SENIOR DRIVERS & AUTOMATED VEHICLES: KNOWLEDGE, ATTITUDES & PRACTICES

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SENIOR DRIVERS & AUTOMATED VEHICLES: KNOWLEDGE, ATTITUDES & PRACTICES

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EXECUTIVE SUMMARY

Canadians over the age of 65 currently represent one in seven Canadians. In the next two decades, the population of seniors will grow to more than 10 million and account for one in four Canadians (Statistics Canada 2015; Robertson and Vanlaar 2008). As one of the largest age cohorts, older adults will be a significant segment of the driving population. Age-related declines in perceptual, cognitive, and physical capacities that can degrade their driving ability, in addition to their over-representation in crash statistics, are concerning and a major road safety challenge.

Yet, research suggests that mobility and the ability for seniors to continue to drive as they age is integral to their health. Therefore, it is imperative that older drivers are protected on the road, and able to continue to drive safely as they age. Advanced safety features and automated vehicles offer great potential to improve road safety and the mobility of older drivers. However, previous research from the Traffic Injury Research Foundation (TIRF) has suggested that older drivers are less confident in these technologies, are less familiar with them, and are least likely to rely on them to improve their safety on the road (Robertson et al. 2016, 2017).

To address this issue, TIRF, with funding from the Toyota Canada Foundation, conducted several focus groups with licensed drivers over the age of 65 to better understand their perceptions and attitudes towards semi-automated vehicles. Another objective was to understand how their knowledge and beliefs about automated vehicles can affect the likelihood they will rely on this technology to improve their safety on the road and increase their mobility. Effective ways to increase their knowledge and awareness of semi-automated vehicles were also explored. To augment the qualitative data from the focus groups, quantitative data from an online, representative survey conducted in previous studies (Robertson et al. 2016, 2017) were also used in this project.

The primary focus of the study was on limited, self-driving, semi-automated vehicles (LSDVs) and explored the following issues:

- driver knowledge, attitudes, and practices
- driver education and training

Results regarding driver knowledge, attitudes and practices

Knowledge

- The majority of senior drivers reported they were not very familiar with LSDV technology and had limited understanding of self-driving vehicles generally, although many of them were familiar with specific examples of some features of LSDV technology.
- They were most familiar with current vehicle safety technology, but most had limited experience using advanced driver assistance systems. Awareness was also low regarding the role of drivers and the ability of LSDVs to function in complex road environments.
- A large majority of participants had questions about how the technology works and when it will become publicly available. While most were aware that their knowledge of this topic was limited, they expressed interest in receiving more information about LSDVs.

Attitudes

- Senior drivers perceived safety to be the greatest benefit of LSDVs. They mentioned that LSDVs could help improve personal safety for them as drivers, as well as road safety generally.

- It was widely acknowledged by participants that LSDVs could help increase confidence in their driving skills as they age, and LSDVs would enable them to handle more challenging situations on the road with more confidence as opposed to avoiding them.
- The greatest concern expressed by participants was that over-reliance on self-driving technology could ultimately degrade their driving skills.
- An equal level of concern was expressed regarding the potential of LSDV technology to extend the driving lifetime of seniors who may not be safe to drive anymore.
- They also expressed concern that relying on the self-driving capabilities of LSDVs might perhaps entice them as well as other drivers to engage in dangerous driving behaviours (distraction, fatigue, impairment).
- Significant concern was expressed regarding the learning curve for senior drivers, and how overwhelming it might be to use LSDVs. It was generally agreed that they would require training and practice with LSDV technology before feeling comfortable enough to drive a vehicle.
- Senior drivers were also greatly concerned about the cost of LSDVs. The vast majority of participants believed that LSDVs would be significantly more expensive than traditional vehicles. This was related to the higher costs typically associated with new technology, as well as the additional costs such as higher insurance premiums and more expensive maintenance and repairs.

Practices

- More than three-quarters of participants reported that they were willing to use a LSDV if it were available today, and once they had observed others using the technology safely and without incident.
- The majority of senior drivers reported that they would build their trust in this technology as they gained more experience with it, and better understood the reliability of the self-driving capabilities.
- Online survey results supported focus group findings, as quantitative analyses suggested that if you felt more safe using LSDVs and more knowledgeable about LSDVs, you were more likely to believe LSDVs will be easy to use and you will be more likely to declare that you will use LSDVs.
- Online survey results also suggested that female drivers were less likely to agree that they were knowledgeable about LSDVs, and that they felt safe. They were also less agreeable to the perceived ease of use of LSDVs, and their intention to use LSDVs.
- Older adults, aged 50 and over, reported in the online survey that they were less agreeable regarding the ease of use of LSDVs. Older adults, aged 70 and over reported that they were less likely to feel safe using LSDVs.
- Focus group results suggested that senior drivers would most likely use the self-driving capabilities of LSDVs for long distance drives, or in stressful driving conditions. Less than 5% of participants reported that they would turn off the autonomous mode to engage in dangerous driving behaviours.
- This finding was consistent with the online survey results, where both female and older drivers were less likely to declare they would engage in risky driving behaviours.
- Focus group results highlighted the primary barriers to adopting this technology. The potential learning curve associated with using LSDVs was a major barrier, and the vast majority of senior drivers agreed that educational resources and training would be essential for this age group to safely adopt the use of LSDVs.
- Cost of LSDVs was also considered to be a significant barrier because many focus group participants reported that they tended to drive less frequently as they aged. As such, they expressed

more reluctance to purchase LSDVs and pay a premium price for it when they did not drive frequently.

Results regarding driver education and training

- Online survey data analysis suggested that an opportunity may exist to increase safety, conditional on the availability of education for senior drivers. Interest in, and a need for, education was also a clear finding from the focus groups.
- Focus group participants most frequently requested information about the safety and performance of LSDVs. They wanted to know how LSDVs would help to keep them safe in a hazardous situation, and how LSDVs would help to avoid potential collisions in addition to the traditional information such as crashworthiness, vehicle functionality, and the programmable specifications of LSDVs.
- Participants reported that a hands-on context, a classroom environment or an online learning forum were the environments best-suited to learning about LSDVs. Most participants expressed the desire to have practical experience with LSDVs.
- The majority of participants believed that the best format to provide this type of education would be a simulator or on-road training course.
- There was variation regarding the amount of time that participants were willing to invest in learning to drive LSDVs. Some participants suggested that education be offered as a one-time intensive course, and others indicated that a multi-module curriculum over a period of time would be more beneficial.
- Educational institutions and community groups were favoured as the best providers of LSDV training. Many participants and their peers already attended lifelong learning programs or were part of community groups for seniors.

Conclusions

In conclusion, there was significant evidence that drivers in older age cohorts were very interested in semi-autonomous vehicle technology. They were also quite receptive to using it if certain conditions are met. To this end, it is important that the increased safety of these vehicles is proven, that costs of vehicles, insurance and repairs are affordable, and that key questions are answered regarding how and under what conditions the technology works best.

This research revealed that older drivers recognize the potential of LSDV technology to increase their safety on the road and instill greater confidence in their ability to drive under challenging conditions that are typically avoided. Of greater importance, this technology can enhance mobility among older drivers and help them to safely prolong driving and mitigate errors that are associated with age-related factors. As such, this cohort of drivers was very receptive to strategies and tools to help them learn to use LSDVs in ways that maximize safety benefits. There was widespread recognition that increased knowledge of LSDVs gained through education and training can help senior drivers to reap the greatest benefits from this technology.

This means that educational strategies that accommodate the needs of seniors and their comfort in using new technologies are necessary to help them manage a significant learning curve, and thereby increase their receptivity to adopting LSDV technology. Tailored education is especially pertinent given that the main conclusion from the online survey data analysis suggested that an opportunity may exist to increase safety, conditional on the availability of education for senior drivers.

Perhaps most notably, the widespread and early adoption of LSDVs by aging drivers can help to demonstrate the true safety potential of LSDVs. Older drivers generally have a low crash risk as a result of their accumulated years of driving experience and exposure to all types of road environments and conditions. This is in sharp contrast to younger drivers, and those who drive longer distances who are most likely to be early adopters of LSDVs, but whom also often represent the population of drivers involved in

crashes. In other words, the population of older drivers may be more sensitive to the inherent risks and limitations associated with semi-automated vehicles, and thereby best-suited to test them in the real world. Their experiences using semi-automated vehicles can be insightful regarding optimal strategies and conditions that are needed to safely integrate automated vehicles into the existing vehicle fleet consisting of – almost exclusively – traditional vehicles. Of equal importance, their ability to adapt to a new vehicle and road environment, as some of the safest drivers on the road, can help to set standards regarding the level of education and skills that drivers of all ages must possess before using semi-automated vehicles.

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INTRODUCTION

Canadians over the age of 65 currently represent one in seven Canadians. In the next two decades, the population of seniors will grow to more than 10 million and will account for one in four Canadians (Statistics Canada 2015). As one of the largest age cohorts, older adults will be a significant segment of the driving population. Based on current licensing rates, it is expected that in the next few years 4.6 million Canadians aged 65 or older will hold a valid licence (Robertson and Vanlaar 2008). This is concerning because senior drivers are susceptible to age-related declines in perceptual, cognitive, and physical capacities that can degrade their ability to perform common driving maneuvers and make them less safe on the road (Wood et al. 2008; Klavora & Heslegrave 2002).

In addition to this age-related decline in driving capacities, seniors are often over-represented in crash statistics. An important reason for their higher involvement in crashes is that seniors tend to drive mostly on local streets and avoid freeways. Since local streets tend to be more congested and contain more intersections than freeways, there are more opportunities for seniors to be involved in crashes. In addition to driving mostly on busy city streets, older drivers tend to drive less overall than younger drivers. Despite years of driving experience, the typically low annual mileage rate of senior drivers is positively correlated with an increased crash risk (Janke, 1991). Furthermore, seniors are over-represented in crash statistics and have one of the highest motor vehicle fatality rate among licensed drivers, as those who are crash-involved are at increased risk for injury and death because of their frailty (Evans, Gerrish, & Taheri 1998; Li, Braver, & Chen 2003).

