Chapter

Ethical Issues in the New Digital Era: The Case of Assisting Driving

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Abstract

Mobility is associated with driving a vehicle. Age-related declines in the abilities of older persons present certain obstacles to safe driving. The negative effects of driving cessation on older adults' physical, mental, cognitive, and social functioning are well reported. Automated driving solutions represent a potential solution to promoting driver persistence and the management of fitness to drive issues in older adults. Technology innovation influences societal values and raises ethical questions. The advancement of new driving solutions raises overarching questions in relation to the values of society and how we design technology (a) to promote positive values around ageing, (b) to enhance ageing experience, (c) to protect human rights, (d) to ensure human benefit and (e) to prioritise human well-being. To this end, this chapter reviews the relevant ethical considerations in relation to assisted driving solutions. Further, it presents a new ethically aligned system concept for assisted driving. It is argued that human benefit, well-being and respect for human identity and rights are important goals for new automated driving technologies. Enabling driver persistence is an issue for all of society and not just older adult.

Keywords: driverless cars, older adults, ethics, well-being, self-efficacy

1. Introduction

Mobility is defined as "the ability to move oneself (either independently or using assistive device or transportation) within environments that expand from one's home to the neighbourhood and regions beyond" [1]. The ability to move about the community is essential for carrying out the instrumental activities of daily living (i.e. basic life-maintenance activities) and ensuring social participation [1].

Growth in ageing populations is a global trend. A recent United Nations report states that the number of persons aged 60 (or older) is expected to grow from 962 million in 2017, to 2.1 billion in 2050, and 3.1 billion in [2]. According to the Global Status Report on Road Safety published by The World Health Organization (WHO), approximately 1.35 million people around the world die each year in traffic accidents [3]. The NHTSA estimates that 94% of serious crashes are due to human error or poor choices—including distracted driving and drunk driving [4].

The driving task necessitates interacting with the vehicle and the environment at the same time. Many body systems need to be functional to ensure the safe and timely execution of the skills required for driving [5]. Specific factors that contribute to maintaining a licence include vision, physical health and cognitive health [5]. Research indicates that cognitive abilities are important enabling factors for safe driving [6]. Research also indicates that adaptive strategies are essential to maintaining the normal parameters of driving safety in the face of illness and disability [7].

Age-related declines in the abilities of older adults provide certain obstacles to safe driving. A 2001 survey by the OECD found that 15% of those 65 or older had stopped driving, while an overwhelming number of those who continued to drive were very selective about when they did so [8]. In general, driving cessation has been linked to increasing age, socioeconomic factors, and declining function and health [9]. Negative effects of driving cessation on older adults' physical, mental, cognitive, and social functioning have been extensively studied [10–12].

Many automotive companies are developing and/or testing driverless cars. Largely, the proposed solutions follow established automation models such as the six levels of automation as defined by NHTSA [13]. Driver assistance technology presents a potential solution to problems pertaining to driver persistence and the management of fitness to drive issues in older adults. As this technology is not fully implemented and in use by the public, it is very difficult to both predict and assess its potential ethical implications and impact. Should the purpose of these systems go beyond safety? Is full automation an appropriate solution to effectively managing the apparent conflict between two goals—(1) promoting driver persistence and (2) ensuring road safety? That is, is it appropriate to enable an older driver to continue driving, even if there is a risk of a serious accident given their medical background? With crashes also comes the question of liability. Currently, lawmakers are considering who is liable when an autonomous car is involved in an accident. Such discussions raise many complex legal and ethical questions. Largely, the literature around ethics and driverless cars appears to focus on issues pertaining to (1) addressing conflict dilemmas on the road (machine ethics), (2) privacy and (3) minimising technology misuse/cybersecurity risks. These are indeed important ethical issues. However, the literature and public debate tends to avoid other serious ethical issues—specifically, issues concerning (1) the intended use and purpose of this technology, (5) the role of the person/driver (including older adult drivers) and (6) issues pertaining to the potential negative consequences of this technology.

In relation to (6), this concerns the social consequences of this technology and the potential impact on older adult identity and well-being. The future is indeed unknown. The advancement of new driving solutions raises overarching questions in relation to the values of society and how we design technology to: (a) promote positive values around ageing and enhancing ageing experience, (b) protect human rights, (c) ensure human benefit and (d) prioritise well-being. Specifically, it raises fundamental questions in relation to the value we place on promoting autonomy and social participation for older adults and optimising quality of life/well-being.

The public opinion on self-driving cars (including solutions for older adults) will determine the extent to which people will purchase and accept such systems [14]. We should not proceed with this technology just because it is available. Critically, designers must carefully consider the human dimensions of this technology and its social implications. To this end, this chapter reviews the relevant ethical considerations in relation to assisted driving solutions. Further, it presents a new ethically aligned system concept for driver assistance. In so doing, it addresses the philosophical principles that underlie the proposed driving system concept, and specifically, the role of the person.

2. Ethics, rights, digital ethics and ontological design

Ethics concerns the moral principles that govern a person's behaviour or how an activity is conducted [15]. A key distinction in ethics is the distinction between that which is unethical and that which is undesirable.

Primarily, moral principles apply to a person. However, moral code can also be ascribed to the behaviour of automated or intelligent systems (A/IS). Accordingly, driverless cars are termed 'artificial moral agents'.

The Universal Declaration of human rights (1948) enshrines all persons with human rights [16]. This includes rights pertaining to dignity (Article 1), autonomy (Article 3), privacy (Article 12), and safety (Article 29) [16]. Some would argue that rights also apply to technology and artificial agents. These are referred to as 'transhuman rights' [17, 18]. To this end, the field of roboethics has emerged. Specifically, roboethics is concerned with the moral behaviour of humans as they design, construct, use and treat artificially intelligent beings.

More broadly, 'digital ethics' or 'information ethics' deals with the impact of digital Information and Communication Technologies (ICT) on our societies and the environment at large [19]. As defined by Capurro [19], it addresses the ethical implications of things which may not yet exist, or things which may have impacts we cannot predict.

Progress is typically defined in relation to concepts of advancement and improvement. As stated by the Organization for Economic Co-Operation and Development's (OECD) 'Being able to measure people's quality of life is fundamental when assessing the progress of societies' [20]. Future technology is shaping (and will shape) our political, social and moral existence. The application of ethics to questions concerning technology development is not new. In his seminal work 'The Question Concerning Technology', the philosopher Heidegger suggests that in asking what technology is, we ask questions about who we are [21]. In so doing, we examine the nature of existence and human autonomy [21]. Such ideas have led to the concept of 'ontological design' which focuses on the 'the relation between human beings and lifeworlds' [22]. As argued by Winograd and Flores, new technology does not simply change the task, it changes what it means to be human [22]. Put simply, we are designed by our designing and by that which we have designed [23].

