Advancing a 'Human Factors & Ethics Canvas' for New Driver Assistance Technologies targeted at Older Adults

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Abstract. Automated driving solutions represent a potential solution to promoting driver persistence and the management of fitness to drive issues in older adults. This paper reports on the application of a 'Human Factors & Ethics Canvas' and associated methodologies, to support the preliminary specification of an ethically responsible solution for a new driver assistance system. The proposed driving assistance solution has emerged from an analysis of certain ethical principles in relation to the goals and needs of specific older adult drivers (i.e. personae) in different situations (i.e. scenarios). The driving solution is designed to optimize the abilities and participation of older adults.

Keywords: Automated Driving, Human Factors, Ethics, Successful Ageing, Wellbeing, Research & Innovation, Fitness to Drive

1   Introduction

Mobility in the form of driving is very important for older adults. There is a relationship between driving, mobility, independence and quality of life/living a fulfilled life. Age-related declines in the abilities of older adults provide certain obstacles to safe driving. Automated driving solutions represent a potential solution to promoting driver persistence and the management of fitness to drive issues in older adults. However, such solutions need to be carefully thought out in relation to promoting successful ageing, wellbeing and self-efficacy for older adults. New driving solutions should not have negative consequences on an older adult's identity, autonomy, mental health and their ability to achieve their goals.

The responsibilities of designers and questions concerning the moral quality of technology belong to the field of Applied Ethics. However, such questions also pertain to the field of Human Factors. Design/technology teams must carefully consider the human and ethical dimensions of automated driving systems. Specifically, they must question the purpose and intended use, implications in relation to human identity and rights, psychosocial implications and broader societal impacts.

This paper reports on the use of a 'Human Factors and Ethics Canvas' (HFEC) along with other human factors (HF) methodologies, to support the preliminary specification of an ethically responsible driver assistance system. Primarily, the focus is on reporting the vision and system logic for the proposed system, as defined using the HFEC. Further, the paper reports on certain other elements recorded in the HFEC, namely, underlying ethical principles, ethical issues, impact assessment and key performance indicators (KPI).

2 Introduction

2.1 Older Adults & Older Adult Drivers

Older adults are a highly heterogeneous group. Often, older adults are segmented based on factors such as aging phases, levels of fitness, severity of physical limitations, mobility patterns and social activities. Successful aging 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 [1]. Factors that contribute to maintaining a license include vision, physical health and cognitive health [2]. Several medical conditions and associated impairments are more prevalent in the older adult population. These medical conditions can potentially impact the crash risk of older road users [3]. A systematic review of the literature by Marshall (2008) identified specific conditions including: alcohol abuse and dependence, cardiovascular disease, cerebrovascular disease, depression, dementia, diabetes mellitus, epilepsy, use of certain medications, musculoskeletal disorders, schizophrenia, obstructive sleep apnea, and vision disorders [4].

2.2 Automated Driving Solutions

Automated driving systems are defined as 'systems that control longitudinal and lateral motions of the vehicle at the same time' [5]. Largely, the proposed solutions follow established automation models such as the six levels of automation as defined by the National Highway Transportation Safety Administration [6]. 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) (2018) [7]. Overall, the goal is to 'create technology that improves the human condition and prioritizes wellbeing' [7].

2.3 Vehicle Automation & Ethical Issues

The public opinion on automation and driverless cars will determine the extent to which these new systems will be purchased and accepted [8]. Four clusters of issues have been identified [9]. These are (1) legal issues, (2) functional safety issues, (3) societal issues (including issues of user acceptability) and (4) human machine interaction (HMI) design issues [9]. Largely, the literature around ethics and driverless cars

addresses issues pertaining to ethical issues related to transferring the responsibility of driving to vehicles, managing conflict dilemmas on the road, protecting privacy, and minimizing technology misuse. However, other ethical issues are worth addressing. This includes issues pertaining to the intended use and purpose of this technology, the role of the person/driver and the potential negative consequences of this technology. In relation to the latter, this includes the social consequences of this technology and the potential impact on older adult identity and wellbeing.

2.4   Human Factors & Ethics Canvas

According to Cahill (2019), methodologies are required to enable the active translation of ethical issues pertaining to the human and social dimensions of new technologies [10]. Critically, developers/designer's human factors and ethical issues must be explored in an integrated way. The 'Human Factors & Ethics Canvas' introduced by Cahill (2019) reflects an integration of ethics and HF methods, particularly around the collection of evidence using stakeholder evaluation methods [11, 12], personae-based design [13] and scenario-based design approaches [14]. Further, it makes use of ethical theories/perspectives that are used in relation to the analysis of technology innovation (i.e. analysis of benefit versus harm) including Consequentialism, Deontology & Principlism [15].

