Driving Choices for the Older Motorist

The role of self-assessment tools

Lang, Parkes and Fernández Medina
Transport Research Laboratory
February 2013

RAC Foundation

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About the Authors

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Britta Lang is a German Traffic Psychologist who has worked in TRL's Road Safety Group since 2005. She specialises in the development and evaluation of transport-related behaviour change interventions, e.g. through driver training and testing, road safety campaigns or web-based driving risk assessment and mitigation measures.

In addition to her fulltime position at TRL, Britta undertakes a TRL-funded part-time PhD on older drivers' risk perception at Trinity College Dublin which received a Prince Michael of Kent Road Safety Award in 2009.

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Andrew Parkes joined The Transport Research Laboratory following academic appointments at Birmingham, Loughborough and Leeds Universities. His background is in Psychology and Human Factors, with very broad experience in domain of driver behaviour and traffic safety research. Interests over his career have expanded from the psychology and ergonomics of accident causation, through to a much wider view of the efficiency, acceptability and safety of transport systems. He has published over 170 journal articles, book contributions and sponsored reports in the areas of driver behaviour and performance. He is Visiting Professor of Life Sciences at Herriot-Watt University and Vice-President of the Forum of European Road Safety Research Institutes (FERSI).

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Kristen joined TRL in July 2012. Her role involves interfacing with clients, conducting qualitative and quantitative research tasks such as literature reviews and telephone interviews, report writing, on-road trials, and providing support with a range of projects across the team.

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Foreword

As individuals we recognise, and often try to forget, that every day we get older. Not only are we ageing, but the structure of society is changing. We are living longer. Life expectancy has been increasing steadily over the past fifty years. There are now more pensioners than children in the UK.

These changes matter. Barely a day goes by without reference being made to the 'black hole' in provision for pensions or the rising cost of healthcare for older people. The news is full of the impacts of our maturing society.

What about transport? Often the Cinderella story, but with the number of driving licences amongst older people rising it is indisputable that the car is and will remain crucially important to this group. But do current relicensing rules work? Do they allow people to continue enjoying the freedom provided by the car whilst staying safe? What support systems are in place to encourage people to make considered decisions about their driving skills as they progress through life? How are family members, health professionals and assessors brought into this process?

This report investigates whether self-assessment tools can help older drivers make the right choices about their driving. It tells us something about how our abilities change with age and how this impacts on driving skills, how you can go about testing for these, and whether self-assessment tools can help drivers self-regulate. Most importantly this report tells us what self-assessment tools can do, what they cannot do and what they should include if they are to be helpful.

The right self-assessment tools can provide useful feedback on driving strengths, weaknesses and future mobility options. They can help facilitate discussion between older drivers and family members. They cannot, however, replace the professional assessment of driving skills and they should not be promoted for this purpose unless significant effort and resource is available for their validation.

Ultimately, the problem remains that there is no consistent support system in place to assist members of the public with decisions about driving in older age. Although the majority of motorists cease driving at the right time, up to a third may be stopping driving earlier than necessary, with a further 10 per cent continuing to take to the roads with poor levels of driving fitness.

Government needs to take a leadership role. It must, as the national licensing authority, set out the framework within which initiatives and decisions on driving in old age can be made. Self-assessment tools, once validated, could provide an important part of the support system for older drivers, but their success, uptake and use will be very much dependent on how national policy addresses driving in later life.

Inaction is where we find ourselves today. Government needs to go further in its policies to address the demographic certainty that we are all getting older. Self-assessment tools for drivers are not uncommon. Some are useful and effective, others less so. Scientifically rigorous work is now urgently needed to develop a coherent package for the maturing driver. Self-assessment tools may well play an advisory part within this, but independent, professional and independent assessment is likely to remain the mainstay of licensing decisions. The number of older drivers on our nation's roads is growing by the day. Policy needs to keep up with this reality.