The Information Technology (IT) sector is taking some leaps in relation to addressing these questions. Currently, there is a large focus on issues pertaining to well-being, data privacy and cybersecurity. In 2016, Amazon, Google, Facebook, IBM, and Microsoft have established a non-profit partnership (i.e. the Partnership on Artificial Intelligence to Benefit People and Society) to formulate best practices on artificial intelligence technologies [24]. Further, the IEEE Standards Association has recently articulated a desire to create technology that improves the human condition and prioritises well-being. Specifically, the 'IEEE Global Initiative on Ethics of Autonomous and Intelligent Systems' have defined a set of core ethical principles for autonomous and intelligent systems (A/IS). As stated in 'Ethically Aligned Design (EAD1e), A Vision for Prioritizing Human Well-being with Autonomous and Intelligent Systems' [25] 'for extended intelligence and automation to provably advance a specific benefit for humanity, there needs to be clear indicators of that benefit'. Further, the IEEE Global Initiative argue that 'the world's top metric of value (Gross Domestic Product) must move beyond GDP, to holistically measure how intelligent and autonomous systems can hinder or improve human well-being' [25].

3. Well-being, identity, quality of life and self-efficacy

The concept of identity has three pillars: the person, the role and the group [26]. Personal identity refers to the concept of the self which develops over time and the life-span. This includes the aggregate of characteristics by which a person is recognised by himself/herself and others, what matters to the person and their values [27]. Crucially, autonomy is central to personal identity [27].

According to the 'Six-factor Model of Psychological Well-being', six factors contribute to an individual's psychological well-being, contentment, and happiness [28]. This includes positive relationships with others, personal mastery, autonomy, a feeling of purpose and meaning in life, and personal growth and development [28].

Quality of life is inextricably connected to well-being. As defined by the OECD, well-being can be defined/measured in relation to (1) quality of life (i.e. health status, personal security, social connection and participation/activity, work/life balance, subjective well-being, environmental quality, etc.), and (2) material conditions (i.e. income and wealth, job and earnings and housing) [29].

Self-efficacy is defined as a person's belief in his or her own ability to accomplishing a task or succeeding in specific situations. One's sense of self-efficacy can play a major role in how one approaches goals, tasks, and challenges. The promotion of self-efficacy is a key element for success in interventions designed to reduce depressive symptoms in late life [30].

4. Successful ageing

The beginning of old age is between the age of 60 or 65 [31]. Definitions of old age are multi-dimensional and include a combination of chronological, functional and social definitions [31]. Older adults are a highly heterogeneous group. Often, older adults are segmented based on factors such as ageing phases, levels of fitness, severity of physical limitations, mobility patterns and social activities. According to Rowe and Kahn, successful ageing is multidimensional, encompassing the avoidance of disease and disability, the maintenance of high physical and cognitive function, and sustained engagement in social and productive activities [32].

The prevalence of mental health issues is high in older adults as compared with the general population [30]. Older adults are at risk for developing anxiety and depression, given increased frailty, medical illnesses and medication and the potential for loss, reduced social connection and trauma (arising from injuries/accidents such as falls). On the other hand, younger older people are generally happier with a strong happiness increase around the age of 60 followed by a major decline after 75 [33].

Growth in ageing populations is a global trend. In Japan, Taiwan and Singapore, governments are defining smart ageing strategies to ensure that the growing ageing population ages well. This includes the promotion of multi-generational living, awareness of Dementia and other age-related health conditions and smart devices to monitor vital signs [34].

5. Driving task, older adult drivers and health conditions impacting on driving

5.1 Driving task

The driving is not a task isolated from everyday life. It occurs for a purpose (to get to somewhere, to see the scenery, etc.) and is often undertaken in parallel with other activities (for example, talking, listening to the radio, singing, planning-ahead and eating).

The driving task involves a complex and rapidly repeating cycle that requires a level of skill and the ability to interact with both the vehicle and the external environment at the same time [5]. Information about the road environment is obtained via the visual and auditory senses. The information is operated on by many cognitive and behavioural processes including short and long-term memory and judgement, which leads to decisions being made about driving [5]. Decisions are put into effect via the musculoskeletal system, which acts on the steering, gears and brakes to alter the vehicle in relation to the road [5]. As reported by Fuller, the overall process is coordinated via a complex process involving behaviour, strategic and tactical abilities and personality [35]. As stated in Fuller's task capability model (2005), loss of control arises when the demand of the driving task exceeds the driver's capability [35].

5.2 Older adult drivers

It is estimated that by 2030, a quarter of all drivers will be older than 65 [36]. Further, by 2030, more than 90% of men over 70 will be driving [37]. Research indicates a general increase in both car access and licensing rates in the older population [38]. This increase is mainly attributable to significant increases in the number of older female drivers [38].

A number of studies have sought to categorise older adults in terms of their physical abilities [39] their economic, geographic/spatial and activity patterns [40], use of cars as a transportation mode [41], and lifestyles and associated requirements in relation to transport services [42]. The most nuanced categorisation is that of the GOAL project which proposes five distinctive profiles or segments of older people [43]. The segments take demographics, physical and mental health characteristics, social life, living environment, mobility-related aspects and transition points into account. The five profiles differ significantly according to age and level of activity/mobility and health [43]. They include.

- A younger and more active profile ("Fit as a Fiddle")
- A young, fit and active elderly ("Happily Connected")
- A young, severely impaired and immobile elderly ("Hole in the Heart").
- A very old, highly impaired and immobile segment ("Care-Full")
- A quite mobile and still independent senior despite his/her old age ("Oldie but a Goldie")

5.3 Older adult driving challenges

As we age, we face decisions as to whether we should (1) continue, (2) limit, or (3) stop driving. Age related declines in the abilities of older adults can be treated as obstacles/barriers to safe driving performance. These age-related changes yield specific challenges for older adults. As reported by Langford and Koppel [44], this includes:

- Psychomotor functions: joint flexibility, muscle strength, manual dexterity and coordination.
- Sensory abilities: visual acuity, contrast sensitivity, sensitivity to light, dark adaptation, visual field, space perception, motion perception, hearing.
- Cognitive abilities: fluid intelligence, speed of processing, working memory, problem solving, spatial cognition and executive functions like inhibition, flexibility and selective and divided attention.

A recent study has identified the prevalent driving errors of older adults [45]. Following a systematic review of the literature, the authors categorised the prevalent driving errors into eight categories: (1) decision-making, (2) direction and lane control, (3) lack of regulation compliance and awareness, (4) speed performance, (5) visual checking and physical control, (6) recognising and responding to signs, (7) recognising and responding to traffic lights and (8) skills involved in turning and parking. It was found that (2) direction and lane control, (1) decision-making, (7) recognising and responding to signs, and (5) visual checking and physical control were most frequent as prevalent issues for older drivers [45].

Certain unsafe driving behaviours increased in frequency as age, with drivers of 40 years or over—older people more likely to engage in driving behaviours such as (1) little or no sign of attempts to avoid dangerous driving situations, (2) lack of attention to other people and cars, (3) improper manoeuvring around curves and (4) improper or no turn signals [46].

5.4 Driver self-regulation

Self-regulation and/or compensatory behaviour of older adults is defined in relation to the tendency of older adults to minimise driving under conditions that are threatening and/or cause discomfort and conversely, to restrict their driving to conditions perceived as safe and/or comfortable [44].