The HFEC can be used at any stage in the HCI design/evaluation process and spans the classification of ethical assessment methods as proposed by Reijers et al (2017) [16]. Overall, it blends anticipatory/foresight approaches and participatory/deliberative ethics approaches [17]. The specific canvas is divided into seven stages or sections [10]. Stage 1 is all about framing the problem. Stage 2 involves understanding how the technology fits to the problem, defining stakeholder goals and needs and the specification of expected benefits for different stakeholders. This is followed by several more detailed examinations of core themes. These are: benefits, outcomes and impact (stage 3), personae and scenario (stage 4), data ethics (stage 5) and implementation (stage 6). The final stage (stage 7) presents the outcomes of the preceding analysis.

3   Method & Overview of Human Factors & Ethics Canvas

3.1   Research Objective

The project objective is to advance a driving assistance system which enables older adult mobility, independence and quality of life. The technology should support a driving experience which promotes driver satisfaction through increased control (and therefore confidence and enablement).

3.2 Overview of Research Methods & Status

Overall, this research has involved the application of human factors (HF) methodologies to the specification of a proposed driving assistance system. As indicated in Table 1, this research is structured in terms of two parts – the first of which is complete. The first part of this research has been theoretical (i.e. does not involve field research with participants). As indicated in Table 1 below, this has comprised seven stages of research.

Table 1. Summary of Research

Part	#	Description	Status
1	1	Multidisciplinary Literature Review – including (a) older adults and positive ageing, (b) driving task, (c) segmentation of older adult drivers, (d) medical and age-related conditions that impact on driving ability and safety, (e) the detection/interpretation of driver states (i.e. physical, cognitive and emotional states) using a combination of sensor-based technology and machine learning techniques, (f) innovative human machine interaction (HMI) communication methods, (i) new driver monitoring, task support and feedback systems and (j) the analysis of legal, ethical and acceptability issues.	Complete
	2	Secondary analysis of data from the Longitudinal Study on Ageing in Ireland (cite)	
	3	Advancement of preliminary driver profiles	
	4	Specification of driver personae and demonstration scenarios	
	5	Application of 'Human Factors & Ethics Canvas' to support specification of system concept	
	6	Detailed specification of system concept	
	7	Detailed specification of multimodal solution using personae/scenarios and outcome of HFEC analysis	
2	8	Participatory co-design and evaluation	To do
	9	Simulator Evaluation	

To date, a preliminary workflow and multimodal communications concept have been specified in relation to several demonstration scenarios. In Part 2 of this research, the proposed multimodal solution will be further validated using a combination of co-design techniques and simulator evaluation, involving the participation of older adults reflective of the specified older adult driver profiles.

3.3 Driver Profiles

Driver profiles were created following an analysis of the overall literature review and Tilda data (i.e. Part 1, phase 1 & 2). Specifically, drivers were segmented based on health and ability attributes (fitness to drive characteristics) and the goals of the project (i.e. safety, driver persistence and driver experience/enjoyment).

3.4 Specification of Personae & Scenario

In line with a HF approach, these user profiles were further 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 behavior's and driver pain-points. For more information, please see Appendix 2.

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 behaviors, as identified in the literature review (i.e. Part 1, phase 1). 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

The different scenarios were then classified in terms of several interpretation challenges. This includes, Task support/feedback, Activation/ "Flow", Distraction & Concurrent Task Management, Fatigue & drowsiness, Intoxication (alcohol/drugs) & Heart Attack/ Stroke. Following this, the scenarios were associated with specific user profiles and personae. Figure 1 below provides an example of a personae.

Fig. 1. Example Personae

James, 79 years

Retired Banker. Concerned about losing independence.

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

" My driving is not as good as it used to be. I should talk to my Dr about these near misses and attention problems".

Ability & Health	Early cognitive decline (not formal Dementia diagnosis). Insomnia. Back pain. Bifocals.
Medications	Takes occasional painkillers for back pain and sleep medicines for Insomnia (hypnotics).
Driving Routines	Drives two to three times a week, often accompanied by wife. Recently, had one or two driving incidents (near miss), but not accident.
Behaviour	Meandering in lane, maintaining attention.
Pain-points & Challenges	Avoids high traffic density, night driving and motorways/high speed areas, difficulties maintaining attention.