Stephen Glaister
Director, RAC Foundation

Executive Summary

Ageing and mobility

Low birth rates, coupled with increased longevity and a generation of post-war baby boomers moving into retirement, mean that the populations of many Western industrialised countries, including the UK, are ageing. The growth in the number and proportion of older people is accompanied by a diversification in the lifestyles, socioeconomic circumstances and health of the elderly. Many of today's older people are more mobile and enjoy better health than previous generations, owing to higher incomes, better nutrition, increased physical exercise and improved medical provision. The developments, however, present a challenge to transport policymakers, as one-size-fits-all solutions will not adequately meet the mobility needs and expectations of this increasing, and increasingly heterogeneous, elderly population. Whilst current transport policies in the Western world aim to expand the use of more-sustainable, alternative transport modes, the private car is likely to retain its importance for facilitating the safe mobility of older people – and with that, their autonomy, participation in social activities and well-being. Licensure rates of elderly people, especially females, are on the rise, and in older people's travel patterns in Britain, increased car use has in recent years replaced the use of public transport and walking.

Collision risk for older drivers

There is a considerable body of research into the safety of older drivers. If collision rates are calculated on a per-licensed-driver basis, older drivers up to the age of 80 have collision rates that are comparable to those of middle-aged drivers. However, the increased frailty of older drivers means that they are more likely to be killed or injured in a collision than their younger counterparts.

Licensing arrangements for older drivers

Licensing procedures in Britain stipulate that from the age of 70 onwards, older drivers must self-certify their continued fitness to drive every three years with the Driver and Vehicle Licensing Agency (DVLA) to extend their licence (at no cost). Licensing practices in European countries and the states of Australia and the USA vary considerably. These variations include differences in the minimum ages at which age-related controls commence, medical testing procedures prescribed, and frequency of relicensing. There is, however, good evidence to suggest that age-related controls are neither cost-effective, nor beneficial to road safety. On the contrary, research suggests that age-related testing may lead to reduced licensure rates and may put older people at an increased risk of injury by triggering modal shift towards less safe forms of transport for this group, such as walking.

As a result, the scientific debate has shifted in recent years towards a functional definition of age, and towards procedures that can most successfully identify the small proportion of unsafe older drivers on the road. Large research programmes in the USA and Australia have explored the links between age-related declines and collisions, and have underpinned the development of new approaches towards driver screening and licence assessments. Because chronological age, or a particular medical diagnosis, is a poor predictor of functioning and does not of itself determine an individual's fitness to drive, new model procedures comprise multi-tiered screening and assessment processes. In these, older drivers whose safety may be at risk undergo cost-effective office-based screening tests before more specialised assessments are carried out.

Age-related capability changes and their impact on driving

Even in healthy older adults, ageing brings about eventual deteriorations in the ability to gather appropriate and accurate information through sight, hearing and balance; to move correctly or effectively; and to make successful, timely decisions. These reductions vary markedly between individuals, and the rate of decline of a particular ability is not necessarily accompanied by similar declines in others. These three classes of ability can be labelled sensory, motor and cognitive, and decline in them affects the ability to drive safely in the following ways.

Sensory decline:

- Vision: vision is essential to the driving task as it facilitates attention allocation, hazard perception and decision-making. Visual acuity (both static and dynamic), and contrast sensitivity (the ability to distinguish between an object and its background) all deteriorate with age.
- Hearing: whilst hearing provides the driver with all-round information, including warnings and alarms from the traffic environment, there does not seem to be a strong association with collision risk.

Motor decline:

- Motor abilities, in terms of range of movement, speed of execution and strength, are necessary for the safe operation of vehicles and for turning to view mirrors and oncoming traffic. Lower and upper limb mobility, as well as head and neck range of motion, are believed to affect older drivers' ability to drive safely. Difficulties with reaching out and turning one's head have also been shown to be predictive of collision involvement.

Cognitive decline:

- One prerequisite for driving is the integration of high-level cognitive functions with perception and motor function. Age-related declines have

been found for attention, working memory, executive function, task-switching, hazard perception, perceptual speed and visual perception. Judgements of speed and distance and the ability to ignore distractions have been associated with collision risk.