Compensatory behaviour of older adults includes avoiding driving in the following situations/conditions:

- In the dark
- In bad weather
- In heavy traffic
- In new areas
- On motorways and complex road layouts
- Avoid long journeys (fatigue/tiredness)

As stated in the Eldersafe Report (2016), older road users need to be aware, acknowledge and have insight into their functional impairments in order to self-regulate [47].

5.5 Driving cessation

Health deterioration is the primary trigger/key determinant for driving cessation among older adults [48]. Medical conditions either (1) impact the fitness to drive of older drivers and/or (2) an older person's perceived fitness to drive (i.e. attitude, confidence levels, etc.). Several medical conditions and associated impairments are more prevalent in the older adult population and are, therefore, associated with ageing. These medical conditions can potentially impact the crash risk of older road users [49]. Specifically, a systematic review of the literature by Marshall identified specific conditions including: alcohol abuse and dependence, cardiovascular disease, cerebrovascular disease/TBI, depression, dementia, diabetes mellitus, epilepsy, use of certain medications, musculoskeletal disorders, schizophrenia, obstructive sleep apnoea, and vision disorders [50].

6. Self-driving cars and ethical issues

The path to automated/driverless cars began before 2000 with the introduction of cruise control and antilock brakes. Since 2000, new safety features such as electronic stability control, blind spot detection and collision and lane shift warnings have become available in vehicles. Further, since 2016, automation has moved towards partial autonomy, with features that enable drivers to stay in lane, along with adaptive cruise control technology, and the ability to self-park.

Automated driving systems are defined as systems that control longitudinal and lateral motions of the vehicle at the same time [51]. Self-driving cars use a combination of sensors, cameras, radar and artificial intelligence (AI) to travel between destinations without a human operator. The Society of Automotive Engineers (SAE) has defined six levels of driving assistance technology (level 0–5) [52].

- No automation
- Driver assistance
- Partial automation
- Conditional automation
- High automation
- Full automation

In addition, BASt [53] and the National Highway Traffic Safety Administration (NHTSA) [13] have defined equivalent standards.

Many automotive companies are developing and/or testing driverless cars. This includes Audi, BMW, Ford, General Motors, Tesla, Volkswagen and Volvo. Solutions are also being advanced by Google and Uber. As of 2019, a number of car manufacturers have reached Level 3 [54]. This level involves an automated driving system (ADS) which can perform all driving tasks under certain circumstances, such as parking the car. In these circumstances, the human driver must be ready to re-take control and is still required to be the main driver of the vehicle [54]. According to the Vienna Convention on Road Traffic (2017), as of 2017, automated driving technologies will be explicitly allowed in traffic, provided that these technologies are in conformity with the United Nations vehicle regulations or can be overridden or switched off by the driver [55].

As noted earlier, technology innovation influences societal values and raises ethical questions. As posed by BMVI, how much dependence on technologically complex systems will the public accept to achieve, in return for increased safety, mobility and convenience [56]? In relation to the advancement of assisted driving solutions, Gasser distinguishes four clusters of issues, (1) legal issues, (2) functional safety issues, (3) societal issues (including issues of user acceptability) and (4) human machine interaction (HMI) issues [53]. A recent literature review on the ethical, legal and social implications of the development, implementation, and maturation of connected and autonomous vehicles (CATV) in the United States groups the issues into the following themes: privacy, security, licensing, insurance and liability, infrastructure and mixed automation environment, economic impact, workforce disruption, system failure/takeover, safety algorithm and programming ethics, and environmental impact [57].

Largely, the literature around ethics and driverless cars appears to focus on a subset of important ethical issues. This includes issues pertaining to (1) addressing conflict dilemmas on the road, (2) privacy and protecting personal sphere, (3) minimising technology misuse and (4) the digital self and transhuman rights. In relation to (1) operational decisions have moral consequences. The issue of managing conflict dilemmas on the road poses significant challenges for autonomous vehicles. As outlined in the literature, operational decision making raises many serious questions in terms of how human life is valued. Equally, such solutions raise significant ethical questions in terms of data privacy and the sharing of sensitive/private information about a person's health condition and potential driving risk. The possibility of technology hacking is also a potential threat to the implementation of this technology. Further, issues around defining rights in the context of the augmented self (i.e. the mix of human rights and rights as apply to our digital self which is enabled/transformed by the reach of artificial technology) are real. As argued by some, we may have to devise a set of ethics that applies to the whole continuum of our digital self and identity. Potentially, the specification of a Universal Declaration of Transhuman Rights should underpin the development of these technologies. Data gathered in a recent cross-national acceptability surveys concerning driverless vehicles indicates that the above issues are also a significant public concern [58, 59].

These are of course important both ethical and societal issues. However, the literature and public debate tends to avoid other significant issues. This includes issues pertaining to (4) the purpose and intended use of this technology, (5) issues around the role of the person/driver (including older adult drivers) and (6) the potential negative consequences of this technology, including the social consequences of this technology and its impact on well-being.

7. Research design/methodology

7.1 Objective

The high-level objective of this research was to specify the requirements for a new driving assistance system which prolongs safe driving for older adults with different ability levels, and in so doing, helps maintain cognitive and physical abilities. Importantly, the proposed system must carefully reconcile the potential conflict between (1) ensuring road safety and (2) promoting driver persistence (i.e. enabling an older driver to continue driving, even if there is a risk of a serious accident given the Drivers' medical background). From a design perspective, the challenge was to high-tech solution for users who are often averse to technology.

7.2 High level methodology

Overall, this research has involved the application of human factors methodologies to the analysis and specification of a proposed driving assistance system. Several phases of research have been undertaken. These are detailed in Appendix A. To date, this research has mostly been theoretical. Overall, the proposed driving system concept follows a multidisciplinary analysis of relevant literature pertaining to

- Older adults and positive ageing
- Segmentation of older adult drivers
- Driving task and theories of driver cessation and explanations of self-regulation
- Automated driving solutions and ethical issues
- The detection/interpretation of driver states (i.e. physical, cognitive and emotional states) using a combination of sensor-based technology and machine learning techniques
- Innovative human machine interaction (HMI) communication methods

Further, it follows the application of Human Machine Interaction (HMI) design methods including personae-based design [60] scenario-based design [61] and participatory co-design [62], to the modelling of a proposed solution. Currently, a new assisted driving solution has been defined. A preliminary workflow and multimodal communications concept has been specified in relation to several demonstration scenarios. The proposed multimodal solution will be further validated using a combination of co-design techniques and simulator evaluation.

7.3 Advancement of personae and scenarios to specify the system concept and HMI design solution

In line with a human factors approach, the proposed concept was modelled using both personae based and scenario-based design methods. Driver profiles were segmented from the perspective of driver persistence, driver health situation and ability. Overall nine driver profiles were identified. This includes:

1. Older adults in optimal health and driving as normal
2. Older adults who regulate their driving in relation to managing specific driving challenges and/or stressful (difficult) driving situations
3. Older adults who are currently driving but have a medical condition that impacts on their ability to drive
4. Continuing drivers—older adults who have continued to drive with a progressing condition—but have concerns in relation to medical fitness to drive and are at risk of giving up
5. Older adults who are currently driving and at risk of sudden disabling/medical event
6. Older adults who have stopped driving on a temporary basis
7. Older adults who have stopped driving (ex-drivers) before it is necessary
8. Older adults who have stopped when it is necessary

9. Older adults who have never driven a car (never drivers)

10. These nine profiles reflect 'ideal categories' based on the explicit project goals (safety, driver persistence, driver experience/enjoyment and health several monitoring).