3.5 Application of 'Human Factors & Ethics Canvas'

As the first part of this study did not involve field research, the ethics canvas has made use of evidence obtained in the literature review, and the outcomes of team problem solving activities – in particular, the specification of user profiles, personae and scenarios. Thus-far, 6 stages of the HFEC have been completed. This includes Stages 1 to 5 and Stage 7. As noted previously, stage 1 is about formulating the problem. The initial literature review outputs (Part 1, phase 1) were analyzed to understand the multidimensional nature of the problem, contributory factors to the problem, the impact of the problem and ethical issues embedded in the problem statement. Stage 2 concerns stakeholder needs and expected benefits. This was analyzed using the outputs of the initial literature view (Part 1, phase 1) and the outcomes of the TILDA analysis (Part 1, phase 2). Benefits, impacts and outcomes were then documented – linking to problem solving undertaken in a series of group workshops with project researchers. The existing user profiles, personae and scenarios (Part 1, phases 3 & 4) were then further decomposed in relation to specific impacts and consequences. Critically, the system logic is advanced in relation to addressing the needs and requirements of these specific personae. Currently, it is anticipated that the solution will be developed for profiles 1 to 7, and potentially profile 9. A deep dive was then undertaken in relation to data ethics (phase 5 of HFEC). As implementation has not occurred, phase 6 was skipped. The overall analysis was then summarized (phase 7 of HFEC).

4 Understanding Human & Ethical Issues, Framing Human Factors & Ethics Problem & Specifying Design Challenge

4.1 Driver Profiles

Older adult drivers can be segmented into nine profiles. The profiles are as follows:

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)

4.2   Ethical Issues

In principle, ethical issues and issues concerning societal/user acceptability pertain to all driver profiles. Table 2 provides a summary of key ethical issues and questions.

Table 2. Key Ethical Issues & Questions

#	Issue/Question
1	Should the purpose of these systems go beyond safety? Is it ethical to promote driver persistence?
2	How is the human role and wellbeing being considered in relation to the development of these systems?
3	Should the system determine the level of automation/assistance, or the older adult?
4	What is the role of older adult and what level of choice do they have in relation to mode of operation?
5	What level of impairment is acceptable for an older driver to keep driving?
6	Should the driver be able to take control of the car at any point?
7	Overreliance on technology and impact on driver competency & identity
8	Is full automation an appropriate solution to effectively managing the apparent conflict between two goals – (1) promoting driver persistence and (2) ensuring road safety?
9	Ethics in terms of how the system/algorithms treats older adults with different conditions (i.e. bias re MH or other conditions)
10	Ethics of personalization and nudging older adult towards specific automation modes. Appropriateness of mode options – for example, consideration of safety for persons with sensory or functional limitations?
11	How is information about the health status of the driver, their driving

	challenges, driving routines and any driving events being stored?
11	How is information about the health status of the driver, their driving challenges, driving routines and any driving events being stored?
12	Who has access to driver profiles, health information and incident information?
13	Who is to blame if there in accident – the driver or the co-pilot? What are the legal obligations of the driver, if the driver is taken out of the loop (i.e. full automation)? Should the human back-up driver of intervened?
14	Addressing conflict dilemmas on the road?
15	Software hack and misuse
16	Should the system provide the driver with feedback about their health?
17	Environmental implications of pursing driver persistence

4.3   Ethical Principles Underpinning System Concept

Specific principles underpinning the system concept include:

1. The system should benefit all road users including older adults
2. The system should support road safety (benefits all road users)
3. The system should protect the rights of other road users and pedestrians who may be negatively impacted by older adult driving challenges and specifically, health events such as strokes and heart attacks.
4. The system should enable continued and safe driving for all adults, including those adults at risk of limiting their driving and/or giving up
5. The system should enable driver persistence – thereby supporting mobility and social participation for older adults
6. The system should be premised on concepts of successful/positive ageing and self-efficacy (i.e. avoid ageist stereotypes)
7. The system should promote driver engagement and provide alternatives to full automation
8. The proposed technology should maintain the autonomy of older adults (i.e. the starting point is the engaged driver).
9. The system should support all three pillars of older adult wellbeing (i.e. biological, psychological & social)
10. The system should enable social inclusion and participation of older adults - this benefits society as a whole
11. The system should protect human rights – including right to autonomy/choice, privacy (information access and protecting health and driver profile information)
12. The system should be usable, accessible, and understood by people of all ages with different abilities and health conditions.
13. Solution needs to comprehensively address real needs of people (diversity) and potential adoption barriers