Standardised tests have been developed to quantify the relationship between cognitive abilities and collision risk in older and medically impaired drivers, as well as to provide a systematic and reliable assessment of such abilities. Research suggests that the 'Rapid-Pace Walk' and the 'Alternating Foot-Tap Test' measure motor ability and are predictive of collision involvement. Similarly, the Useful Field of View (UFOV) test, which measures processing speed and attention, and the Trail-Making Test, which measures executive function, have been found to be predictive of collision involvement.

Current specialist assessments of fitness to drive in Britain, Australia and the USA involve comprehensive, multi-hour assessments, carried out by trained health professionals. Such assessments typically comprise batteries of tests of cognitive, visual and psychomotor impairment, and frequently also assess on-road driving performance. Although there is not complete agreement on the level of association between the results of the tests and future driving ability, there is a degree of agreement on the most promising components of an appropriate assessment. However, it should be noted that the research to date has not incorporated the most recent thinking about how to develop tests that tap into the important aspects of risk-taking, situation awareness and resistance to distraction.

Self-regulation in older drivers

The relative safety of older drivers regarding their collision risk has been attributed to the process of 'self-regulation', a term that describes compensatory adaptations made by older drivers to match their changing cognitive, sensory and motor capabilities. Several studies have established associations between older drivers' health, their ratings of confidence in – or avoidance of – difficult driving situations, and driving performance or collision involvement. However, observed changes in driving patterns have also been attributed to lifestyle changes, personal preferences and increasingly negative appraisals of driving as an activity, rather than simply awareness of decline and compensatory adjustments. Whilst the interplay of the drivers and the process of self-regulation are not yet fully understood, research suggests that older drivers are generally sensitive to the effects of ageing and general health on driving competence, and will adjust their driving accordingly. Driving cessation forms the eventual endpoint of a continuum of gradual reduction of driving activity. Because of the loss of autonomy and independence, decisions about driving cessations are frequently perceived as extremely difficult by older drivers and their family members alike. Results from a large American survey suggested that the majority of drivers felt that they had timed their decision to cease driving correctly, whilst about a third (mostly women) felt that they

had stopped too early, and 9% felt that they had stopped too late. Australian research suggests that approximately 10% of current older drivers may have unacceptable levels of driving fitness. Whilst the self-regulation of older drivers therefore appears to successfully maintain the safety of the majority of older drivers, it is also generally acknowledged that it is not to be relied on exclusively.

Tools to support self-regulation

Several researchers have suggested that increasing the accuracy of older drivers' awareness of their driving-related capabilities should facilitate the calibration of driving ability and, with that, self-regulatory changes to driving patterns and driving styles. There is also evidence to suggest that non-mandatory interventions are well accepted and that older drivers are receptive to feedback on their driving-related capabilities. Voluntary self-assessment tools that can be completed by the older driver at home provide an opportunity for feedback and increased awareness in a non-threatening, confidential environment, and may help to address identified driving-related problems at an early stage.

In the past, such tools had to be paper-and-pencil based; however, the emergence of the PC and of fast, stable Internet connections enables their implementation as computer-based or Web-based assessments. Whilst Internet use by older people in Britain at present is still somewhat limited (60% of those aged 65 and over reported not using the Internet in 2011), year-on-year increases are steady at around 4%. Computer-based or Web-based solutions not only permit the implementation of more complex and automated scoring mechanisms, but also the provision to the respondent of tailored feedback, as well as cost-effective and wider dispersion among the older driver population. Research indicates that tailoring feedback to respondents is important to avoid the negative effects of stereotyping older drivers.

Two types of self-assessment tools are currently available, frequently free of charge to older drivers: (1) tools that aim to increase self-awareness, typically by requiring the respondent to reflect on and self-report (health) concerns, experiences and attitudes related to safe driving; and (2) tools that measure the driver's maximum performance on a test (or tests) in order to screen for functional impairment of abilities relevant to driving. Self-assessment tools of both kinds aim to provide the respondent, after completion, with feedback on driving abilities and advice on how safe mobility can best be maintained.