However, research also suggests that mobility and the ability for seniors to continue to drive as they age is integral to their health. This has become evident with numerous studies reporting significant social and psychological consequences of driving cessation such as social isolation, loss of independence, and depression (Fonda et al. 2001; Yassuda et al. 1997; Marottoli et al. 2000; Marottoli et al. 1997). In light of these facts, it is imperative that older drivers are protected on the road, and are able to continue to drive safely as they age. Advanced safety features and automated vehicles offer great potential to improve road safety and the mobility of older drivers. However, previous research from the Traffic Injury Research Foundation (TIRF) has suggested that older drivers are less confident in these technologies, are less familiar with them, and are least likely to rely on them to improve their safety on the road (Robertson et al. 2016, 2017).

The objective of the present study was to better understand the perceptions and attitudes of older drivers towards semi-automated vehicles, and to understand how their knowledge and beliefs about automated vehicles can affect the likelihood they will rely on this technology to improve their safety on the road and

increase their mobility. Both qualitative data from focus groups and quantitative data from an online survey were used in this project.

In the methodology section of this report, methods are described, first for the focus groups, followed by methods used for the online survey. A similar structure is adopted for the results section where focus group results are described first, followed by survey data analysis results. Important findings are summarized in both results sub-sections. The report ends with overall conclusions that synthesize the key-findings from both sources of data.

METHODOLOGY

Focus groups

A total of 38 people participated in eight focus groups conducted in Ottawa, Ontario during the months of January and February 2018. All participants were licensed drivers over the age of 65, with a mean age of 73 years. Participants were recruited through local community groups, or through newspaper or online recruitment ads. Each focus group consisted of three to eight participants. A discussion guide was developed (see Appendix 1) to provide structure to the discussion and to help facilitate the sharing of spontaneous thoughts. The guide was based on key findings from the research literature on this topic, as well as results of a previous study on automated vehicles by TIRF to investigate the knowledge, attitudes and behaviours among drivers of all ages (Robertson et al. 2016, 2017). Discussion lasted for approximately two hours. Focus groups were conducted to gather qualitative data related to the knowledge, driving context and experiences of this segment of the population, and to examine their perceptions, beliefs and concerns about safety features and semi-automated vehicles. Efforts were made to ensure that the focus groups were representative in terms of age, sex, education and income. Focus group data were analysed using the Knowledge, Attitudes and Practices (KAP) theoretical framework, in which practices can be modified by adjusting attitudes through knowledge and awareness.

Online survey

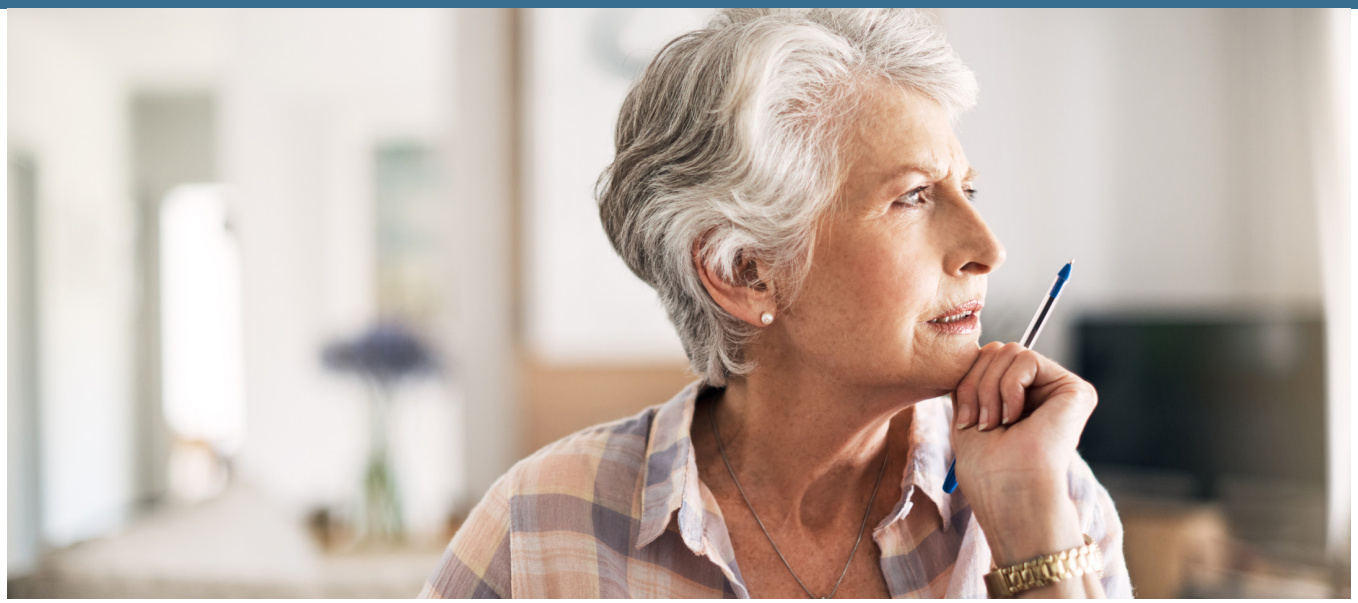
Data. The quantitative component of the study consisted of the analysis of online survey data. The survey was developed to explore the knowledge, attitudes, and practices of Canadians in relation to limited self-driving vehicles (LSDVs). Priority areas that were explored included acceptance of vehicle technology regarding perceived ease of use and perceived usefulness, trust in automation, and behavioural adaptation by drivers in response to these vehicles. Most of the survey questions used Likert-type answering scales ranging from one ("strongly disagree" or "not very likely") to six ("strongly agree" or "very likely"). Respondents could also choose "don't know". The survey took approximately 30 minutes to complete. Results of the survey can be considered accurate within ±1.9% using a confidence interval of 95%.

A total of 2,662 Canadians completed the survey in April 2016 which was fielded by Nielson Opinion Quest. The sample was representative of Canada and used a disproportional stratified (by region) random sample. Jurisdictions were grouped in the following five regions: British Columbia, the Prairies (Alberta, Saskatchewan and Manitoba), Ontario, Quebec and the Atlantic provinces (Nova Scotia, New Brunswick, Prince Edward Island, Newfoundland and Labrador). All respondents possessed a valid driver's licence and had driven within the past 30 days. The age of respondents ranged from 16 to 93 years of age, with an

average age of 53. Slightly less than half (47%) of respondents were male and slightly more than half (53%) were female.

Data analysis. The data were analyzed to understand perceptions of, trust in, and behavioural adaptation to LSDVs and their possible association with intention to use and adopt this technology. Previous studies (Robertson et al. 2016, 2017) analyzed the same data using univariate descriptive methods and multivariate regression analysis. In this study structural equation modeling (SEM) was used, which is an extension of multiple regression analysis by allowing more than one dependent variable at a time as well as allowing variables to be dependent with respect to some variables and independent with respect to others (Rabe-Hesketh et al. 2004; Skrondal et al., 2004). Furthermore, SEM enables the use of latent variables, which are underlying factors that are not directly observable (i.e., "unseen constructs") but can be associated with observable, measured variables. Ultimately, SEM helps to determine if a set of variables fits well with a particular *a priori* theoretical model.

All quantitative data analyses were conducted using Stata/MP 14.1 for Windows 64-bit x86-64 (StataCorp, 2015). Responses were weighted by sex, age, and population to account for variations across Canada. All analyses corrected results for design effects of our sample (i.e., stratification and weighting) using Stata's svy-procedures.



RESULTS

This section contains the results of the focus groups and online survey. Findings related to driver knowledge are presented first, followed by driver attitudes, and then benefits and concerns. In particular, benefits and concerns are described according to perceived benefits for drivers as well as those associated with LSDVs. Results about driver practices are summarized according to determinants of trust, acceptance, and determinants of use. External factors that may contribute to usage, or be barriers to usage, are summarized. Preferences of older drivers with regard to education and training opportunities are shared, including key topics, the learning environment, the format and duration of training, as well as appropriate sources to deliver education. Finally, results from the online survey data analysis are presented.

Focus group results regarding driver knowledge, attitudes and practices

Driver knowledge

Prior to providing definitions of limited self-driving vehicles (LSDVs) and fully automated self-driving vehicles (FSDVs), focus group participants were invited to share their knowledge about limited self-driving vehicles. When describing LSDVs, participants most often referenced vehicles with automated safety features such as self-parking features, lane keeping, and adaptive cruise control. Approximately half of participants were aware that the testing and development of automated vehicle technology was underway. A smaller proportion (25%) of participants believed that this technology was already available to the public, and referred to Tesla vehicles and the Autopilot feature specifically. A few participants also referenced examples of transport truck platoons that possessed self-driving technology. All participants had either seen or read about aspects of automated vehicles in the media. However, their knowledge was in relation to very specific, individual examples of autonomous vehicles, rather than a broader understanding of the technology. Once the definitions for LSDVs and FSDVs were provided, participants had many questions about how the technology works and when it will be publicly available. Participants were also aware that their knowledge of this topic was limited, but were interested in receiving more information about LSDVs.

Participants were aware that their knowledge of this topic was limited, but were interested in receiving more information about LSDVs.

Driver attitudes

Participants were asked about their attitudes and beliefs about LSDVs, specifically in terms of the expected benefits associated with this technology and their primary concerns and needs in relation to these vehicles. The benefits of LSDVs are presented according to the driver-focused benefits, followed by the vehicle-focused benefits. The concerns surrounding LSDVs are organized according to the driver-focused concerns and the vehicle-focused concerns.