14. Human activity should not compromise the long-term balance between the economic, environmental, and social pillars (triple bottom line)
15. The proposed mobility solution should consider environmental issues

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. Human benefit, wellbeing and respect for human rights and identity are key goals/principles for new assisted driving technologies. From a design perspective, this includes promoting driver persistence and self-efficacy and protecting driver data (i.e. privacy and rights). The driver assistance system must also be verifiably safe and secure. In this way, the solution needs to carefully balance potentially conflicting goals around driver persistence and safety.

4.4   Design Challenge & Framing the Problem

The design challenge (i.e. prolonging safe driving for older adults) is framed in relation to a philosophy of (1) driver persistence and 'enablement' and positive models of ageing – and (2) benefit for all – specifically in relation to safety and driver experience. This philosophy is further refined in relation to specific driver profiles and personae. To this end, a traffic light coding is assigned to specific personae. For more information, please see Appendix 3: Example Personae. The traffic light coding is in relation to risk of not obtaining the predefined goals (i.e. goals in relation to persistence, safety and experience). In principle, all older adults should be green for persistence, safety and experience. If the older adult is having health issues, and taking some medications, or struggling with driving task, they might be at risk in relation to persistence (i.e. red on persistence mean close to giving up). If prone to anger, or have penalty points for speeding, then this gives you different colors for safety (i.e. yellow or amber depending on severity). Older adults who find driving difficult, and often drive with passenger and get easily stressed have amber or yellow on experience, meaning it is less fun for them. The co-pilot system should put all older adults 'back in the green' for relevant project goals.

5   Addressing Human Factors & Ethical Issues: Specification of Driving Assistance System Concept

5.1   Vision & Underlying Concept of the Older Adult/Person

The vision for this system is to promote the active participation of older adults in society (i.e. social inclusion and positive ageing). The proposed co-pilot system is premised on concepts of successful/positive ageing and self-efficacy. Ageing (and the associated changes in functional, sensory and cognitive function) is a normal part of life. To this end, the system seeks to normalize ageing, and not treat ageing as a 'problem' or 'disease'. To this end, the proposed driving assistance system is prem-

ised on a conceptualization of the driver/older adult as a person (and not a set of symptoms/conditions/holistic approach).

The driving solution (i.e. car, sensor system, co-pilot and HMI) is designed to opt mise the abilities and participation of older adults. 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.

Further, 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.

5.2 Goals and Intended Purpose

Three high level goals for the system have been defined. These are enabling safe driving for older adults, driver persistence a positive driver experience. Overall, the purpose is to prolong safe driving for older adults with different ability levels, and in doing so help maintain cognitive and physical abilities. In so doing, the system should detect the health and psychological/emotional condition of the driver, so that the vehicle responds as appropriate. This can be achieved by promoting engagement/alertness, providing task supports and taking over the driving task if the driver is impaired and/or calling an ambulance. As indicated in Table 3, these goals can be further refined in relation to specific user profiles.

Table 3. System Goals & User Profiles

#	User Profiles	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	As (1) and…New tech might monitor condi-

	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	tions 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

5.3 System Concept & Logic

The system logic is underpinned by concepts of ability, adaption and assistance as opposed to full vehicle automation. The ability of the driver to perform the driving task depends the driver's ability (i.e. physical, sensory and cognitive), their 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).

We are proposing a collaborative system underpinned by the 'co-pilot' concept. The co-pilot is conceptualized a supportive and vigilant friend, who works in partnership with the driver to ensure a safe and enjoyable drive. The driving assistance system logic is predicated on the idea that driving is accomplished as a team task. Accordingly, it is conceived as a collaboration between the vehicle and the driver interacting with the driving environment/road context. The team includes driver and the vehicle (including car/hardware, sensing system, co-pilot and multimodal HMI). It is

this team (and not simply the driver), that enables the different goals of safe driving, driver persistence and positive driving experience.

The driving assistance system is predicated on three levels of co-pilot intervention in response to driver factors (no response, driving assistance and safety critical intervention). The system recommends different levels of assistance based on the driver's profile (level of ability), and real time context (i.e. driver state and driver behavior). In principle, the driver selects the level of assistance required. However, 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 the 'co-pilot'.