Several assessment areas have been recommended for inclusion in self-assessment tools, based on research evidence and current clinical practice.

Tests that can be transferred for self-assessment include:

- visual performance – in terms of static acuity, which describes the ability to perceive fine detail ;

- executive function – measured by trail making or maze following;
- cognition – in terms of UFOV;
- driving style – by questionnaire;
- driving problems – by questionnaire;
- range of motion – by questionnaire.

Higher cognitive functions, such as hazard perception and change blindness in older drivers, have yet to be included in self-assessment tools.

The majority of available tools have been developed in the USA, amongst which the most notable are the (Enhanced) Driving Decisions Workbook (DDW), a representative of the first type of tool (i.e. to increase self-awareness), and the Roadwise Review, a representative of the second type (i.e. performance measurement). Both have emerged from large research programmes and were informed by extensive reviews of the literature. Research indicates that the (Enhanced) DDW significantly increased the self-awareness of older drivers and facilitated discussion about driving-related problems with family members.

However, evaluation studies on the predictive validity of self-assessment tools have been limited to date, and restricted to opportunity samples of older drivers. Where reliable correlations between self-assessment scores and clinical tests or on-road tests have been found (as for example, for the DDW, these correlations have been of modest size, and the relationships are not strong. This finding may be partly attributable to the challenges that both types of self-assessment tools face. Tools that rely on self-report require the respondent to answer honestly and are thus subject to self-report bias, and potentially to 'socially desirable responding', in particular self-deception. Tools that measure functional ability rely on the respondent's adherence to the testing protocol and may disregard the fact that driving is a self-paced task in which drivers rarely operate at their upper performance limit. Moreover, as voluntary measures, both types of tools suffer from the self-selection of older drivers completing them.

Several researchers have pointed out the potential risks associated with inaccurate feedback about driving abilities to older drivers. These include the risks of encouraging unsafe drivers to continue driving as well as the (cost) implications of encouraging safe drivers to seek further assessment or to unnecessarily reduce or discontinue driving. Because of these challenges and the limited evidence for their predictive validity, self-assessment measures cannot replace more stringent assessment procedures in relation to fitness to drive and licensure decisions.

To date, there has been no systematic research into the question of how the outcomes of self-assessment tools impact older drivers' actual self-regulation, and how this in turn impacts their safety on the road. Further research is therefore urgently needed, as statements on the capability of existing self-assessment tools to improve self-regulation are currently speculative.

The main recommendations arising from the current review are as follows:

- Self-assessment tools can serve a valuable purpose in raising driver awareness of abilities and problems, but they cannot act as a definitive measure of driving competence, and should not be promoted as such.
- The limitations and benefits of current tools should be acknowledged, so that they can be used appropriately.
- There are components of the driving task that can be self-assessed, and which have been shown to have some predictive value for determining driving abilities, but more research should be conducted to validate them, particularly in the areas of risk-taking and situation awareness.
- Self-assessment tools should include the following features:
    - self-report of medical history and health concerns;
    - self-report of driver experience (including the experience of difficulties) and attitudes;
    - tests of component abilities:
        - vision: static, dynamic and contrast threshold;
        - UFOV;
        - the Clock-Drawing Test and the Maze Test;
        - hazard perception and change blindness.

- Self-assessment tools should be refined by testing with older drivers of different pathologies and experience levels. Randomised controlled trials are needed.
- Self-assessment tools can usefully complement older driver programmes and interventions, and provide a growing number of drivers with quick and easy-to-access checks of driving ability; self-assessments should not replace clinical assessments of fitness to drive which are carried out to inform decisions on licensure.
- Available self-assessment tools tend to be free of charge, but are likely to suffer from self-selection bias – respondents to such tools are more likely to have a proactive attitude to driving safety; possible solutions to this issue, to encourage their use by all older drivers, should be considered.
- Self-assessment tools are not suitable for older drivers suffering from significant cognitive impairment; this should be stated on the tool and supporting materials.
- Self-assessment tools must avoid creating a sense of false security in drivers, or conversely provide incorrectly negative feedback on driving abilities to the driver, as both outcomes are associated with significant costs to the individual and/or to society.
- Feedback provided by self-assessment tools should be as tailored and individualised as possible.
- Government should acknowledge demographic developments and the perceived need to make provision for older drivers to maintain their mobility and associated well-being for as long, and as safely, as possible.
- Government should encourage research into the potential contribution and predictive validity of self-assessments to the safety of older drivers.