These profiles were then decomposed into a series of personae. Each persona included information about the older adult's goals, their ability and health, medications, typical driving routines, typical driving behaviours and driver pain-points. For more information, please see Appendix B.

In parallel, several scenarios were defined. These scenarios followed from (1) the project goals (i.e. top down approach) and, (2) specific driving challenges and older adult driver behaviours, as identified in the literature review (i.e. bottom up approach). These include:

1. Driver is enjoying drive—everything going well

2. Driver is distracted by their mobile phone ringing

3. Driver feels stressed given traffic delays

4. Driver has taken pain medications and is drowsy

5. Driver is fatigued after long day minding grandchildren

6. Driver is having difficulty parking (visual judgement)

7. Sudden advent of acute medical event

8. Driver is having difficulty remembering the correct route

9. Driver has taken alcohol and is over the legal limit

As indicated in **Table 1**, the different scenarios were classified in terms of interpretation challenges.

Following this, the scenarios were associated with specific user profiles and personae (see **Table 2**).

Lastly, the specific scenarios were further decomposed in relation to (1) a time sequence/text narrative, (2) the sensing framework and behaviour of sensor technology and machine learning, and (3) multi-modal communications.

8. Key findings/results

8.1 Segmenting older adult drivers and role of new technology

Nine end user profiles have been identified—see **Table 3**. Specific system goals/requirements are associated with different profiles. It is suggested that the proposed solution might target profiles 1–7, and potentially profile 9.

8.2 Driving scenarios and ethical issues

The different driver scenarios as defined in **Table 1** raise a myriad of ethical questions—in addition to legal issues and issues pertaining to societal/user acceptability. For example,

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Interpretation challenge		Explanation of the interpretation challenge	Scenario examples
1	Task support/feedback	Addresses driving challenges and typical supports required	Parking support Navigational assistance Assistance changing lanes
2	Activation/“flow”	Incorporates multiple psychological states: stress/anger/excitement/workload/engagement including driver difficulties and driver behaviour	Flow/enjoying drive Stress given traffic delays Intelligent driving
3	Distraction and concurrent task management	Addresses age-related cognitive and perceptual challenges including driver difficulties and driver behaviour	Distraction from mobile phone ringing Talking with passenger/checking GPS directions and driving
4	Fatigue and drowsiness	Many medical conditions and drugs also manifest this way	Fatigue
5	Intoxication—alcohol/drugs/related medical conditions	Other drugs and some medical conditions manifest similarly	Alcohol Prescription drugs
6	Heart attack/stroke	Addresses fear factor—which may discourage older drivers from driving	Heart attack Stroke

Table 1.
Interpretation challenges and scenarios.

Interpretation challenge		Scenario	Profile	Personae
1	Task support/feedback	Driver needs assistance with parking	2. Older adults who regulate their driving in relation to managing specific driving challenges and/or stressful (difficult) driving situations (perceived safety risk or complexity)	Mary
2	Activation/flow	Flow	4. Continuing drivers: older adults who have continued to drive with a progressing condition, but have concerns in relation to medical fitness to drive and are at risk of giving up	Sarah/James
		Stress	5. Older adults who are currently driving and at risk of sudden disabling/medical event	Louise
		Intelligent driving	2. Older adults who regulate their driving in relation to managing specific driving challenges and/or stressful (difficult) driving situations (perceived safety risk or complexity).	Mary
3	Fatigue and drowsiness	Fatigue	1. Older adults in optimal health and driving as normal	Elizabeth/Sam
4	Distraction and concurrent task management	Distraction	2. Older adults who regulate their driving in relation to managing specific driving challenges and/or stressful (difficult) driving situations (perceived safety risk or complexity)	Tom
		Concurrent Task Management	3. Older adults who are currently driving but have a medical condition that impacts on their ability to drive	Richard
5	Intoxication	Alcohol	1. Older adults in optimal health and driving as normal	James
		Prescription drugs	5. Older adults who are currently driving and at risk of sudden disabling/medical event	Rory
6	Heart attack/stroke	Heart attack	5. Older adults who are currently driving and at risk of sudden disabling/medical event	Brian
		Stroke	5. Older adults who are currently driving and at risk of sudden disabling/medical event	Louise

Table 2.
Interpretation challenges, scenarios, user profiles and personae.

- How is the human role and well-being being considered in relation to the development of these systems?
- What is the role of older adult and what level of choice do they have in relation to mode of operation?
- What level of impairment is acceptable for an older driver to keep driving?

#	User profile	Goals/role of new technology
1	Older adults in optimal health and driving as normal.	Driving enabling life-long mobility Monitor driver's task and driver's capability Monitor driver states that impact on driver capability and provide task assistance to ensure safety Promote confidence for older driver Promote comfortable, enjoyable and safe driver experience
2	Older adults who regulate their driving in relation to addressing specific driving challenges	As (1) and... Technology directly addresses causes of self-regulation
3	Older adults who are currently driving but have a medical condition that impacts on their ability to drive	As (1) and... New car directly addresses challenges associated with condition Monitor driver state in relation to specific medical condition, and provide task assistance to ensure safety
4	Continuing drivers—older adults who have continued to drive with a progressing condition—but have concerns in relation to medical fitness to drive and are at risk of giving up	As (1) and... New tech might monitor conditions and provide feedback—continue with licence/evidence, keep safe
5	Older adults who are currently driving and at risk of sudden disabling/ medical event	As (1) and... New tech might monitor conditions and provide feedback New tech might take relevant action based on detection of onset of medical event
6	Older adults who have stopped driving on a temporary basis	As (1) and... Monitor driver state and health condition and provide task assistance to optimise safety
7	Older adults who have stopped driving (ex-drivers) before it is necessary	As (1), (2), (3), (4) and (5)
8	Older adults who have stopped when it is necessary	N/A
9	Older adults who have never driven a car (never drivers)	As (1) and... Motivate to buy car/learn to drive, given protections provided by new car and associated driver experience

Table 3.
User profiles and goals.

- Should the system determine the level of automation/assistance, or the older adult?
- Should the driver be able to take control of the car at any point?
- How is information about the health status of the driver, their driving challenges, driving routines and any driving events being stored?
- Who has access to driver profiles, health information and incident information?

For a full list of issues, please see Appendix C.

Overall, there is much overlap between ethical issues and legal issues. There is also much commonality between ethical issues and user acceptability/societal issues. Further, many of the ethical and societal/user acceptability issues are also HMI/human factors issues (for example, handover of control and role of the older adult in the system, etc.).

In principle, ethical issues and issues concerning societal/user acceptability pertain to all profiles as defined previously. Critically, these ethical issues have meaning in the context of different degrees of automation. Some issues pertain to the specific level of driving automation (i.e. manual, partially automated/function specific, highly automated, fully automated), while others present to all.

8.3 Framing the design problem and system objectives

The design problem is framed in relation to advancing systems that can detect the health and psychological/emotional condition of the driver, so that the vehicle responds as appropriate, while also ensuring a positive/enjoyable driving experience and promoting driver self-efficacy.