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. In this way, the system logic addresses 'interpretation challenges' rather than the driver condition or state. As indicated in Table 4, this is achieved in relation to six high level interpretation challenges.

Table 4. Interpretation Challenges

#	Interpretation Challenge	Explanation of the interpretation challenge
IC1	Task support/ feedback	Addresses driving challenges and typical supports required (i.e. parking support, navigational assistance and assistance changing lanes)
IC2	Activation/ "Flow"	Incorporates Multiple Psychological States: Stress/ Anger/ Excitement/ Workload/ Engagement including driver difficulties & driver behaviours
IC3	Fatigue & drowsiness	Many medical conditions & drugs also manifest this way
IC4	Distraction & Concurrent task management	Addresses age-related cognitive & perceptual challenges including driver difficulties & driver behaviours
IC5	Intoxication – alcohol/drugs/related medical conditions	Other drugs & some medical conditions manifest similarly
IC6	Heart Attack/ Stroke	Addresses fear factor – "What if … ?" which may discourage older drivers from driving

5.4 Goals, Objectives & Key Performance Indicators

As specified in Part 1 & Part 7 of the HFEC, it is possible to define key performance indicators (KPIs) relevant to the potential success of this technology once it is introduced and used by the public. As indicated in Table 5, system goals can be reformu-

lated in terms of objectives concerning human benefit and wellbeing and associated measures/KPI's.

Table 5. Key Performance Indicators (KPI)

#	System Goal	Human Benefit & Wellbeing 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 wellbeing (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 wellbeing

5.5 Defining & Managing Impacts: Design Considerations

Stage 3 and Stage 4 of the HFEC requires the specification of potential impacts and unknowns. These are grouped as follows: positive impacts, negative impacts, specific psychosocial impacts, specific environmental impacts, unintended consequences and unknown impacts. Table 6 provides an overview of those identified.

Table 6. Defining Impacts

#	Impact Type	Description
1	Positive impacts	Simplify driving task for all Promote driver persistence for all

		Enable older adults with health issues, impairments and/or disability to continue driving
		Promote older adult wellbeing
		Promote older adult enablement
		Increase older adult mobility
		Enable social participation
		Enable older adults to undertake instrumental activities of daily living
		Increase older adult cognitive functioning
		Augment driver ability
		Mitigate the crash risk of specific medical conditions on driver
		Reduce risk of safety events for all
		Reduce no of road accidents
		Reduce crash risk of older road users
		Reduce/mitigate ageism
		Reduce anxiety for family members/concerns about fitness to drive
		Reduce passenger anxiety
		Increase medical attention response time for older adults experiencing health events while driving
2	Negative impacts	Unnecessary monitoring of older adult drivers
		Impact in terms of older adult drivers' identity – reduction to a set of symptoms to be monitored by technology – and not a person (holistic sense)
		Impact on perception of older adult driver by other drivers – need protections
		Impact on perception of older adult driver by other car occupants
		Impact in terms of privacy and changing norms for this
		Potential negative environmental impact – more cars on road (older adults driving themselves and not taking public transport or ride-shares)
		Potential data hacking and malicious intent (safety issues)
		Potential data hacking and data sharing breeches - sharing of sensitive/private information about a person's health condition and potential driving risk.
		Overreliance on technology and impact on driver competency
3	Specific Psychosocial impacts	Contributing to a culture of over-intrusive assessments/monitoring of persons including older adults, impacting on morale and dignity
		Loss of individual privacy – feedback about real time driving available to other occupants in car
		Increase anxiety of passengers

4	Specific environmental impacts	Older adults using cars/e-cars and not public transport or ride shares – impact on transport behavior and sustainability (carbon emissions)
5	Unintended consequences	Unnecessary nudging towards automation
		Over reliance and automation and loss of ability (driving task and competency)
		Changing norms about individual freedoms/rights
		Unnecessary monitoring of drivers – including older adult drivers
		Contribute to a reduction in freedom for older adults
		Contribute to lack of trust in older adult drivers
		Contributing to a culture of over-intrusive assessments/monitoring impacting on morale and dignity
		Older adults using cars/e-cars and not public transport or ride shares – impact on transport behavior and sustainability (carbon emissions)
6	Unknowns	Contribute to a reduction in freedom for older adults
		Contribute to lack of trust in older adult drivers
		Contributing to a culture of over-intrusive assessments/monitoring impacting on morale and dignity