1. Introduction

This report builds on previous work undertaken by the RAC Foundation which culminated in the publication of the report *Maintaining safe mobility for the ageing population: The role of the private car* (Box et al, 2010). Following this research, which aimed to inform and encourage the debate on safe mobility in old age, the current report homes in on the question of what role self-assessment tools, and in particular computer-based or Web-based self-assessments, can play in supporting the safety of older drivers.

After providing an overview of current knowledge on older driver mobility, this report considers the licensing arrangements and formal assessment procedures for older drivers in Britain, before moving on to look at how self-assessments could be embedded in this context.

This is followed by a review of evidence on the capabilities that are required for safe driving, and how they change with age. How these capabilities are measured, and whether they lend themselves to self-assessment through Web- or computer-based tools, is then assessed.

The subsequent sections review the potential and limitations of Web- and computer-based assessments in general, and consider their usability for both the current and future older driver.

An overview of existing self-assessment tools is then provided, describing the capabilities tested, the context of the tools, and evaluation results of the tools where available.

The discussion section summarises the main themes identified and outlines recommendations for the best use of self-assessment tools in Britain in future.

1.1 Methodology

The current report was based on information gathered from two main project activities:

1. the search and review of published scientific literature;
2. the consultation of experts and practitioners in the field of older driver safety, supplemented by requests for information about existing self-assessment tools, including, in addition to computer- and Web-based tools, those that are paper-and-pencil based.

The search of literature databases served two purposes:

a. to identify the literature on capabilities and functionalities required for safe driving, evidence of how these change as a function of age, and their link to road safety outcomes;
b. to identify existing assessment procedures and tools that are currently used to assess fitness to drive.

A list of search terms and key words was developed and agreed with the client. A subsequent search of literature databases was conducted by Transport Research Laboratory (TRL) library staff which comprised searches of Transport Research International Documentation (TRID), Science Direct, British Standards, PubMed, the Social Research in Transport (SORT) Clearinghouse, the Transport Research Knowledge Centre (TRKC), Cochrane Library and Scirus. Approximately 300 publications were initially identified and screened for inclusion in the review by the project team. Only publications detailing age-related changes to capabilities relevant to driving, or assessment tools for older drivers, were retained for further review.

In addition to the search of the published literature, a consultation exercise was carried out with a range of experts and practitioners in the field of older driver safety to identify 'grey literature[1]', and knowledge about available tools and self-assessment procedures which may not be published (at this stage). It was anticipated that this part of the review may yield less scientifically robust information, which would then be compared against the previously accumulated body of evidence on capabilities relevant to driving and their change as a function of age.

This task included the compilation of a list of national and international contacts, the drafting of a request for information (including a brief outline of the aims of the project), and the development of a questionnaire to be completed by the respondents on any available self-assessment tool they were aware of. The contacts were also asked to forward the request for information to any other person or organisation in a position to provide relevant information. This included publishing the request for information in organisational newsletters or website postings.

Table 1.1 provides an overview of the responses to the request for information.

1 Material that is not foramally published, such as institutional or technical reports, working papers, conference proceedings, or other documents not normally subject to editorial control or peer review.

Table 1.1: Number of persons and organisations contacted and responses to information requests

	Europe	Australia	USA & Canada
Number of persons/organisations contacted	**46**	**5**	**12**
Number of non-responders	11	0	5
Email undeliverable	2	0	2
Responded, but did not provide information	12	0	0
Some information provided	19	5	5

Source: Authors' own

Not all information provided was necessarily pertinent to the research question. All links and materials provided were reviewed and, where relevant, integrated into the report. Whilst not all of the information provided focused on self-assessment tools, those publications that contributed to current knowledge on older driver mobility are included in Section 2 or 3 of this report.