To this end, three high level goals for the system have been defined. These are:

1. Safe driving for older adults

2. Driver persistence

3. Positive driver experience

Accordingly, the requirement is to advance a system which can detect the health and psychological/emotional condition of the driver so that the vehicle responds as appropriate (i.e. promoting engagement/alertness, providing task supports, taking over the driving task if the driver is impaired and/or calling an ambulance).

8.4 Refining system goals: human benefit and well-being (objectives and measures)

It is very difficult to both predict and assess the potential ethical implications and impact of this technology. However, we can document key performance indicators (KPIs) relevant to the potential success of this technology once it is introduced and used by the public.

As stated previously, we have defined three high level goals for the system. These goals have been reformulated in terms of objectives concerning human benefit and well-being and associated measures/KPI's. These are described in **Table 4**. As indicated in **Table 4**, there is a relationship across goals (1), (2) and (3), and the associated objectives and metrics.

#	System goal	Human benefit and well-being objectives/ targets (design outcomes)	Metric (outcome indicators)
1	Safe driving for older adults	Driver feels safe Driver feels in control The car is in a safe state	Subjective perception of safety/security Objective measure of car safety (position on road/lane, speed)
2	Driver persistence	Car as an enabler of active ageing/positive ageing—and allied health benefits Car contributing to eudaemonia (living well) Car contributing to a sense of having a purpose Car as an enabler of mobility Supporting social connection and participation Supporting citizenship, etc.	Health status Mobility status Positive human functioning and flourishing Social capitol Personal growth
3	Driver experience	Driver feeling happy/enjoying driving activity Emotional state/psychological well-being (avoidance of stress) Driver in control Focus on ability (available capacity) Promote adaptation and bricolage	Subjective enjoyment of driving Subjective feeling of human agency/ independence Subjective well-being

Table 4.
System goals, well-being objectives and well-being metrics.

9. Proposed co-pilot/adaptive automation driving solution

9.1 High level principles underlying system concept

The third phase of research involved the specification of the high-level system logic and associated principles associated with this concept. The high-level principles associated with the system logic are grouped into six themes as follows:

1. Philosophy of the system
2. Technology and the conceptualization of the driver
3. Technology and the conceptualization of the driver task and driving experience
4. Driver health conditions and emotional/psychological State
5. Detecting symptoms with sensors
6. Using multi-modal technology to promote safe driving and a positive driving experience

As indicated in **Figure 1**, the principles associated with (1) are derived from related principles relating to (2), (3), (4), (5) and (6). In addition, the principles related to (5) follow from an understanding of (4) and feed into (2) and (3) and so forth. Subsequent sections focus on principles related to (1) and (2).

9.2 Philosophy of the system

9.2.1 Assistance/adaptive automation (balancing safety and driver persistence/quality of life)

The proposed co-pilot system carefully reconciles the potential conflict between two goals—(1) ensuring road safety and (2) promoting driver persistence (i.e. enabling an older driver to continue driving, even if there is a risk of a serious accident given the drivers' medical background). Overall, the technology is designed to provide different levels of assistance/automation to drivers so that accidents are avoided (i.e. safety). Three levels of assistance are proposed.

1. No response—all seems to be in order, the driver is alert and attentive, driving well; there is no basis for an intervention
2. Driving assistance—one or more driver factors have been identified; they are not an immediate threat, but the driver could do with some assistance to drive safely and/or manage their own emotions. Driving assistance could take a range of forms:
    - An alert to the driver
    - Adjusting car settings
    - Auto-braking/speed reduction

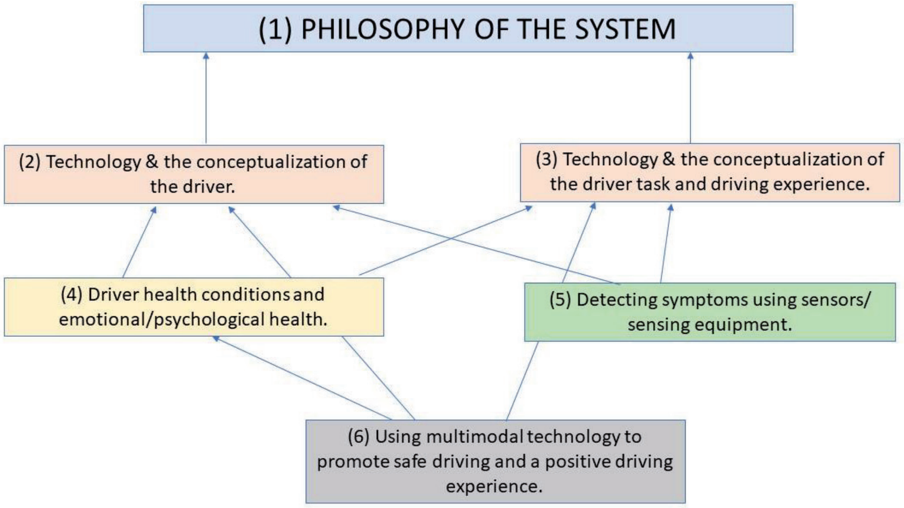

Figure 1.
High level principles.

- Temporary co-pilot in charge
- Task assistance
- Task information

3. Safety critical intervention—the driver's health and/or safety are at immediate risk; the co-pilot needs to make a strong intervention. This could include:

- Auto-park and engine stop
- External warnings to other road users
- Alerts to emergency services

To this end, we are proposing assistance (i.e. adaptive automation) and not full automation. Normally, the older adult driver chooses the level of task assistance required. However, the system also recommends different levels of assistance based on the driver's profile (level of ability), and real time context (i.e. driver state and driver behaviour). In particular circumstance, if the system detects that (1) the driver is in a seriously impaired state (i.e. alcohol or medications), (2) there is a potential for a safety critical event, or (3) the driver is incapacitated, then authority moves to 'automation'. Accordingly, the proposed co-pilot system is both reactive and predictive.

9.2.2 Universal design

The system is designed to be usable, accessible, and understood by people of all ages with different abilities and health conditions. To this end, the system/co-pilot system provides three levels of assistance, taking into account the diverse driving situations and needs of different drivers (including older adult drivers).

9.2.3 Positive ageing and self-efficacy

The proposed co-pilot system is premised on concepts of successful/positive ageing and self-efficacy. Although certain conditions occur in old age (and impact on the driving task), old age itself is not a disease. Ageing (and the associated changes in functional, sensory and cognitive function) is a normal part of life. To this end, the system seeks to normalise ageing, and not treat ageing as a 'problem' or 'disease'. The driving solution (i.e. car, sensor system, co-pilot and HMI) is designed to optimise the abilities and participation of older adults. That is, it addresses what older adults can do as opposed to focusing on declining capacities.

9.2.4 Ability, adaption and assistance (not automation)

The co-pilot is conceptualised as a means/intervention to ensure that older adults drive safely and for longer. Critically, the technology supports continued and safe driving for all adults, including those adults at risk of limiting their driving and/or giving up. Accordingly, concepts of ability, adaption and assistance (as opposed to vehicle automation) underpin the system logic. To achieve this, the proposed technology provides different levels of assistance, tailored to the older adults (1) ability, (2) health and (3) the real-time physical and psychological/emotional health. In general, this will deliver benefits for the wider population and not just older adults.