Driver benefits. The primary driver-focused benefits mentioned by participants included increased personal safety and general road safety, greater confidence in one's driving ability, and improved mobility.

- **Safety:** The most frequently identified benefit was the increased level of safety that LSDVs could provide. Participants primarily discussed the benefits to their personal driving safety, but they also mentioned how LSDV technology could instill in other motorists safer driving. The majority of participants agreed that LSDVs would improve personal safety, and that this technology would be particularly beneficial to older drivers because it could complement their existing efforts to be a diligent driver on the road. Benefits to personal safety were expanded upon by one participant who suggested that "the more workload you can take off the driver, the bigger the safety benefit".

  Participants also described how LSDVs could ameliorate unsafe driving habits of other motorists, and consequently improve road safety overall by reducing the opportunities for human error, and the number of motor vehicle collisions. More specifically, the majority of participants expressed that LSDVs could mitigate unsafe driving habits, such as speeding and aggressive driving, as well as dangerous driving behaviours such as distracted or drowsy driving.

- **Confidence:** An equally prominent benefit raised by participants was the increased level of confidence in their driving. The majority of participants reported that LSDVs would increase their level of confidence in their driving ability, because it would act as a support system that would help them drive. One participant said that they would feel like "they were not alone in monitoring the road", and that "it was like a second pair of eyes on the road". All participants believed that LSDVs would provide support for older drivers and increase their confidence by helping them manage more difficult driving conditions (long distance drives, night driving, new routes, bad weather) which are often stressful for them. A smaller proportion of participants recognized that LSDVs could also overcome reluctance to drive among seniors who do not enjoy driving.

- **Mobility:** Another important benefit identified by participants was the increased mobility that LSDV technology could offer senior drivers. LSDVs were perceived to improve senior mobility specifically because they provided a means to minimize barriers to driving that frequently result from advancing age. The majority of participants indicated that LSDVs would help surmount age-related, physical, and cognitive limitations to some degree, such as slower reaction time and limited range of motion for shoulder checks. In addition, two-thirds of participants believed that LSDVs could help extend the driving lifetime of seniors. Increased mobility for seniors living in rural areas was also a perceived benefit of LSDVs, as approximately one-quarter of participants expressed that this technology could help reduce isolation and increase the independence of seniors living in rural communities.

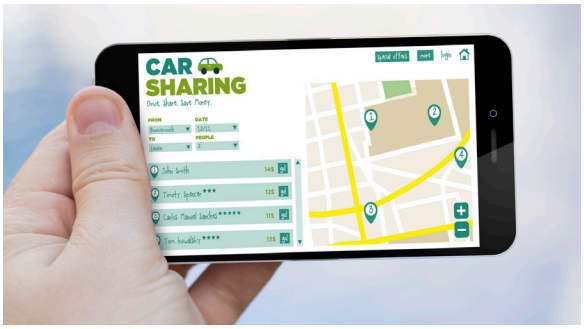
  LSDVs were perceived to improve senior mobility and help extend the driving lifetime of seniors.

Vehicle benefits. The main vehicle-focused benefits included the better performance of LSDV features, more efficient means of transportation for public transit and trucking industries, and improved roadways with reduced congestion.

- **Performance:** The performance of LSDV features was a vehicle-focused benefit raised by slightly less than half of participants. They expressed that the performance of features, such as hazard detection, immediate response to road conditions, and self-parking abilities would be beneficial,

especially for older drivers. Some of them further agreed the reaction time of LSDVs would be much faster than their own reaction time in the event of a hazard.

- **Transportation:** Slightly less than half of participants noted that LSDV technology could benefit public transportation systems, by incorporating fleet vehicles into local public transit services.



One-third of participants also stated that LSDVs could benefit the trucking industry through fleet technology, and that this could help the economy by producing a much more efficient means of transporting goods. There was also an interest among participants in terms of the inclusion of autonomous technology into car-sharing services. These participants valued a car-sharing service where one could order a vehicle to take them to their desired destination in autonomous mode. Although participants were aware of the distinction between semi-autonomous and fully autonomous vehicle functioning, this was still a commonly desired benefit for seniors.

- **Traffic congestion:** A benefit that was less often mentioned was the effect of LSDVs on roadways. Less than one-quarter of participants expressed that LSDVs could help reduce congestion and traffic jams. They indicated that LSDVs would optimize the flow of traffic because the self-driving capacities would standardize and reduce the number of maneuvers by individual drivers which interrupt traffic flow.

Driver concerns. The main driver-focused concerns emerging from the focus groups included the over-reliance on LSDV technology, the learning curve associated with adopting this technology, and the dangerous driving behaviours that may develop as a result of using a LSDV.

- **Over-reliance:** A frequently raised concern by the majority of participants was the over-reliance on LSDV technology that would likely result from its availability. Participants expressed concern that the over-reliance on LSDV technology would result in the degradation of general driving skills and that, depending on the self-driving capabilities of a LSDV, would reduce driver vigilance and ultimately "erode one's driving skills over time". Some participants also noted that this may affect their ability to respond to a hazard if prompted to take over control of the vehicle. One-quarter of participants expanded on this concern and stated that the dependence on LSDVs to perform most of the driving task might accelerate the rate of cognitive decline, since they believed that driving a LSDV does not require drivers to remain as vigilant as when driving a traditional vehicle. One-third of participants were concerned that LSDVs could artificially extend the ability to drive, and may encourage seniors, particularly those with cognitive issues, to drive beyond the point where they are able to do so safely. In particular, it was suggested that LSDVs could create a false sense of security and result in drivers not recognizing their errors behind the wheel, and continuing to drive when they should not.

- **Learning curve:** An equally prevalent concern was the learning curve associated with driving LSDVs. Three-quarters of participants agreed that there would be a significant learning curve and that they would need education and training with LSDVs before being able to drive them safely. One participant noted that LSDVs would have an overwhelming number of notifications and alerts, and that it would be a "completely new visual experience" and "somewhat of a sensory overload". Of those who believed that LSDVs would require a significant learning period, some indicated it would likely be easier for younger generations to learn this technology because they do not have a lifetime of driving experience in a traditional vehicle. It was also added that seniors who drove vehicles with advanced safety features may be more apt to learn how to use a LSDV. The remaining one-quarter of participants did not agree that it would be difficult to learn to use LSDVs. Among

this group, some participants reported it would not be in the best interest of manufacturers to make LSDVs difficult or complex to learn. A different perspective was shared by one participant who did not think LSDVs would require much learning, and stated that older adults had lead the development of many technologies that were readily available today, and that it was incorrect to assume that older adults were opposed to learning new technology.

- **Dangerous behaviours:** All participants expressed significant concern regarding a possible increase in distracted driving when using LSDVs in autonomous mode. Participants were concerned that using LSDVs would not keep them engaged in the driving task and that they would have trouble staying focused on the road. They imagined that relying on LSDVs for all critical driving functions would result in boredom for drivers. Some participants stated that it would be too difficult to resist the temptation to use their phones, talk to passengers or fall asleep while self-driving capabilities were engaged. One participant made the comparison between being at the wheel of a LSDV to being the designated driver in a vehicle full of intoxicated friends. She expressed that "even though you are not driving, you would still have to remain attentive at the wheel while your passengers would be able to have fun".

  In addition to concerns relating to one's personal driving experience, there were also concerns over the incidence of dangerous behaviours among other drivers. All participants were equally concerned that other drivers would become distracted while using a LSDV in autonomous mode. They thought that other drivers would have trouble staying focused on the road, thus allowing their mind to wander. They were equally concerned that other drivers would be tempted to use their phone, talk to passengers or fall asleep. One participant added that "most crashes are due to inattention or willful disregard, and that LSDVs would not change that". However, some participants speculated that there would be a function to ensure that drivers are paying attention, such as the detection of eye movements away from the road or an alert to signify the absence of hands on the wheel.

  To a lesser degree, participants were concerned about the likelihood of other drivers being impaired while using LSDVs in autonomous mode. Slightly less than half of participants expressed concern about those who would drive impaired because LSDVs could assume all critical driving functions. One participant stated that "drivers may be tempted to have one more drink because they are driving a LSDV".

  Some concern was expressed regarding an increase in dangerous behaviours by pedestrians. Approximately one-quarter of participants were concerned that pedestrians would become less vigilant when crossing the road, because of assumptions that hazard detection technology in LSDVs would be able to detect their presence and respond accordingly.

Vehicle concerns. Primary vehicle-focused concerns included the response of LSDVs to hazards, the potential for technology failure, the significant costs associated with LSDV technology, the effects of inclement weather on LSDV functioning, and the need for LSDV-friendly roadways.

- **Hazard response:** There were significant concerns surrounding the response of LSDVs to hazards, as well as several related concerns in the event of a potential or impending collision. One-third of participants questioned whether LSDV technology would be able to respond to all possible situations that may occur on the road. Since human behaviour is so unpredictable, many believed

it was unlikely that LSDVs would be able to account for all random events that may occur. Contrary to this, one participant stated that they were concerned that LSDVs would over-react and be too cautious in a majority of situations, since the technology would be programmed to take the utmost caution with any severity of hazard. This over-cautiousness was also perceived to be problematic.

If LSDVs were not able to respond safely to a hazard, and the vehicle prompted the driver to resume control, a minority (< 10%) of participants expressed concern that some drivers would be unprepared or unable to respond to the hazard due to inattention, lack of skill, or inability to respond rapidly to unexpected events.

An estimated 25% of participants were concerned about the ethical decision-making capabilities of the technology if the LSDV were to experience an impending collision. More specifically, they questioned whether the decision made by LSDVs would be similar to the decision that drivers would otherwise make. Furthermore, one-third of participants were concerned about liability in the event of a collision, especially incidents involving injury or death. Some participants expressed uncertainty whether insurance penalties would be higher if drivers did not have the self-driving capabilities engaged.