2. Current Knowledge on Older Drivers

2.1 Definitions of older drivers

Although older drivers are recognised as an important area of research, there is no agreement on when people start to be 'older' drivers (Cobb & Coughlin, 2004). Kostyniuk and Shope (2003: 408) remark that "there is no precise age at which a driver becomes an older driver". Age in its chronological sense (i.e. time elapsed since birth) is ruled out by Coughlin (2001: 2), who states that the "chronological age is not a perfect indicator of who is an older driver". Hakamies-Blomqvist (1998) points out that whilst the probability of older-driver-like characteristics increases with chronological age, ageing patterns are subject to considerable variation from one individual to another. She instead discusses the biological, psychological and social definitions of ageing, and proposes the use of changes in important performance variables to mark the transition to older driving.

The difficulty of defining the onset of 'older driving' is reflected throughout the literature, where different ages are adopted arbitrarily as starting points, for example 55 years, 60 years or 65 years. Whilst some researchers (e.g. Center for Urban Transportation Research, 2005; Clarke et al., 2010) define the cut-off point by the age associated with discernible changes in crash risk, others define it socially, by linking it to the entry into retirement age, as this transition is typically associated with changes to driving patterns and purposes. However, most frequently no explicit rationale is provided to justify the classification of drivers as 'older drivers'.

2.2 The term 'self-assessment'

A variety of terms are also used in the academic and practitioner community to describe tools that older drivers can use to assess their driving capabilities.

In the USA, Eby et al. (2000) characterised their development of a paper-and-pencil-based workbook for older drivers as a 'self-evaluation instrument'. Subsequently the group, based at the University of Michigan Transportation Research Institute, adopted the term 'self-screening tool' to describe self-completion instruments for older drivers. According to Eby (personal communication, 30 October 2012) the term 'assessment' is now reserved for the in-depth evaluation of driving capabilities by specialists to determine older drivers' fitness to drive and, with that, licensure decisions. Self-screening tools precede such formal assessments and allow the older driver to screen for gross impairment of driving ability (Eby et al., 2003).

Staplin (personal communication, 30 October 2012) also advocates the use of the term 'self-screening' and suggested that a number of researchers and representatives of the US Department of Transportation and the National Highway Traffic Safety Administration (NHTSA) were working with the American Occupational Therapy Association to make a clear distinction between 'screening' and 'assessment' among practitioners in the USA. Staplin recommended that

the term ‘self-screening’ should replace the term ‘self-assessment’, as the former (screening) emphasised primarily education, which should trigger those with apparent deficits in key functions to seek a formal evaluation (an assessment) from an appropriate healthcare provider. Such formal assessments would then be accompanied by advice about whether/how to adjust or cease driving, and how to access transportation alternatives in the community.

In Europe, Heikkinen et al. (2010) undertook a review of traffic safety measures aimed at older drivers, including a review of tools available to older drivers to assess their own driving capabilities. The group referred to these tools as self-evaluation instruments. In the UK, the term ‘self-assessment’ seems to be generally accepted to describe voluntary self-screening measures for older drivers. Whilst acknowledging the American terminology, this report uses ‘self-assessment’ in line with common British practice.