9.2.5 Interpretation of driver profile and real-time context

The ability of the driver to perform the driving task depends on the driver's ability (i.e. functional, sensory and cognitive), his or her driving experience and the 'real time' state of the driver (i.e. health, level of fatigue, emotional state, etc.) and the operational context (i.e. cabin context, road context, weather and traffic). Thus, to provide targeted task support to the driver, the system combines (1) an understanding of the driver's profile (i.e. ability and driving experience) and (2) an interpretation of the real time context (i.e. the state of the driver and the operational context).

9.2.6 Focus on interpretation challenges and not conditions/state

The critical objective for the system is not to precisely diagnose the drivers' condition/state but to interpret the implications for the driving task and the driver. According, the driving assistance system logic addresses 'interpretation challenges' rather than the driver condition or state. This is achieved in relation to six high-level interpretation challenges. These include.

1. Task support/feedback

2. Activation/flow

3. Distraction and concurrent task management

4. Fatigue and drowsiness

5. Intoxication

6. Heart attack/stroke

9.2.7 A learning system will enable driver persistence and a positive driver experience

Underpinning the system logic, is a vision of the co-pilot as a learning system. Arguably, a human-centric design philosophy necessitates continuous learning on the behalf of the co-pilot (i.e. including AI/machine learning). If the co-pilot can learn about those situations and tasks that prove challenging and/or stressful for the older adult driver (i.e. driving in traffic, poor visibility, changing lanes, parking and so forth, etc.), then it can truly tailor the task support that it provides to the driver. This tailored task support is predictive/intelligent, ensuring that the driver persists in challenging driving situations, while also enjoying their drive.

9.3 Technology and the conceptualization of the driver

9.3.1 Role of driver in the system and adaptive automation

The proposed system maintains the autonomy of the individual. In principle, the driver is able to choose (and/or switch off) task support and advanced levels of automation, if they so choose. Overall, we are starting from the point of the engaged driver, who has capacity and ability. In this way, the system supports a vision of the older adult driver as 'in control'. The role of the driver is to work in partnership with the 'co-pilot', to achieve a safe and enjoyable drive. Critically, the system treats the driver as 'capable' and 'in charge' unless it detects that the driver is incapacitated and/or there is a potential for a safety critical event (i.e. level 3 assistance/safety critical intervention). If the system detects that the driver is in a seriously impaired state and/or incapacitated, or that a safety critical event is imminent, then the principle of 'driver autonomy' is outweighed by that of safety. In such cases, authority moves to 'automation'.

9.3.2 Driver as a person (holistic approach)

The proposed driving assistance system is premised on a conceptualisation of the driver/older adult as a person and not a set of symptoms/conditions (i.e. holistic approach). Specifically, biopsychosocial concepts of health and wellness inform the logic of the proposed driving assistance system. The system is concerned with all aspects of the driver's wellness, including the driver's physical, social, cognitive and emotional health.

9.3.3 Diversity in older adult population

Critically, the driving assistance system logic is premised on the idea that all older adult drivers are not the same. Older adult drivers vary in many ways including body size and shape, strength, mobility, sensory acuity, cognition, emotions, driving experience, driving ability (and challenges) and confidence. In relation to driving situation and ability, we have segmented older adults into the following high-profiles or clusters—as indicated previously. These profiles have been further specified in relation to a series of personae. Critically, the system logic directly addresses the needs and requirements of these specific personae.

9.3.4 Upholding rights (autonomy, dignity and privacy)

The acceptability of the proposed system largely depends upon how it treats certain issues pertaining to driver rights. Overall this technology is designed to uphold an older adult's rights. This is specifically salient in relation to preserving driver autonomy, monitoring the driver state and recording driver health information. As outlined earlier, the technology maintains the autonomy of older adults (i.e. the starting point is the engaged driver). Further, we are proposing that information captured about the person's current health and wellness and driving challenges/events is NOT shared with other parties. In all cases, the driver is in charge of their own data and decisions about how it is stored and shared with others.

10. Discussion

10.1 Ontological design, digital ethics and coping with change

As highlighted by Fry, the introduction of new technology has the potential to transform what it means to be human [23]. In this way, the introduction of new assisted driving solutions presents a challenge to our being. Design decisions are normative—they reflect societal values concerning human agency and human identity/avoiding ageism. In particular, they provide an opportunity to foster quality of life for older adults as they age, and to promote positive ageing. Design/technology teams thus exercise choice in relation to what is valued and advancing technology that improves the human condition (and not worsens it).

The discovery and utilisation of fire by early humans was of course transformative and positive [63]. It shaped how we eat, kept warm and how we protected ourselves. However, less examined are the negative by-products that came with fire, and the ways in which humans may or may not have adapted to them [63]. In the same way, it is important that designers consider issues pertaining to potential technology impact in terms of the three strands of health and wellness (i.e. biological, psychological and social health). In particular, designers should consider protections concerning the 'unknown' future implications of this technology (including the potential negative social consequences).

In relation to the introduction of other consumer and information technologies (for example, mobile phones and social media), many important questions were posed 'post hoc'. As stated by Heraclitus, 'One cannot step twice in the same river' [64]. These technologies have resulted in many changes to previously established social norms. Arguably, social norms in relation to identity and privacy and associated information sharing, have appeared to change—and without serious questioning of the implications of this. Further, in its early stage, designers need not properly consider the potential social consequences of this technology (for example, social isolation and depression).

Nonetheless, just because the horse has bolted (i.e. the automotive industry is currently advancing and testing driverless cars), does not mean there is nothing to be achieved and/or that we are powerless. As mentioned previously, the availability of this technology does not mean that we have no choice. Critically, we need to challenge existing design assumptions from the perspective of human benefit, well-being and rights. In this regard, the IEEE Global Initiative represents a positive step in this direction.

Salganik proposes a hope-based and principle-based approach to machine ethics [65]. This is contrasted with a 'fear-based and rule-based' approach in Social Science, and a more 'ad hoc ethics culture' as emerging in data and computer science [65]. Hope is not enough! As evidenced in this research, principles need to be both articulated and then embedded in design concepts. Importantly, human factors methods are useful here—in relation to considering different stakeholders and adjudicating between conflicting goals/principles.

10.2 System purpose and human benefit

In line with what is argued by the IEEE, A/IS technologies can be narrowly conceived from an ethical standpoint. Such technologies might be designed to be legal, profitable and safe in their usage. However, they may not positively contribute to human well-being [25]. Critically, new driving solutions should not have 'negative consequences on people's mental health, emotions, sense of themselves, their autonomy, their ability to achieve their goals, and other dimensions of well-being' [25].

Arguably, as demonstrated in this research, we can define an ethically aligned design in relation to several key concepts. This includes (1) human role, (2) human benefit, (3) rights, (4) progress and (5) well-being. These concepts provide structuring principles to guide the design of new driving assistance systems.