- **Technology failure:** Another primary concern that was reported by most participants was the potential for LSDV technology failure. Slightly more than half of participants believed that LSDV technology would be susceptible to failure in the event of hacking. Participants believed that this type of technology failure would cause chaos for road safety. They believed that the potential to hack LSDVs could create opportunities for terrorist attacks, or a hacker looking to "prank" automotive companies. Participants were also concerned about the safety and protection of their consumer information and location data in the event of hacking.

  Additionally, there was concern about potential malfunctioning of LSDV technology. If LSDVs malfunctioned, due to general technological error, or the inability to perform in certain conditions, the majority of participants (75%) were concerned that they would not be notified immediately if certain functions suddenly stopped working. They stressed the importance of proper notification regarding the failure of any and all features related to the self-driving capacities, as well as prior knowledge of conditions when self-driving features would be most likely to fail.

- **Cost:** Of equal significance, participants were concerned about the cost of LSDVs. The vast majority of participants were concerned that LSDVs would be significantly more expensive than traditional vehicles. Some participants said that they were not willing to pay extra for LSDVs because they did not drive as often as they used to, and they did not want to pay high prices for premium safety features. The cost to insure LSDVs was also a concern to most participants. They expressed reluctance to pay higher insurance premiums for these types of vehicles. Similarly, the maintenance and repairs for LSDVs were another cost-related concern noted by participants. They believed that costs associated with regular maintenance and repairs would be much higher due to the complexity of the technology. In addition, they were concerned that they would have to go to a dealership or specially-trained automobile repair mechanics who were qualified to work on LSDVs, instead of using the service centre that they trusted with previously-owned vehicles.

  Some participants were not willing to pay extra for LSDVs since they did not drive as often as they aged, and they did not want to pay high prices for advanced safety features.

- **Weather:** Another substantial concern for all participants was the effects of inclement weather on LSDVs in self-driving mode. The majority of participants indicated that they would be worried about the impact of typical Canadian weather (snow, sleet, ice, heavy rain) on the functioning of LSDVs. They were also concerned that the self-driving functions would fail in road conditions where older drivers may need them the most (icy roads, freezing rain, snow storm). They suggested that

this technology was much less feasible for the Canadian climate, and would be better-suited for warmer climates.

- **Road environment:** The ability to implement LSDV technology in the current road environment in Canada was of some concern to a minority of participants. Slightly less than half of them were concerned that LSDVs would not be able to function well in mixed traffic with traditional vehicles due to the unpredictability of the road environment. Some participants hypothesized that LDSVs would need their own traffic lanes or completely separate infrastructure. Furthermore, they proposed that the mix of LSDVs and traditional vehicles on the roads would create frustration for drivers, and potentially dangerous situations. Some stated that drivers of traditional vehicles may be impatient with LSDVs because they would be programmed to obey the rules of the road.

Summary. Overall, these findings suggest that despite the perceived benefits of increased personal safety, greater confidence in certain driving situations, and increased mobility for seniors, participants were concerned about the potential negative impact that LSDVs would have on driver behaviour (driving distracted, drowsy or impaired) and thereby increase risk on the road. They were also concerned about the learning curve associated with using LSDVs, the response of LSDVs to hazards, the costs associated with owning and maintaining LSDVs, the effects of weather on the functioning of LSDV technology, and the ability of LSDVs to integrate with traditional vehicles in the current road environment.

Driver practices

Participants were asked about their practices in terms of trust, acceptance and behaviour related to LSDVs. Trust was explored through perceptions of integrity of the technology, specifically in relation to safety. Trust in personal capabilities required to handle LSDV technology was also investigated since perceived ability and control is an important contributor to driver practices. The acceptance of LSDV technology was gauged through participants' intention to use the vehicle, and by examining participants' intended behaviours while driving LSDVs. Finally, external determinants and barriers to the use of these vehicles were explored.

Trust determinants. The key determinants of trust were discussed in relation to perceived safety and control of LSDV technology. Trust in the integrity and safety of LSDVs was approached by asking participants whether they would trust LSDVs to keep them safe. In addition, perceived control was examined to gauge the level of trust participants possessed in their own ability to use LSDVs. Finally, participants were also asked whether they trusted their ability to take over driving control of LSDVs in the event of a hazardous situation. Results are presented below.

- **Integrity and safety.** Participants were asked whether they would trust the ability of LSDVs to keep them safe in a vehicle. The majority of participants indicated that initially they would distrust the technology, and instead believed that trust would develop over an extended period of time with experience driving. They acknowledged that they would need to understand and observe the reliability of LSDVs in various situations before feeling trust and confidence in the technology. Some participants further indicated that having the choice to engage self-driving capabilities would help them become accustomed to the technology at their own pace. Therefore, personal experience with LSDVs was reported to be an essential internal determinant of trust. Less than 10% of participants said that they would trust a LSDV without any prior knowledge or experience. They also highlighted the role of external determinants of trust which included consumer reviews, testing in Canadian climates, and reports on vehicle safety from manufacturers as well as independent third parties.

- **Perceived control:** Trust was also explored in relation to the hand-over or take-over process, which is defined as when drivers are prompted to take over control from autonomous driving mode because the vehicle cannot respond safely or cope with the situation. Participants were asked if they trusted their ability to take over control of LSDVs if it was unable to drive in certain conditions. Half of participants trusted their ability to take over control of the vehicle if they were prompted to do so. These participants reported that taking over control would not be problematic since they would be attentive and had experience driving vehicles in hazardous situations. They indicated that this experience would help them to anticipate hazards and be ready to take over. One participant added that it was beneficial for LSDVs to be programmed to hand over control when it cannot proceed safely, otherwise the technology would be dangerous. Conversely, the remaining participants were unsure about their ability to take over control when prompted by LSDVs. Among these participants, approximately 40% expressed that it depended on the situation in which they would be responsible for taking over control. They were much less trustful in their ability to take over in high-speed scenarios, or stressful scenarios involving a potential collision. They thought that it also depended on the amount of time that they had to take over control before the vehicle was no longer in autonomous mode. In this regard, it was proposed that if the take-over warning provided them at least 10 to 20 seconds to regain control, they would be able to do so safely. A small minority of these participants (10%) did not trust their ability to take over control of vehicles when prompted. These participants were mostly those who were not confident in their current driving ability as a result of age-related declines in reaction time and other skills necessary for safe driving. Many of these participants were not receptive to the potential for LSDVs to hand over control to drivers in situations where they would most need to rely on autonomous driving functions.

Half of participants trusted their ability to take over control of the vehicle if they were prompted to do so.

Acceptance. Acceptance of LSDV technology was also examined in relation to driver practices. These findings are organized according to the probability and intention to use it. Probability of use was considered in terms of how likely participants would be to use LSDV technology if it was currently available. Of those who indicated that they would use the technology, intended behaviours with LSDV technology were discussed.

- **Probability of use:** With regards to acceptance and use of this technology, participants were asked whether they would use LSDVs if they were available today. Approximately 85% of participants indicated they would use this type of vehicle if it was available today. Most of the remaining participants reported they would only consider using a LSDV if it was significantly safer than traditional vehicles, or if they were planning to purchase a new vehicle. Fewer than 5% of participants stated they would not use LSDVs if they were available today. This minority of participants were most reluctant to give up control of driving, or were uncomfortable with shared control of the driving task.
- **Intention to use:** Participants were asked how they would use a LSDV and what behaviours they would engage in while using LSDVs in order to further explore the concept of use. Three-quarters of participants indicated that they would be most likely to use LSDVs to drive long distances, whereas one-quarter of them stated they would use LSDVs for city commutes and if traffic was congested. The majority of participants reported they would not turn off self-driving capabilities to disobey traffic rules, and just a small percentage of participants (< 5%) revealed they would turn off self-driving capabilities to run a red light or speed. Other preferred uses of this technology included nighttime driving, to find an address, and on mundane or uninteresting routes. Although discussion was focused on LSDVs, some participants indicated that they saw the advantages of using LSDVs or FSDVs as part of rideshare or transit systems to help increase mobility and independence among seniors.

Determinants of use. External factors that were most likely to affect decisions by participants to adopt LSDV technology were also explored. In addition, barriers that might deter the use of LSDV technology were examined. Barriers to using LSDVs are equally relevant to determine the intention of drivers to adopt LSDV technology.

External factors: The external factors that contribute to the willingness of senior drivers to adopt automated vehicle technology included having a tech-savvy family member, the cost associated with LSDV ownership, and the influence of reviews from, and the experiences of, peer groups, neighbours or media.

- **Tech-savvy family member.** The most important external factor identified by focus group participants that would influence their use of LSDVs was having a younger family member that was technologically savvy and able to help them learn how to set up and use the features of LSDVs. One participant shared that she had bought a new car with the most advanced safety features, and drove the car from where she purchased it with her son in Quebec, back home to Ontario. During the drive, her son was there to instruct her how to use all the "bells and whistles" of her new car, by explaining it as she drove. This made it possible for her to practice using features as she learned about them which made this information easier to recall. She stated that as a result of this hands-on experience, she felt well-equipped to benefit from the many safety features available on her new vehicle.

- **Cost.** Another highly influential factor related to the decision to use LSDVs was the cost associated with them. The majority of participants reported they did not think LSDV technology would be affordable to most seniors. However, they acknowledged that with time, the cost associated with a new technology would slowly decline and would eventually become more affordable due to economies of scale.

- **Other external factors.** To a slightly lesser extent, reports about LSDVs in the media, and reviews from independent sources would influence the decision of some participants to adopt LSDV technology. They suggested that peer groups or neighbours who owned LSDVs would also help influence their decision to use these vehicles. Only a small percentage (< 5%) of participants agreed that their decision would not likely be affected by such factors, and that they would solely depend on informing themselves through research and experience with LSDVs.

Barriers: Focus group participants were also queried about potential barriers that may impede senior drivers from adopting LSDV technology. Key barriers that were identified included the significant learning curve associated with using LSDVs, as well as the cost to purchase, insure and maintain these vehicles.