Positive impacts (for example, promoting driving persistence and the participation of older adults in society) must be supported by the system concept. Potential negative impacts must be carefully managed in relation to the design concept and execution. To this end, we are recommending:

- Stepped level automation (not full automation)
- Sensors capture data about physical and emotional/psychological state
- Smart sensors to monitor vital signs
- Include functionality to call emergency services if serious health event detected

5.6 Data Ethics

This proposed system must uphold an older adult's rights in relation to the protection of personal information (i.e. data protection and data sovereignty). The driver is in control of their own data and any decisions about how it is stored and shared with others. Information captured about the person's current health and wellness and driving challenges/events is private and not accessible to other parties. Models and algorithms must avoid bias in terms of model of older adults and specific medical conditions impacting on driving performance.

6 Discussion

Typically, the human factors discipline is concerned with issues around intended use, user interface design and technology acceptability. Arguably, human factors and

human machine interaction design research must extend its remit and 'go beyond the user interface'. Specifically, it should address issues pertaining to the psycho-social impact of technology, and how wellbeing, rights and human value/benefit are considered in terms of the design solution.

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. The analysis of relevant health literature and TILDA data has identified specific conditions that impact on older adult driving ability (2019). 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.

The proposed system maintains the autonomy of the individual. In principle, the driver can choose (and/or switch off) task support and advanced levels of automation, if they so choose. As such, the starting point for the system concept is an engaged older adult driver (i.e. older adult 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'. As such, our vision of 'technology progress' is closely intertwined with concepts of progress from a societal values perspective (i.e. how we think about ageing and how we value the participation of older adults in society – including enabling older adult mobility).

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.

The HFEC requires further development and iteration. Participatory evaluation of ethical issues and principles to consider will be undertaken with stakeholders (Steps 3 & 4). Moreover, the HFEC requires further consideration of ethical issues as part of

implementation and evaluation research. This step will require completion and will generate a further iteration of step 7 of the HFEC.

Assisted driving solutions are evidently very positive in relation to promoting positive ageing and older adult mobility and social participation. However, potential negative impacts such as the impact on travel models and transport decisions must be considered. Further research is required in relation to understanding how environmental impacts might be considered. Potentially, these concepts could be extended in relation to a consideration of car-pools and ride shares.

7 Conclusions

Design/technology teams exercise choice in relation to what is valued and advancing technology that improves the human condition (and not worsens it). Technologies need to positively contribute to human wellbeing and our lived experience.

Overall, it is argued that the specification of an ethics canvas as part of a broader human factors design approach ensures that ethical issues are considered. Although valuable, the existing ethics canvases require further emphasis on framing the problem, specifying the psychosocial dimensions and impacts of new technologies and addressing specific stakeholder/end user requirements and impacts. The HFEC supports the production and documentation of evidence in relation to addressing the human and ethical dimensions of future technologies and their potential impacts (including both positive and negative impacts). The HFEC is employed as one strand of HF method. This is not a stand-alone method and requires integration with other HF methodologies.

Arguably, existing high automation approaches do not support positive ageing. Intelligent assisted driving solutions must put the human at the center and consider benefits in relation to the three pillars of human wellbeing.

The proposed driving assistance solution has emerged from an analysis of certain ethical principles in relation to the goals and needs of specific older adult drivers (i.e. personae) in different situations (i.e. scenarios). The driving solution (i.e. car, sensor system, co-pilot and HMI) is designed to optimize the abilities and participation of older adults. That is, it recognizes what older adults can do as opposed to focusing on declining capacities. 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.

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Appendix 1: Scenarios & Personae

Table 7. Scenarios & Personae

#	Interpretation Challenge	Scenario	Profile	Personae
IC1	Task support/ feedback	Driver needs assistance	2. Older adults who regulate their driving in	Mary

		with parking	relation to managing specific driving challenges and/or stressful (difficult) driving situations (perceived safety risk or complexity).	
IC2	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
IC3	Fatigue & drowsiness	Fatigue	1. Older adults in optimal health and driving as normal	Elizabeth/Sam
IC4	Distraction & 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
IC5	Intoxication – alcohol/drugs/related	Alcohol	1. Older adults in optimal health and driving as normal	James

		medical conditions		
		Prescription Drugs	5. Older adults who are currently driving and at risk of sudden disabling/medical event	Rory
IC6	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