A key theme of this research has been about defining the purpose and role of new driving assistance technologies. As designers we decide what ethical guidelines AI in autonomous vehicles will follow. The analysis of relevant health literature and TILDA data has identified specific conditions that impact on older adult driving ability [66]. As such, it has provided an empirical basis for addressing ethical dilemmas around whether full automation is an appropriate solution to effectively managing the conflict between two goals—namely, (1) promoting driver persistence and (2) ensuring road safety. It is argued that the three levels of driver assistance represent an ethically aligned solution to enabling older drivers to continue driving, even if there is a risk of a serious accident given their medical background. Evidently, some medical conditions do not negatively impact on safe driving. However, there are other conditions that pose challenges to safe driving, and others still that make it unsafe to drive. The proposed solution is designed to directly address this fact—to promote driver persistence and enablement in these different circumstances, albeit while simultaneously maintaining safety.

Human benefit is an important goal of A/IS, as is respect for human rights. In terms of rights, this includes the rights of (1) older adult drivers and (2) other road users and pedestrians who may be negatively affected by older adult driving challenges and specifically, health events such as strokes and heart attacks. The specification of benefits is not straightforward. People benefit differently. Also, benefits are not always equal for all people, as driving system that benefits older adults must also benefit other road users and pedestrians. In this way, the proposed system must be verifiably safe and secure. We must ensure the safety of all drivers and pedestrians. Benefits in relation to older adult mobility must not outweigh safety concerns (i.e. we cannot address benefit from a narrow perspective/prioritise one stakeholder).

10.3 Design problem and ethical vision: enablement and positive ageing

The design problem—prolonging safe driving for older adults is framed in relation to a philosophy of 'enablement' and positive models of ageing. Crucially, the proposed vision of 'technology progress' in closely intertwined with concepts of progress from a societal values perspective. The proposed co-pilot system is premised on concepts of successful/positive ageing and self-efficacy. The system seeks to normalise ageing, and not treat ageing as a 'problem' or 'disease'. The driving solution (i.e. car, sensor system, co-pilot and human machine interface) is designed to optimise the abilities and participation of older adults. That is, it recognises what older adults can do as opposed to focusing on declining capacities. Further, the co-pilot is conceptualised as a means/intervention to ensure that older adults drive safely and for longer. The proposed technology supports continued and safe driving for all adults, including those adults at risk of limiting their driving and/or giving up when there is no medical/physical reason for doing so.

Arguably, existing high automation approaches do not support positive ageing. Crucially, 'technology progress' in closely intertwined with concepts of progress from a societal values perspective. New assisted driving solutions provide an opportunity to change/improve the lived experience of older adults, particularly in relation to autonomy and social participation. Enabling driver persistence is an issue for all of society, not just older adults.

10.4 Personalisation and role of AI

Many negative driving experiences are linked to frustrations with the vehicle not being configured for the driver. Drivers are highly diverse in terms of size, strength, angle of vision and experience of different vehicles. Older drivers present even greater diversity when limitations of movement, hearing, eyesight, memory emerge. It is argued that personalisation is central to fostering a positive driver experience. For example, vehicle sensors can be used to detect which driver is driving and to adjust the vehicle parameters accordingly (i.e. angle of mirrors, steering wheel, seat, etc.). Moreover, personalisation offers an enormous opportunity to ensure that task support and multimodal feedback is configured according to knowledge of the particular driver's ability (including sensory ability), driving routines and routes and typical challenges/errors.

A human-centric and ethically aligned design philosophy necessitates continuous learning on the behalf of the assistance system (i.e. including AI/machine learning). If the assistance system can learn about those situations and tasks that prove challenging and/or stressful for the older adult driver (i.e. driving in traffic, poor visibility, changing lanes, parking and so forth, etc.), then it can tailor the task support that it provides to the driver. This tailored task support is predictive/intelligent, ensuring that the driver persists in challenging driving situations, while also enjoying their drive.

10.5 Role of human factors

New technology raises complex ethical questions. Assessing the ethical implications of things which may not yet exist, or things which may have impacts we cannot predict, is very difficult. However, this should not be barrier to posing important questions and ensuring that these questions are addressed as part of the design process. Typically, the human factors discipline is concerned with issues around intended use, user interface design and technology acceptability. As demonstrated in this research, human factors research should extend its remit to include examination of ethical issues pertaining to new technology, and specifically, how well-being, rights and human value/benefit should be considered in terms of design solutions. In this way, HF methods can be used to provide some protections to ensure that ethical issues are considered. As demonstrated in this research, the application of a personae/scenario-based design approach allows us to consider the ethical dimension of these technologies. Further, the translation of system objectives in relation to well-being and human benefit objectives and associated metrics—ensures that well-being and human benefit is both a reference point and a design outcome. We may not have certainty as regards potential future technology impact, but at least we are asking important questions so as to pave the way for an ethically aligned technology of which well-being and human value is a cornerstone. The design and implementation of ethically aligned technology takes leadership and education. It also requires adopting a multi-disciplinary perspective and ensuring diverse disciplines are involved in solution design (including persons trained in ethics and moral reasoning). Further, a crucial element of the design process to ensure an ethical product is rigorous experimentation in a simulator using a co-design approach.

10.6 Next steps

The initial concept requires further elaboration and specification. In line with a human factors approach, a series of co-design and evaluation sessions will be undertaken with end users. In addition, the proposed solution will be evaluated in using a driving simulator. A health event cannot be induced as part of a driving simulation exercise. However, we can evaluate the overall concept, driver responses and the usability of specific driver input/output communication mechanisms.

11. Conclusions

The proposed design/automation approach reflects an ethically aligned and principled approach to a multi-dimensional design problem. Human benefit, well-being and respect for human rights and identity are important goals for new assisted driving technologies. Such systems must also be verifiably safe and secure. In this way, the solution needs to carefully balance goals around safety and human benefit. As indicated in this research, well-being and human benefit goals and associated KPI are defined to ensure that these concepts are properly considered in the design process, and to ensure that well-being and human benefit is a tangible outcome of new assisted driving solutions.

Arguably, existing high automation approaches do not support positive ageing. Crucially, 'technology progress' in closely intertwined with concepts of progress from a societal values perspective. New assisted driving solutions provide an opportunity to change/improve the lived experience of older adults, particularly in relation to autonomy and social participation. Enabling driver persistence is an issue for all of society and not just older adults.

The application of new car-based sensors underpinned by machine learning techniques, and innovative multimodal HMI communication methods can support driver persistence, driver enablement and successful ageing. The proposed adaptive automation/co-pilot concept is predicated on an analysis of the literature and relevant ageing data (i.e. TILDA data). The co-pilot concept and associated innovative multimodal HMI will be further elaborated using human factors/stakeholder evaluation methods (for example, participatory co-design and evaluation in a test simulator).

It is anticipated that this new car-based technology will deliver (1) safe driving (2) driving persistence and (3) an enhanced driver experience. (4) Health monitoring is built into (1), (2) and (3). In this way, health monitoring is not a goal of new driving assistance systems. Rather, it is an enabler of driver assistance systems and promotes safe driving, driving persistence and an enhanced driver experience.

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Conflict of interest

The authors declare no conflict of interest.