- **Learning curve.** A primary barrier that all participants cited was the substantial learning curve associated with driving LSDVs, particularly if they had not purchased a new vehicle in the past few years. It was noted that the technology of new vehicles had changed rapidly, and the longer it had been since they had purchased a new vehicle then the more significant the learning curve. Most participants (75%) agreed that using LSDVs would require much more knowledge and education to be able to use them safely. Conversely, the remaining one-quarter of participants believed that it would require some learning, but that it would not be too difficult to become familiar with the new technology and features of LSDVs.

- **Cost.** Another barrier that was reported by a majority of participants was the perceived high costs associated with purchasing, insuring and maintaining LSDVs. Many participants agreed that cost could impede senior drivers from adopting this technology, particularly because seniors ultimately drive less and less as they age. As such, the ratio of cost to benefit for seniors would have to be weighted towards the benefits for seniors to consider paying a higher cost for LSDVs.

Summary. Overall, participants reported that their trust in LSDVs would be developed over time and with experience. In other words, as they became more familiar with the technology and the reliability of its functions, they would be more inclined to trust and have confidence in LSDVs to keep them safe on the road. Most participants had trust in their ability to take over control of LSDVs when prompted to do so, and only a small proportion of them expressed concern about their ability to take over driving when prompted. Most notably, they were concerned about their ability to take over control in stressful conditions or react to an emergency situation.

The majority of participants indicated they would use LSDVs, especially if they thought that they would be safer to drive than traditional vehicles. Most participants stated they would use LSDVs when travelling long distances, and that they would engage autonomous driving functions to take a break from driving. Almost all participants indicated that they would not turn off the self-driving functions to break traffic rules.

The main factors that participants reported would have an impact on their decision to adopt LSDV technology were the help of a technologically savvy family member, and the cost of purchasing, insuring and maintaining LSDVs. Participants cited the cost of LSDVs as a barrier to using the technology, as they were concerned that many seniors would not be able to afford the purchase of LSDVs since it was believed to be much more expensive than traditional vehicles. Another barrier that participants indicated was the learning curve associated with driving LSDVs. Most participants believed that they would need education and training seminars on LSDVs before being able to use the technology safely.

Participants reported that their trust in LSDVs would be developed over time and with experience. In other words, as they became more familiar with the technology and the reliability of its functions, they would be more inclined to trust and have confidence in LSDVs to keep them safe on the road.

Focus group results regarding education and training

Education about LSDVs was explored during focus group discussions to gain insight into the most effective ways to reach the senior driver population, and increase their knowledge and awareness of this technology. The following section summarizes these findings according to the key areas of education, types of learning environments, format, duration, and source of education.

Topics of education

There was generally a high-level of consensus among focus group participants regarding important topics that any educational strategy should address. Each of these topics is described briefly below.

- **Safety:** Participants reported that information about how LSDVs would keep them safe in the event of a collision was a priority. This included knowledge of the traditional metrics such as the safety score and crashworthiness of LSDVs which are typically used to rank vehicles on this dimension. However, participants also wanted to learn about other metrics such as how resistant LSDVs were to hacking, and how these vehicles would respond in the event of technological failure.
- **Performance:** Participants were interested in learning about the various functions and features of LSDVs and how these vehicles would perform in various situations. The general features and functions of self-driving technology and the takeover prompt were the topics of greatest interest. Participants also indicated they wanted to know under what conditions self-driving capabilities would be able to function, as well as the types of situations where they would likely be required to take over control of the vehicle. Participants were also interested in detailed information regarding the takeover process, and how long they would have to resume control of the vehicle when prompted. Other topics related to the performance of the technology included the role and capacity of sensors, and the programmable specifications of the technology.

Learning environment

The preferred learning environment of participants was variable and these findings reflect important differences in learning styles that are consistent with research.

- **Practical learning:** Participants expressed that it would be most beneficial to learn how to use a LSDV in a practical setting that involved hands-on experience with driving LSDVs and this was a strong preference.
- **Classroom learning:** Many participants acknowledged the value of receiving education about LSDVs in a classroom environment so that drivers could acquire the knowledge base necessary to understand how LSDVs function. They reported that such an approach would provide them with materials that they could refer to as they gained hands-on experience.
- **Online learning:** Participants thought that education about LSDVs could be offered in an online environment. In particular, this strategy would allow seniors to learn at their own pace in an environment that was free of judgment of their skills and abilities in relation to those of others.

Educational format

Participants indicated distinct preferences regarding the manner in which they were able to gain experience using these vehicles. These differences may be related, in part, to differences in the current comfort level of participants with driving. Focus group results suggested that those who were more comfortable learning on a closed course were more confident in their current driving ability, whereas those who were more comfortable learning on a simulator, or using videos may have been somewhat less confident.

- **Driving simulator:** Participants believed that the safest format to learn about LSDVs was a driving simulator. They indicated that a simulator would give them the opportunity to become accustomed to the responsiveness of LSDVs, manipulate the controls, and visualize the additional information that may be presented on the dashboard of LSDVs. They also agreed that a simulator would allow senior drivers to practice the takeover in a variety of situations (weather, emergency, road hazard) and become comfortable taking over control from the self-driving mode when prompted.

Participants believed that using a driving simulator was the safest format to learn about LSDVS.

- **On-road driving:** Participants stated that driving LSDVs on a closed circuit road would be the most effective way to learn about this technology. Participants suggested that with the help of an instructor they could learn about how LSDVs work and respond to a variety of situations. Although they acknowledged the greater risk of this hands-on learning format, they believed that this would be the most realistic and could allow them a chance to ask questions as they learn, and gain experience in a safe environment before driving on public roads.
- **Text or video-based resources:** Participants noted that receiving educational materials summarizing the key areas of information would also be valuable, although they acknowledged that it would have to be brief enough to ensure drivers would read it. They added that it was important for this information to be provided in an accessible language, and to be presented in a user-friendly format.

Duration of education

There were some variations in the amount of time that focus group participants were willing to invest in learning to use LSDVs which seemed to be a function of personal preferences.

- **Single session:** Approximately half of participants expressed that they would like to learn about LSDVs during a full-day session, or two half-day sessions. Most of them believed that this would be sufficient time to learn how to use LSDVs.

- **Multi-module course:** The remaining half of participants indicated that they would like to learn about LSDVs in an incremental fashion. They thought that this approach would give them the opportunity to learn about LSDVs without being overwhelmed, and would allow them to gain experience as well as ask questions as they arose.

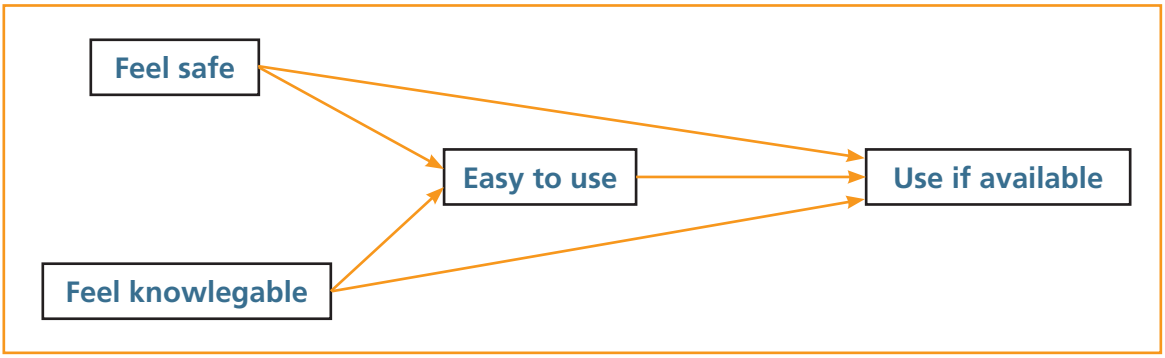
Source of education

- **Educational institutions:** Most participants agreed that education about LSDVs should be offered as part of lifelong learning programs that are available to seniors through colleges or universities. Many participants were already enrolled in these types of lifelong learning initiatives at their local college, and they believed that this type of environment would be ideal to reach the senior driving population since participation in these initiatives is generally high.
- **Community groups:** Similarly, participants expressed great interest in receiving education about LSDVs from local community groups (e.g., Ottawa Council on Aging, 55 alive, service clubs). Many participants were already involved in similar community groups and believed that education offered from local groups would reach a significant proportion of the senior population.
- **Driving schools:** Some participants believed that the best source to educate about LSDVs would be local driving schools. Additionally, they thought that a different class of license would exist for LSDVs, and thus the education and assessment would be regulated by the government as a pre-requisite to owning LSDVs. They suggested that education about LSDVs would be offered by driving schools, and the assessment would be conducted by the provincial licensing bureau, similar to the existing licensing structure.
- **Dealerships:** Fewer participants indicated that it was the duty of dealerships to educate consumers to the extent needed about LSDVs at the point of purchase. While there was consensus that some learning should take place during the buying experience, there was also concern about a perceived conflict of interest, and the level of knowledge about features that sales staff may possess. It was also noted that sales staff may not have the time or availability to deliver the level of education that older drivers might need. In addition, some participants suggested that seniors may be more receptive to education from independent entities as opposed to dealers.

Online survey data analysis results

The SEM analyses were conducted to test hypothetical models. First, a simple model was tested that studies the relationship between respondents' responses about safety, confidence, and knowledge regarding LSDVs and their intention to adopt the technology (Figure 1).

Figure 1: Hypothesized SEM on the relationship between feeling safe, knowledgeable and confident about using a LSDV and the intention to use it



Then, a second more complex model extended the first one by including other observable variables as indicators of the unobserved latent variable "behavioural adaptation" (Figure 2). These observable variables were measured based on responses from respondents about modifying their driving behaviour in negative

ways that would undermine safety while using LSDVs. The model also enabled the testing of hypotheses regarding the relationship between behavioural adaptation and feelings of safety, confidence, knowledge and intention to use the technology.

