomous Vehicle User Perception Survey
CDC – Centers for Disease Control
CTAM – Car Technology Acceptance Model
CVI – Content Validity Index
EFA – Exploratory Factor Analysis
HIT – Human Intelligent Task
ICC – Intra-Class Correlation
I-CVI – Item Content Validity Index
I-MAP – Institute for Mobility, Activity, and Participation
IRB – Institutional Review Board
MoCA – Montreal Cognitive Assessment
MSA – Mokken Scaling Analysis
MSAQ - Motion Sickness Assessment Questionnaire
MTurk – Mechanical Turk
NHTSA – National Highway Transportation Safety Administration
ODD – Operational Design Domain
PEOP - Person-Environment-Occupation-Performance model
PPE – Personal Protective Equipment
SAE – Society of Automotive Engineers
SAV – Shared Autonomous Vehicles
SCAS – Self-driving Car Acceptance Scale
S-CVI – Scale Content Validity Index
SCTAM – Safety Critical Technology Acceptance Model
St. – Street
SW – Southwest
TAM – Technology Acceptance Model
UTAUT – Unified Theory of Acceptance and Use of Technology
VAS – Visual Analogue Scale

9.2 Appendix B – Associated websites, data, etc., produced

Project data has been uploaded to Zenodo.
doi:10.5281/zenodo.4776758

9.3 Appendix C – Summary of Accomplishments

Date	Type of Accomplishment	Detailed Description
8/14/18	Faculty Accomplishment or Award	Dr. Classen received the Distinguished Scholar Award from the Association for Driver Rehabilitation Specialists. Richmond, Virginia.
8/14/18	Educational Product	Classen, S., Jeghers, M., Medhizadah, S., Winter, S. M., King, L, Struckmeyer, L., Pre-conference workshop: Autonomous vehicles and medically at-risk-drivers through the lifespan: Role, function and future directives for the driver rehabilitation specialist. The Association for Driver Rehabilitation Specialists Conference, Richmond, Virginia.
8/14/18	Conference Presentation	Classen, S. General session: Autonomous vehicles and medically at-risk-drivers through the lifespan: Role, function and future directives for the driver rehabilitation specialist. The Association for Driver Rehabilitation Specialists Conference, Richmond, Virginia.
8/14/18	Educational Product	Autonomous vehicles and medically at-risk-drivers through the lifespan: Role, function and future directives for the Driving Rehabilitation Specialist (DRS).
8/14/18	Educational Product	Vehicle automation technologies and medically at-risk drivers through the lifespan: Role, function and future directives for the DRS.
9/11/18	Media (article, etc.)	UF & UAB's Phase I Demonstration Study: Older Driver Experiences with Autonomous Vehicle Technology
9/26/18	Media (article, etc.)	OT celebrates a "Triple Hitter" at recent Association for Driver Rehabilitation Specialists (ADED) Conference in Richmond, Virginia
10/12/18	Faculty Accomplishment or Award	Dr. Sisiopiku received a 2018 Certificate of Meritorious Achievement award from the Southern District Institute of Transportation Engineers
12/16/18	Other	Dean's Scholar Lecture Series with Dr. Carissa Slotterback (12/16/18). This brought together researchers and representatives from the University of Florida, City of Gainesville, and Florida Department of Transportation.

2/22/19	Publication	Classen, S., Jeghers, M., Morgan-Daniel, J., Winter, S., King, L., & Struckmeyer, L. (2019). Smart in-vehicle technologies and older drivers: A scoping review. OTJR: Occupation, Participation and Health Special Issue: Robotics, AI, Automations and Relationship to Health and Occupational Therapy. Advanced online publication. doi:10.1177/1539449219830376
2/22/2019	Educational Product	Dr. Sisiopiku offered a seminar to UAB Civil Engineering Undergraduate and Graduate students titled "Traffic Congestion: Needs, Opportunities, and UAB Research Contributions" highlighting ongoing transportation research at the TRENDLab, including Project D2.
4/4/19	Conference Presentation	Presented: Mason, J., Classen, S., Wersal, J., & Sisiopiku, V. <i>Face and content validity: Perceptions of autonomous vehicles survey design</i> . Poster presented for University of Florida's College of Public Health and Health Professions Research Day, Gainesville, FL, April, 2019.
4/4/19	Conference Presentation	Presented: Classen, S., Jeghers, M., Morgan-Daniel, J., Winter, S., King, L., & Struckmeyer, L. Poster presentation. A scoping review for the use of smart technology with older drivers. American Occupational Therapy Association Conference, April, 2019, New Orleans, Louisiana, USA.
6/6/19	Educational Product	Southeastern Transportation Research, Innovation, Development, & Education Center: Exploring transportation and STEM: From the community to the classroom
6/15/19	Educational Product	Classen, S., & Alvarez, L. Driver Capabilities in the Resumption of Control (Chapter 10). (2019). In Donald L. Fisher, William J. Horrey, Michael A. Regan, & John D. Lee (Eds.), Handbook of Human Factors and Automated, Connected and Intelligent Vehicles. In press.
6/21/19	Conference Presentation	Classen, S., Jeghers, M., Morgan-Daniel, J., Winter, S., King, L., & Struckmeyer, L. <i>Smart in-vehicle technologies and older drivers: A scoping review</i> . Poster presented at Occupational Therapy Summit of Scholars, Charleston, SC. June, 2019
7/16/19	Conference Presentation	Mason, J., Classen, S., Wersal, J., & Sisiopiku, V. <i>Establishing face and content validity of a survey to assess users' perceptions of automated vehicles</i> . Poster presented at the Automated Vehicles Symposium, Orlando, FL, July, 2019.
7/25/19	Conference Presentation	Elefteriadou, L., Crane, C., Classen S., & Ranka S. <i>Autonomous vehicles, traffic, and humans</i> . Presentation: Brookings Institution, Washington D.C., July, 2019.