Appendices and Nomenclature

A. Research phases and status

See **Table 5.**

Phase	Description	Details	Status
1	Literature review	Driver task, older adult driver segmentation, older driver challenges, self-regulation of driving, driver cessation	Complete
		Successful ageing	
		Health conditions that impact on older adult driving	
		Assisted driving concepts and issues pertaining to ethics and user acceptability	
		The detection/interpretation of driver states (i.e. physical, cognitive and emotional states) using a combination of sensor-based technology and machine learning techniques	
		Innovative multimodal communication approaches and driving solutions	
2	Advancement of profiles, personae and scenarios	Segmentation of driver profiles in relation to driver persistence and ability	Complete
		Advancement of personae and scenarios	
3	Specification of theoretical principles underpinning advancement of new driving concept	Advancement of technology role, purpose and approach (adaptive automation)	Complete
4	Specification of high-level multimodal HMI approach	Specification of scenarios Iterative refinement of scenarios and multimodal concept Iterative integration of scenarios with sensor and machine learning research	Complete
5	Co-design of evaluation of HMI concept	Specification of preliminary UI concept Preliminary co-design/evaluation with stakeholder panel (desktop simulation of high-level concept	Ongoing
6	Simulator evaluation	Detailed evaluation in simulator	To do

Table 5.
Research phases and status.

B. Personae

See **Figure 2** and **3.**

Figure 2.
Personae (James).

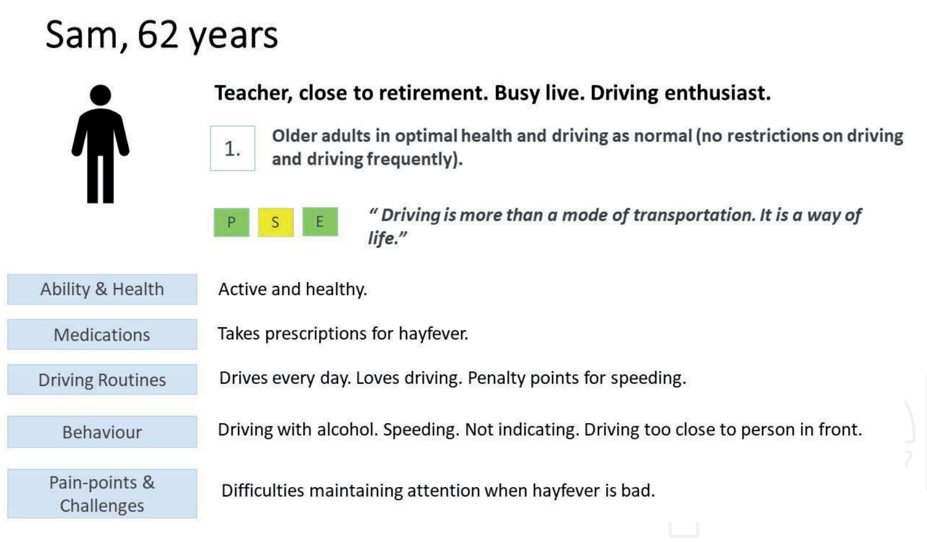

Figure 3.
Personae (Sam).

C. Summary of ethical, legal and societal/user acceptability issues

See **Table 6**.

#	Question/issue	Keywords
1	How much dependence on technologically complex systems (potentially based on artificial intelligence with machine learning capabilities) will the public accept to achieve, in return, more safety, mobility and convenience?	Ethics, user, societal acceptability
2	Agreeing/defining the purpose and role of these systems? Should the purpose go beyond safety?	Ethics, user, societal acceptability, safety
3	Agreeing/defining the role of the individual in the system	Ethics, user, societal acceptability, legal
4	Dealing with conflict between two goals—promoting driver persistence and ensuring road safety (enabling an older driver to continue driving, even if there is a risk of a serious accident given medical background)	Ethics, user, societal acceptability, legal, safety, driver persistence
5	Should the system determine the level of automation/assistance, or the older adult? Is this something that the older adult chooses (and can modify in real-time), or is it prescribed given profile information?	Ethics, user, societal acceptability, legal, safety, driver persistence
6	What is the intended use? Are these reactive and/or predictive systems?	Ethics, user, societal acceptability, legal, HF
7	Balancing expected benefits versus risk (system failure, hacking, etc.)	Ethics, user, societal acceptability, legal, HF
8	What are the legal obligations of the driver, if the driver is taken out of the loop (i.e. full automation)?	Ethics, legal, societal/user acceptability
9	Who is to blame if there in accident—the driver or the co-pilot?	Ethics, legal, societal/user acceptability
10	If the driver is in an impaired state (i.e. Alcohol, drug use, medications) should they be allowed driver only if automation take control? What level of impairment is acceptable?	Ethics, legal, societal/user acceptability
11	Addressing conflict dilemmas on the road? How should the car act (what aught the automated car do/decision logic), in cases where a choice must be made between one of two evils (decision between one human life and another)?	Ethics, legal, societal/user acceptability, safety

#	Question/issue	Keywords
12	In what circumstances, can automation take control over the car (override the decisions of the driver)?	Safety, human factors, legal, ethics, user/societal acceptability
13	Should the driver be able to take control of the car at any point? Should the driver always be in control? What tasks are suitable to delegate to automation?	Safety, human factors, legal, ethics, user/societal acceptability
14	Protection of the personal sphere? User control over own information? Information span personal profile, health profile, location tracking, destination tracking, safety behaviour, etc.	Legal, ethics, user/societal acceptability
15	Handover issues/transition of control (human to technology handover and tech to human, etc.)	Safety, human factors, ethics, user/societal acceptability
16	Software hack and misuse Cybersecurity threats and vulnerabilities—both in relation to personal information and car security	Safety, human factors, ethics, user/societal acceptability
17	Safety issues related to equipment or system failure. System/equipment failure and vehicle performance in unexpected situations	Safety, human factors, ethics, user/societal acceptability
18	Acceptable levels of workload—monitoring automation status.	Safety, human factors, user acceptability
19	Personality traits and assisted driving	Safety, societal acceptability, ethics
20	Dealing with emotions and providing feedback to the driver	Health monitoring, safety, user/societal acceptability, ethics, legal
21	Does the system provide the driver with feedback about their health?	Health monitoring, safety, user/societal acceptability, ethics, legal
22	System and consideration of information available to potential passengers?	Safety, driver experience, ethics, legal, user/societal acceptability
23	Environmental implications	Legal, user/societal acceptability
24	Training required—changes to existing driver training?	Safety, legal
25	Recording of information for crash analysis purposes? Similar to cockpit voice recorder and flight data recorder?	Safety, ethics, legal, user/societal acceptability
26	Should self-vehicles be able to operate in normal traffic or in separate lanes?	Driver experience, ethics, legal, user/societal acceptability
27	Data transmission? Sharing of information with other parties?	Ethics, legal, user/societal acceptability
28	Whether drivers expect to find it enjoyable or not? Should it be enjoyable?	Driver experience
29	Should self-driving vehicles be able to move while unoccupied?	Ethics, safety, driver experience
30	How should self-driving vehicles interact with other non-self-driving vehicles?	Ethics, safety, driver experience

Table 6.
Ethical, legal and societal/user acceptability issues.

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