Age (measured in years as a continuous variable) and sex (1: male, 2: female) of respondents, although not represented in the figures, were included in both models as exogenous variables (determined outside the model, not affected by any other variable). The previous studies (Robertson et al. 2016, 2017) that used only multiple regression analysis reported associations between sex and age on the one hand and behavioural adaptation on the other.

Figure 2: Extended hypothesized SEM including behavioural adaptation variables

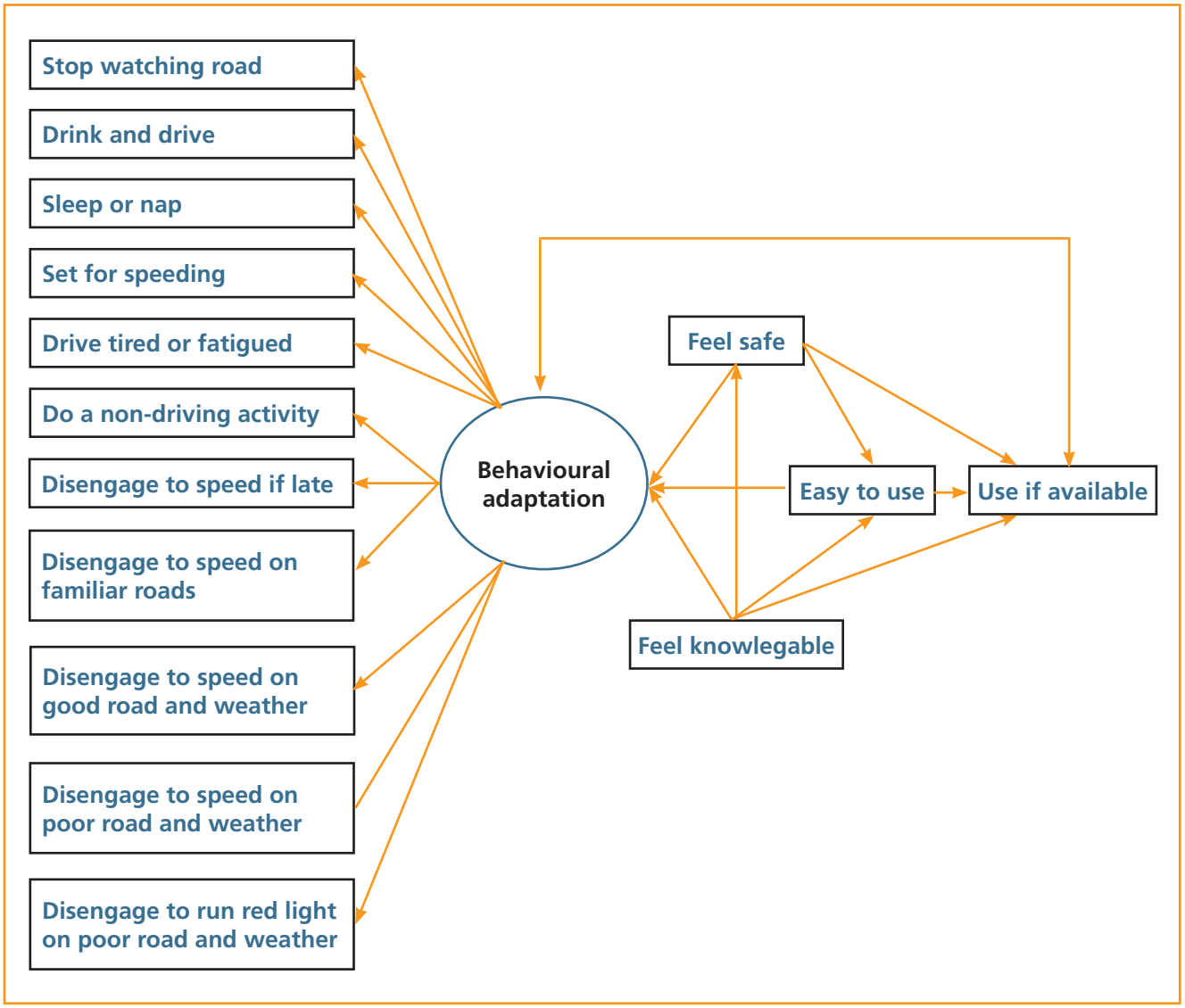


Figure 3 shows the results for the first model, specifically the total effects and the goodness of fit tests. The total effects consider simultaneously all effects variables may have on one another through direct effects (e.g., the arrow from "feel knowledgeable" to "use if available") and indirect effects (e.g., the arrow from "feel knowledgeable" to "easy to use", and from there to "use if available"). The model has a very good fit (SRMR<0.05; Li-tze and Peter 2009) and all hypothesized effects were significant ($p<0.05$) except for age ($p>0.05$).

The results confirmed the hypothesis that feelings of safety and knowledge about LSDVs are positively related to perceived ease of use and adoption of the technology (positive coefficients). In other words, if you feel safer and more knowledgeable about LSDVs, then you are more likely to use it. Female drivers

were less agreeable with the statements about safety, knowledge, perceived ease of use and adoption of the technology than male drivers (negative coefficients). Or, females declared they feel less safe and less knowledgeable than males, and hence were less likely to state they would use a LSDV compared to males.

Figure 3: Results for first SEM on the relationship between feeling safe, knowledgeable and confident about using LSDV and intention to use it

```
Survey: Structural equation model
Number of strata   =        10                  Number of obs     =      2,134
Number of PSUs     =     2,134                  Population size   = 2,139.4883
                                                 Design df         =      2,124

Total effects
------------------------------------------------------------------------------
                     |             Linearized
                     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
Structural           |
  knowledgeable <-   |
                 sex |  -.5695955   .1064889    -5.35   0.000    -.7784289   -.3607622
                 age |    .001504   .0039021     0.39   0.700    -.0061484    .0091564
  -------------------+--------------------------------------------------------------
  safe <-            |
      knowledgeable  |   .4983598   .0323223    15.42   0.000     .4349731    .5617465
                 sex |  -.4702706   .1053321    -4.46   0.000    -.6768355   -.2637058
                 age |   .0016903    .003613     0.47   0.640    -.0053952    .0087757
  -------------------+--------------------------------------------------------------
  easytouse <-       |
      knowledgeable  |   .5349278   .0267763    19.98   0.000     .4824172    .5874384
               safe  |   .4931823   .0299425    16.47   0.000     .4344627     .551902
                sex  |   -.293114   .0946287    -3.10   0.002    -.4786887   -.1075393
                age  |  -.0032895   .0032738    -1.00   0.315    -.0097097    .0031306
  -------------------+--------------------------------------------------------------
  useifavailable <-  |
      knowledgeable  |   .4882538   .0337404    14.47   0.000      .422086    .5544215
               safe  |   .6671202   .0303831    21.96   0.000     .6075363     .726704
          easytouse  |   .3773591   .0399057     9.46   0.000     .2991008    .4556175
                sex  |  -.2396001    .107852    -2.22   0.026    -.4511066   -.0280935
                age  |  -.0001251   .0037051    -0.03   0.973    -.0073912     .007141
------------------------------------------------------------------------------
Fit statistic        |      Value   Description
---------------------+--------------------------------------------------
Size of residuals    |
                SRMR |      0.000   Standardized root mean squared residual
------------------------------------------------------------------------------
```

Figures 4 and 5 show the results for the extended model, including the construct "behavioural adaptation". Figure 4 shows the structural part of the model and Figure 5 the measurement part. The structural part in Figure 4 defined the relationship between the latent variable "behavioural adaptation" (BA) and the observable variables (excluding the indicators of the latent variable). The measurement part in Figure 5 described how the latent variable was measured by its indicators. The overall model had an adequate fit (SRMR<0.08).

The results in Figure 4 confirmed the previous results from the model in Figure 3. Furthermore, the results also indicated that feelings of safety and knowledge about LSDV were positively related to risky behavioural adaptation (positive coefficients). In other words, those who do feel safer and more knowledgeable about LSVDs were also more likely to admit they would engage in risky driving behaviours; these are the ones who are also more likely to use LSDVs. Female and older drivers were on average less likely to express agreement vis-à-vis risky behavioural adaptation (negative coefficients). The hypothesis that behavioural adaptation was directly associated with adoption of the technology was not confirmed (p>0.05).