9/20/19	Other	Classen, S. Older Adults' Perceptions of Autonomous Vehicles. Presented findings at I-STREET Meeting, Gainesville, FL, September, 2019.
10/7/19	Other	Older drivers and autonomous vehicles featured in the University of Florida Transportation Institute newsletter: Older drivers and autonomous vehicles featured in the University of Florida Transportation Institute newsletter:
10/15/19	Conference Presentation	Classen, S., Mason, J., Wersal, J., & Sisiopiku, V. <i>Older drivers' experiences with autonomous vehicle technology</i> . Presentation for Annual Conference of the Road Safety & Simulation (RSS), Iowa City, IA, October, 2019.
11/4/19	Conference Presentation	Sisiopiku, V.P., Classen, S., Mason, J., & Wersal, J. <i>Autonomous vehicle technology: Experiences and preferences of older drivers in the southeast</i> . Presentation for Gulf Region Intelligent Transportation Society (GRITS), Natchez, MS, November, 2019.
11/16/19	Conference Presentation	Mason, J., Classen, S., Wersal, J., & Sisiopiku, V. Poster: <i>Establishing face and content validity of a survey to assess users' perceptions of automated vehicles</i> . Florida Occupational Therapy Association, Orlando, FL, November, 2019.
1/13/20	Conference Presentation	Classen, S., Mason, J., Wersal, J., & Sisiopiku, V. Research presentation: <i>Older drivers' perceptions of autonomous vehicles</i> . AND30 (Simulation and Measurement of Vehicle and Operator Performance) at Transportation Research Board (TRB), Washington D.C., January, 2020.
1/14/20	Conference Presentation	Mason, J., Classen, S., Wersal, J., & Sisiopiku, V. Establishing face and content validity of a survey to assess users' perceptions of automated vehicles. Presentation at the TRB, Washington D.C., January, 2020.
4/20/20	Faculty Accomplishment or Award	Dr. Sisiopiku was nominated for 2020 UAB Supervisor of the Year, UAB Office of Student Involvement
6/2/20	Educational Product	Submitted: Classen, S., Mason, J., Wersal, J., Jeghers, M., & Hwangbo, S-W. <i>Assessment of automated vehicle technology integration for public transportation in Gainesville, Florida</i> . Short course to be presented at the American Occupational Therapy Association, San Diego, CA, April 8-11, 2021
6/8/20	Other	Research Spotlight: Older driver perceptions of autonomous vehicles featured in the University of Florida Transportation Institute newsletter: Research Spotlight:

		Older driver perceptions of autonomous vehicles featured in the University of Florida Transportation Institute newsletter:
6/12/20	Publication	Classen, S., Mason, J., Wersal, J., Rogers, J., & Sisiopiku, V. (2020). Older drivers' experience with automated vehicle technology: Interim analysis of a demonstration study. <i>Frontiers in Sustainable Cities</i> , 2(27), 1-12. Older drivers' experience with automated vehicle technology: Interim analysis of a demonstration study
7/05/20	Publication	Mason, J., Classen, S., Wersal, J., & Sisiopiku, V. 2020. <i>Establishing face and content validity of a survey to assess users' perceptions of automated vehicles</i> . Transportation Research Record: Journal of the Transportation Research Board. Establishing face and content validity of a survey to assess users' perceptions of automated vehicles
7/10/20	Educational Product	Classen, S., & Alvarez, L. Driver Capabilities in the Resumption of Control (Chapter 10). (2019). In Donald L. Fisher, William J. Horrey, Michael A. Regan, & John D. Lee (Eds.), <i>Handbook of Human Factors and Automated, Connected and Intelligent Vehicles</i> . Published
7/22/20	Conference Presentation	Classen, S., Mason, J., Wersal, J., Rogers, J. & Sisiopiku, V. UF & UAB's Phase I demonstration study: Older adults' perceptions of automated vehicle technology. Oral presentation at the Annual Meeting of AUVSI: Breakout Session: The potential for AVs to support active aging and community mobility in suburban and ex-urban areas. San Diego, California, July 22, 2020
8/14/20	Faculty Accomplishment or Award	Dr. Winter (I-MAP Associate Director) received the Distinguished Scholar Award from the Association for Driver Rehabilitation Specialists.
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. <i>American Journal of Occupational Therapy</i> , 74, (4_Supplement_1). Survey design on the perceptions of automated vehicles: Face and content validity
9/11/20	Student Accomplishment or Award	Brandy McKinney, graduate student assistant at UAB, received the 2020 UAB Distinguished Alumni Scholarship.
9/16/20	Other	UF Occupational Therapy Doctoral Student Works on Study to Understand Older Driver Perceptions on AV Technology

		featured in the University of Florida Transportation Institute newsletter: UF Occupational Therapy Doctoral Student Works on Study to Understand Older Driver Perceptions on AV Technology
9/16/20	Other	Classen, S. Older Adults' Perceptions of Autonomous Vehicles. Presented findings at I-STREET Meeting, Gainesville, FL, September, 2020.
9/23/20	Conference Presentation	Classen, S. & Mason, J. Older Adults, New Mobility, and Automated Vehicles, Urbanism Next and RAND Corporation on behalf of AARP Virtual Roundtable, 23 September, 2020
10/16/20	Conference Presentation	Keynote address: Classen, S. Autonomous Vehicle Technology and Older Adults: A Primer for Health Care Professionals and Engineers. <i>Technology in Transportation. FAMU-FSU College of Engineering, Tallahassee, Florida. October 16, 2020. 10:00 AM – 3:00 PM.</i> 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. <i>Frontiers in Future Transportation.</i> Face and content validity of an automated vehicle road course and a corresponding simulation scenario
12/16/20	Podcast	Classen, S. Unstoppable Minds. Episode 4: Empowering older adults to keep their independence. http://www.ufl.edu/unstoppableminds/
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. <i>Frontiers in Psychology: Quantitative Psychology and Measurement.</i> Construct validity and test-retest reliability of the automated vehicle user perception survey
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.
6/03/21	Publication	Classen, S., Mason, J., Hwangbo, S-W., Wersal, J., Rogers, J., & Sisiopiku, V. (In Press). Older drivers' experience with autonomous vehicle technology. <i>Journal of Transport and Health.</i>

9.4 Appendix D – Normality Violations

Appendix D. Skewness, Kurtosis, and Shapiro-Wilk p Values for Older Drivers' Perceptions at Baseline, Post-Exposure 1, and Post-Exposure 2

Domain	Time	Group 1 (N=54)			Group 2 (N=50)		
		Skewness	Kurtosis	<i>p</i>	Skewness	Kurtosis	<i>p</i>
Intention to Use	BL	-1.175	1.156	.001	-0.327	-1.239	.002
	E1	-1.945	5.122	.001	-0.593	-0.771	.001
	E2	-1.070	0.901	.001	-1.194	1.539	.001
Trust	BL	-0.210	-0.247	.685	0.034	-1.104	.043
	E1	-0.136	-0.669	.373	-0.327	-0.431	.009
	E2	-0.445	-0.255	.205	-0.127	-0.951	.071
Perceived Usefulness	BL	-0.682	0.033	.015	-1.093	1.479	.001
	E1	-1.266	1.312	.001	-0.732	-0.092	.005
	E2	-1.258	1.999	.001	-0.761	-0.218	.002
Perceived Ease of Use	BL	-0.976	0.774	.001	-0.671	-0.558	.001
	E1	-0.733	0.418	.008	-0.507	-0.978	.001
	E2	-0.485	-1.139	.001	-0.804	-0.233	.001
Safety	BL	-0.463	-0.207	.158	-0.174	-1.009	.049
	E1	-0.504	-0.743	.011	-0.829	-0.086	.001
	E2	-0.668	0.052	.013	-0.372	-1.139	.002
Control/Driving Efficacy	BL	0.266	0.946	.446	0.321	-0.135	.514
	E1	-0.258	-0.086	.832	0.124	-0.315	.481
	E2	0.181	-0.075	.458	0.426	-0.289	.255
Cost	BL	-0.534	0.088	.088	-0.160	-1.128	.030
	E1	-0.663	-0.289	.007	-0.830	0.462	.005
	E2	-0.410	-0.377	.143	-0.180	-0.659	.201
Authority	BL	-1.688	2.122	.001	-1.266	0.748	.001
	E1	-2.022	4.393	.001	-1.069	-0.390	.001
	E2	-1.079	0.174	.001	-1.562	2.931	.001
Social Influence	BL	-0.887	-0.040	.001	-0.467	-0.463	.001
	E1	-0.534	-0.980	.001	-0.580	-0.871	.001
	E2	-0.440	-1.243	.001	-0.587	-0.708	.001

Note. BL = Baseline; E1 = Exposure 1; E2 = Exposure 2; Group 1 was exposed to the simulator first. Group 2 was exposed to the shuttle first. The *p* value was from the Shapiro Wilk test.