Figure 4: Results for extended SEM including behavioural adaptation; Structural part and model fit

```
Survey: Structural equation model
Number of strata   =        10                  Number of obs     =       2,000
Number of PSUs     =     2,000                  Population size   =  1,998.293
                                                 Design df         =       1,990
Total effects
------------------------------------------------------------------------------
                     |             Linearized
                     |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
---------------------+--------------------------------------------------------------
Structural           |
  knowledgeable <-   |
                 sex |   -.565556   .1096232    -5.16   0.000    -.7805442   -.3505678
                 age |   .0021328   .0040488     0.53   0.598    -.0058076    .0100731
-------------------------------------------------------------------------------------
  safe <-            |
       knowledgeable |   .4845575   .0346593    13.98   0.000     .4165852    .5525297
                 sex |   -.490774   .1076418    -4.56   0.000    -.7018764   -.2796716
                 age |   .0031698   .0037233     0.85   0.395    -.0041321    .0104717
  -------------------+--------------------------------------------------------------
  easytouse <-       |
       knowledgeable |   .5247066   .0284556    18.44   0.000     .4689008    .5805125
                safe |   .4705887   .0309993    15.18   0.000     .4097942    .5313832
                 sex |  -.3341472   .0954921    -3.50   0.000    -.5214222   -.1468722
                 age |  -.0021992   .0033603    -0.65   0.513    -.0087893    .0043908
  -------------------+--------------------------------------------------------------
  useifavailable <-  |
       knowledgeable |   .4798298   .0364982    13.15   0.000     .4082512    .5514085
                safe |   .6607376   .0325452    20.30   0.000     .5969113    .7245638
           easytouse |   .3620188   .0421734     8.58   0.000     .2793102    .4447274
                  BA |   .1350486   .0868531     1.55   0.120    -.0352839    .3053811
                 sex |  -.2534862   .1111032    -2.28   0.023     -.471377   -.0355954
                 age |   .0002804   .0038513     0.07   0.942    -.0072726    .0078335
  -------------------+--------------------------------------------------------------
  BA <-              |
       knowledgeable |   .0362024   .0133135     2.72   0.007     .0100925    .0623124
                safe |   .0820444    .017209     4.77   0.000     .0482948    .1157941
                 sex |  -.2664302      .0568    -4.69   0.000    -.3778238   -.1550366
                 age |  -.0115349   .0021501    -5.36   0.000    -.0157515   -.0073183

------------------------------------------------------------------------------
Fit statistic        |      Value   Description
---------------------+--------------------------------------------------------
Size of residuals    |
               SRMR  |      0.072   Standardized root mean squared residual
------------------------------------------------------------------------------
```

The results in Figure 5 confirmed that all hypothesized indicators were significant to measure behavioural adaptation ($p<0.05$). Furthermore, it also confirmed for each indicator the results observed in the structural part for the latent variable "behaviour adaptation", meaning that feelings of safety and knowledge about LSDVs are positively related to most of the risky behavioural adaptations considered, and that female and older drivers were less agreeable with these behaviours. The exceptions to the above were the relationships between knowledge and "disengage to speed if late" (disspeedlate) and "disengage to speed on good (poor) road and weather" (disspeedgoodcond, disspeedpoorcond), which were not statistically significant ($p>0.05$).

Figure 5: Results for extended SEM including behavioural adaptation; Measurement part

	Coef.	Linearized Std. Err.	t	P>|t|	[95% Conf.	Interval]
Measurement						
unswatch <-						
knowledgeable	.0362024	.0133135	2.72	0.007	.0100925	.0623124
safe	.0820444	.017209	4.77	0.000	.0482948	.1157941
BA	1	(constrained)				
sex	-.2664302	.0568	-4.69	0.000	-.3778238	-.1550366
age	-.0115349	.0021501	-5.36	0.000	-.0157515	-.0073183
unsdrink <-						
knowledgeable	.0800041	.0324966	2.46	0.014	.0162731	.1437351
safe	.1813108	.0333575	5.44	0.000	.1158915	.2467302
BA	2.20991	.3033901	7.28	0.000	1.614914	2.804905
sex	-.5887868	.0934724	-6.30	0.000	-.7721008	-.4054728
age	-.025491	.0033157	-7.69	0.000	-.0319936	-.0189884
unssleep <-						
knowledgeable	.0843792	.0341713	2.47	0.014	.0173641	.1513944
safe	.191226	.0370439	5.16	0.000	.1185771	.2638749
BA	2.330761	.3041452	7.66	0.000	1.734285	2.927237
sex	-.6209852	.0996242	-6.23	0.000	-.8163638	-.4256065
age	-.026885	.0033772	-7.96	0.000	-.0335083	-.0202617
unsspeed <-						
knowledgeable	.0772356	.0316866	2.44	0.015	.0150933	.139378
safe	.1750367	.0321083	5.45	0.000	.1120674	.2380061
BA	2.133438	.3051677	6.99	0.000	1.534956	2.73192
sex	-.5684123	.0884892	-6.42	0.000	-.7419534	-.3948712
age	-.0246089	.0031481	-7.82	0.000	-.0307828	-.0184351
unsotheract <-						
knowledgeable	.0759307	.0314207	2.42	0.016	.0143098	.1375517
safe	.1720794	.0333199	5.16	0.000	.1067338	.237425
BA	2.097392	.2797103	7.50	0.000	1.548837	2.645948
sex	-.5588087	.0830371	-6.73	0.000	-.7216574	-.39596
age	-.0241932	.0028774	-8.41	0.000	-.0298363	-.0185501
unstired <-						
knowledgeable	.0593772	.0258733	2.29	0.022	.0086356	.1101189
safe	.1345647	.0253373	5.31	0.000	.0848743	.1842551
BA	1.640144	.2718785	6.03	0.000	1.106948	2.173341
sex	-.436984	.061998	-7.05	0.000	-.5585719	-.3153962
age	-.0189189	.002207	-8.57	0.000	-.0232471	-.0145907
disspeedlate <-						
knowledgeable	.0478414	.0244787	1.95	0.051	-.0001651	.0958479
safe	.1084215	.0246573	4.40	0.000	.0600646	.1567784
BA	1.321497	.3643991	3.63	0.000	.6068536	2.036141
sex	-.3520868	.0742415	-4.74	0.000	-.497686	-.2064876
age	-.0152433	.0029931	-5.09	0.000	-.0211133	-.0093733
disspeedfamroad <-						
knowledgeable	.0435148	.0219611	1.98	0.048	.0004456	.0865839
safe	.0986162	.021737	4.54	0.000	.0559866	.1412457
BA	1.201984	.3245943	3.70	0.000	.5654041	1.838565
sex	-.320245	.0646153	-4.96	0.000	-.4469657	-.1935243
age	-.0138647	.0026162	-5.30	0.000	-.0189956	-.0087339
disrlightbadcond <-						
knowledgeable	.0464258	.0220643	2.10	0.035	.0031542	.0896974
safe	.1052133	.021957	4.79	0.000	.0621523	.1482744
BA	1.282394	.2929925	4.38	0.000	.7077902	1.856999
sex	-.3416686	.0626774	-5.45	0.000	-.4645889	-.2187483
age	-.0147923	.0023267	-6.36	0.000	-.0193553	-.0102292
disspeedgoodcond <-						
knowledgeable	.0387255	.0201088	1.93	0.054	-.000711	.0781621
safe	.0877624	.0205937	4.26	0.000	.0473749	.1281499
BA	1.069693	.3104294	3.45	0.001	.4608926	1.678494
sex	-.2849986	.0624542	-4.56	0.000	-.4074811	-.1625162
age	-.0123388	.0025474	-4.84	0.000	-.0173345	-.007343
disspeedpoorcond <-						
knowledgeable	.0409935	.0228161	1.80	0.073	-.0037525	.0857396
safe	.0929023	.0301491	3.08	0.002	.0337753	.1520294
BA	1.132342	.4037821	2.80	0.005	.3404617	1.924222
sex	-.30169	.094088	-3.21	0.001	-.4862114	-.1171686
age	-.0130614	.0039863	-3.28	0.001	-.0208793	-.0052436

Different age groups were compared and drivers aged 50 years or older were less agreeable about LSDVs being easy to use than younger drivers (coef.=-0.019, p=0.04). Furthermore, drivers aged 70 years or older were less agreeable about feeling safe using LSDVs (coef.=-0.029, p=0.04).

Summary. The results of these analyses confirmed the hypothesis that feelings of safety and knowledge about LSDVs are positively related to perceived ease of use and adoption of the technology; or, if you feel more safe using LSDVs and more knowledgeable about LSDVs, you are more likely to believe LSDVs will be easy to use and you will be more likely to declare that you will use LSDVs. Female drivers were less

agreeable with the statements about safety, knowledge, and perceived ease of use than male drivers, and consequently, females are less likely to declare that they will use a LSDV than males.

Overall, feelings of safety and knowledge about LSDVs were positively related to each of the risky behavioural adaptations considered. In other words, those who do feel safer and more knowledgeable about LSVDs are also more likely to admit they would engage in risky driving behaviours. These drivers are also the ones who are more likely to declare they will use LSDVs. Conversely, female and older drivers are less likely to agree with engaging in risky driving behaviours. In conclusion, an opportunity may exist to address the lack of knowledge, feelings of safety and perceived ease of use, among older drivers and female drivers, which may lead to an increase in their likelihood of actually using LSDVs. Given their safer driving behaviours and their declared disinclination to engage in risky driving behaviours, they might be a safer group to cater to than younger, male drivers.

CONCLUSIONS

The results of this study build upon previous findings from the study entitled "Automated vehicles: Driver knowledge, attitudes and practice" (Robertson et al. 2016, 2017) that showed older drivers reported being less comfortable with automated vehicle technologies, less confident in them, and least likely to rely on them to improve their safety on the road. The current study explored knowledge, attitudes and practices among older drivers regarding the emergence of automated vehicles. The objective of this study was to better understand how this technology could improve the safety and mobility of older drivers on the road. Key topics that were explored included driver acceptance of LSDVs and perceptions regarding its use, as well as trust and willingness to use this technology. This study also examined education and training to gain insight into the most effective ways to disseminate information about LSDVs to this segment of the population.

Results from both sources of data (i.e., focus groups and online survey) were consistent, although more nuances were revealed during the focus group discussions, when it was possible to explore responses by asking in-depth questions. Key findings are discussed below.

Knowledge. Overall, senior drivers reported they were not very familiar with LSDV technology and had limited understanding of self-driving vehicles generally, although many of them were familiar with specific examples of some features of LSDV technology. They were most familiar with current vehicle safety technology, although many of them had limited experience using advanced driver assistance systems. Awareness was also low regarding the ability of LSDVs to function in complex road environments, and the role of drivers and their ability to take over driving was not consistently recognized by participants.

Attitudes. This study revealed that senior drivers perceived safety to be the greatest benefit of LSDVs. They consistently agreed that using LSDVs would "give them another pair of eyes on the road" and help them monitor and manage changes in the driving environment, particularly in relation to more challenging or complex conditions. Many participants acknowledged that LSDVs could help increase confidence among drivers as they age, and the benefit of this technology that would enable them to handle more challenging situations with more confidence as opposed to avoiding them (e.g., night driving, new routes, higher speed roads).

A primary concern was the over-reliance on self-driving technology that could ultimately degrade their driving skills. Senior drivers were also concerned that relying on LSDV technology would extend the driving lifetime of seniors who may not be safe to drive anymore. They also expressed concern that relying on the self-driving capabilities of LSDVs might entice drivers to drive distracted or impaired.

Another important concern was related to the learning curve for senior drivers, and how overwhelming it might be to use LSDVs. One participant described it as "a new visual experience" because of the various alerts and prompts that will be incorporated into the technology. Most participants thought that they would require training and practice with LSDV technology before feeling comfortable enough to drive one.

Additionally, senior drivers indicated that LSDVs may be unaffordable, because of the higher costs typically associated with new technology, as well as the additional costs such as higher insurance premiums and more expensive maintenance and repairs.

Practices. The willingness to use LSDVs was explored in relation to trust in the technology. The majority of senior drivers reported that they would build their trust in this technology as they gained more experience with it, and better understood the reliability of the self-driving capabilities. Half of participants trusted their ability to take over control when prompted, whereas the other half were unsure or did not like that the vehicle would prompt them to take over driving in situations where they were most likely to need the help of these self-driving capabilities. Despite this, more than three-quarters of participants reported that they were willing to use a LSDV if it were available today, and once they had observed others using the technology safely and without incident (the latter being a qualifying condition that was not measured with the online data). They shared that they would be most inclined to adopt LSDV technology if it were presented as safer than traditional vehicles. The situations in which senior drivers would most likely use the self-driving capabilities of LSDVs included long distance drives, or in stressful driving conditions.

The primary barrier to adopting this technology was the potential learning curve associated with using LSDVs. The vast majority of senior drivers agreed that educational resources and training would be essential for this age group to safely adopt the use of a LSDV. Cost of LSDVs was also considered to be a significant barrier, because many of them reported that they tended to drive less frequently as they aged. As such, they expressed more reluctance to purchase LSDVs and pay a premium price for it when they did not drive frequently.

This study was also designed to investigate the types of education and training that were perceived to be the most effective, and optimal strategies to offer educational resources to this age group. This was especially pertinent given that the main conclusion from the online survey data analysis suggested that an opportunity may exist to increase safety, conditional on the availability of education for senior drivers. Participants most frequently requested information about the safety and performance of LSDVs. They wanted to know how LSDVs would help to keep them safe in a hazardous situation, and how LSDVs would help to avoid potential collisions. In addition to this, they wanted information about crashworthiness, vehicle functionality, and the programmable specifications of LSDVs. Finally, participants also wanted more information on the implications of driving a LSDV in terms of the insurance policy associated with these vehicles, and notably the assignment of liability in the case of a collision when drivers are using the self-driving mode.

Most participants expressed an interest in learning about LSDVS through hands-on experience so that they could get a sense of how the vehicle would respond to a variety of situations.

Participants reported that the environments best suited to learning about LSDVs were in a hands-on context, a classroom environment or in an online learning forum. Most participants expressed the desire to have practical experience with LSDVs so they could get a sense of how the vehicle would react in a variety of situations under safe conditions.

They also believed that the best format to provide this type of education would be as a simulator or on-road training course. Participants also expressed that they would need text-based resources, such as factsheets or information manuals to summarize the functionality of a LSDV in an accessible, user friendly format.

There was variation regarding the amount of time that participants were willing to invest in learning to drive LSDVs. While some participants suggested that education be offered as a one-time intensive course, others indicated that a multi-module curriculum over a period of time would be more beneficial. Participants agreed that the benefit of an extended learning curriculum was the opportunity to learn in an

incremental fashion. This approach would enable them to gain experience using certain functions and have the opportunity to review it once they had attempted it on their own.

Educational institutions and community groups were favoured as the best providers of LSDV training. Many participants and their peers already attended lifelong learning programs or were part of community groups for seniors. As such, there was consensus that these sources would provide the best means of reaching this segment of the population. A smaller proportion of participants agreed that it might be the responsibility of the government to offer education and training, combined with a compulsory assessment to fulfil special licensing requirements for LSDVs. Some participants likened this potential regulation to the separate class of licence that currently exists for other vehicles such as motorcycles or heavy transport vehicles.

In conclusion, there is significant evidence that drivers in older age cohorts are very interested in semi-autonomous vehicle technology. They are also quite receptive to using it if certain conditions are met. To this end, it is important that the increased safety of these vehicles is proven, that costs of vehicles, insurance and repairs are affordable, and that key questions are answered regarding how and under what conditions technology works best or is likely to fail.

This research revealed that older drivers recognize the potential of LSDV technology to increase their safety on the road and instill greater confidence in their ability to drive under challenging conditions that are typically avoided. Of greater importance, this technology is perceived to enhance mobility among older drivers and help them to safely prolong driving and mitigate errors that are associated with age-related factors. As such, this cohort of drivers is very receptive to strategies and tools to help them learn to use LSDVs in ways that maximize safety benefits. There is widespread recognition that increased knowledge of LSDVs gained through education and training can help senior drivers to reap the greatest benefits from this technology.

This means that educational strategies that accommodate the needs of seniors and their comfort in using new technologies are necessary to help them manage a significant learning curve, and thereby increase their receptivity to adopting LSDV technology.

Perhaps most notably, the widespread and early adoption of LSDVs by aging drivers can help to demonstrate the true safety potential of LSDVs. Older drivers generally have a low crash risk as a result of their accumulated years of driving experience and exposure to all types of road environments and conditions. This is in sharp contrast to younger drivers, and those who drive longer distances who are most likely to be early adopters of LSDVs, but who also often represent the population of drivers involved in crashes. In other words, the population of older drivers may be more sensitive to the inherent risks and limitations associated with semi-automated vehicles, and thereby best-suited to test them in the real world. Their experiences using semi-automated vehicles can be insightful regarding optimal strategies and conditions that are needed to safely integrate automated vehicles into the existing vehicle fleet consisting of – almost exclusively – traditional vehicles. Of equal importance, their ability to adapt to a new vehicle and road environment, as some of the safest drivers on the road, can help to set standards regarding the level of education and skills that drivers of all ages must possess before using semi-automated vehicles

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APPENDIX A: FOCUS GROUP – DISCUSSION GUIDE

1.1 Self-driving vehicles - general

No context. Note that because people know that they are participating in a focus group about automated vehicles, there is a chance that some may have read about AVs before coming to the focus group.

1. What have you heard about semi-automated or limited self-driving vehicles?
2. Limited self-driving vehicles are currently in development and are expected to be available to the public within the near future. What do you think such a limited self-driving vehicle will be able to do?
3. If you were using a limited self-driving vehicle, do you think you would do the same things in the vehicle as you do now or do you think you would do different things? Please give some examples.

1.2 Limited self-driving vehicles - specific

Provide context. Explain definition of limited self-driving vehicles and provide handout with the following definition.

Limited self-driving vehicle (LSDV): Drivers can choose to have the vehicle control all critical driving functions, including monitoring the road, steering, and accelerating/braking in certain traffic and environmental conditions. These vehicles will monitor roadways and prompt drivers when they need to resume control of the vehicle.

- Belief & attitudes
  1. Do you believe that a limited self-driving vehicle would be safe to drive? Do you think that these cars will help make roads safer and keep you safe? Please explain.
  2. Do you have any other concerns about using a limited self-driving vehicle?
  3. Do you believe that there would be benefits associated with using a limited self-driving vehicle as an older driver?
  4. How do you think that using a limited self-driving vehicle would affect your driving experience?(Q4 can be dropped if time is running low)
  5. Would you have trust in a limited self-driving to keep you safe on the road?
- Intentions
  1. If this technology were available today, would you use a limited self-driving vehicle that enables you to choose to have either the vehicle or you drive? Or would you prefer to drive a vehicle equipped with today's safety technology?
  2. What factors would be important in the decision-making process for you to consider using a limited self-driving vehicle?
  3. What standard of safety would have to be achieved in order for you to trust the safety of a limited self-driving vehicle?
  4. Would your driving habits be the same or different if you were able to use a limited self-driving vehicle?

5. In what type of driving situations would you be most likely to rely on the self-driving function of your vehicle if you had a limited self-driving vehicle?
    - What about short/long distances?
    - What about in bad weather?
    - Other? What about the presence of hazards on the road (VRUs)?
6. Are there any expected barriers to your ability to use a limited self-driving vehicle? (e.g., knowledge, trust, cost, type of roads or driving?)

- Normative beliefs & subjective norms
    1. What factors may influence your decision to use or not use a limited self-driving vehicle? Who are the people that would influence your decision to use or not use a limited self-driving vehicle?
- Perceived behavioural control
    1. Would you feel confident in your knowledge/skills/abilities to drive a limited self-driving vehicle?
    2. Would you feel confident in your ability to quickly take over control of a limited self-driving vehicle if the vehicle was not able to drive in certain situations?
    3. Do you think you or self-driving vehicles will be better at responding to emergencies or hazards? Please explain.
- External motivators to affect the likelihood of a behaviour
    1. What factors will have the greatest influence on your decision to use or not use a limited self-driving vehicle?
        - Cost of vehicle/insurance
        - Effects on traffic congestion
        - Vehicle regulations or lack thereof
        - Availability of vehicles
        - Vehicle servicing needs

1.3 Knowledge Transfer

1. What types of information or topics related to limited self-driving are of greatest interest to you? What types of information or topics are of the least interest?
2. How much time would you spend learning about limited self-driving vehicles?
3. Where (or to whom) would you be most likely to look for information about limited self-driving vehicles? Where would be the best place to deliver this information to older drivers?
4. In what format would you like this information to be provided to you? Print (facts sheets or short booklet containing short texts and visuals), online, video or voice recordings like a webinar, in-person seminars? One-on-one interactions at dealerships. Driver training course?
5. Who would be a credible authority to deliver this information?

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