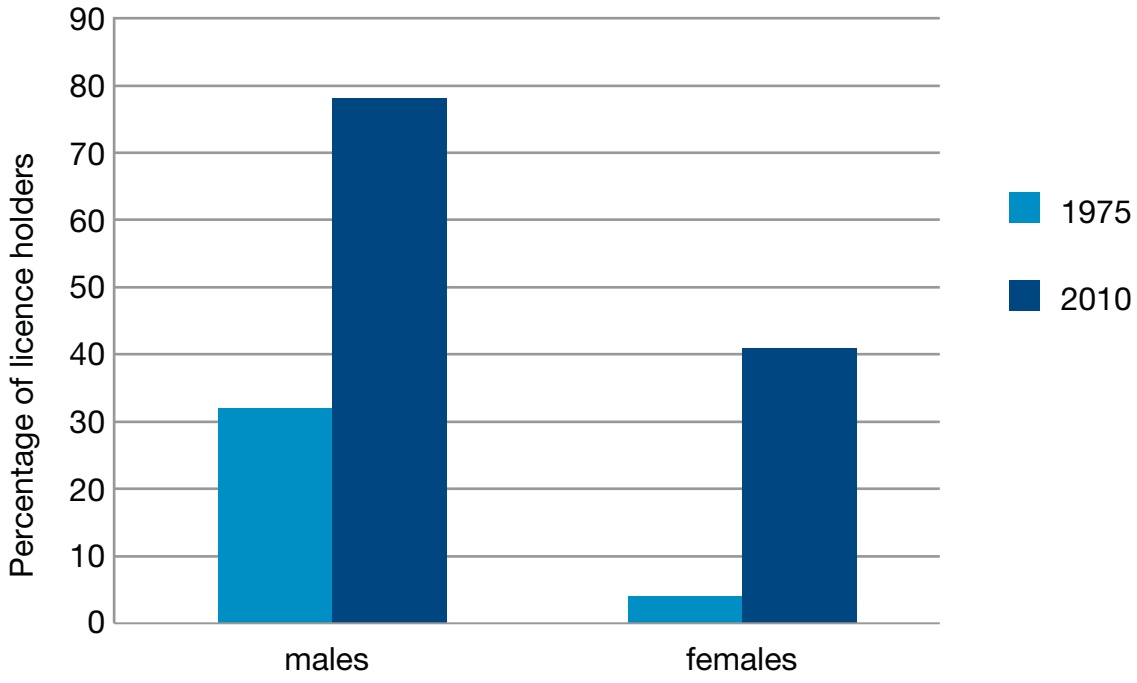
2.3 Demographic and licensing trends

Low birth rates, coupled with increases in longevity and a generation of post-World War II baby boomers moving towards retirement, mean that the UK’s population is ageing (Baster, 2012). Similar trends are prevalent in many other industrialised countries, including the USA, Canada, Russia, Japan and the countries of the European Union. In Europe, the ratio of the number of people aged over 65 to the population aged 15–64 years is projected to double between 2010 and 2050 (Lanzieri, 2011). The change of the age-structure is associated with profound social and environmental changes that alter the material and social circumstances of older people in relation to their housing, pensions, closest personal relationships and proximity to basic services and means of transport (Warnes, 1992; Warnes & Fraser, 1992).

In addition to the increase in the proportion of older people, British statistics indicate a considerable increase in licensure rates, particularly for females, over recent decades (Box et al., 2010).

As shown in Figure 2.1, only 4% of females and 32% of men aged 70 and over held a full car driving licence in 1975; these proportions had increased to 41% and 78% respectively in 2010 according to National Travel Survey data (Department for Transport (DfT), 2010).

Figure 2.1: Comparison of proportions of licensed drivers aged 70 years and over in 1975 and 2010



Source: DfT (2010), Table NTS0201

This equates to just over four million British licence-holders aged 70 and over (Office for National Statistics, 2010). Similar trends are observed in other countries, and currently existing gender differences in licensure rates are narrowing (O'Fallon & Sullivan, 2009; TRIP, 2012; Le Vine & Jones, 2012).

2.4 The role of the car

Many of today's older people have a more active lifestyle, make more trips, and expect to maintain a higher level of mobility in their old age than previous cohorts (Holland, 2001; OECD, 2001; Vincent et al., 2006; O'Fallon & Sullivan, 2009). This is mediated by improvements in medical care, better nutrition, increased physical exercise, better education and higher incomes (TRIP, 2012; Olshansky, 2011). However, the ageing process is characterised by considerable heterogeneity, and trends towards worse health outcomes such as increases in the prevalence of obesity and childhood obesity in most Western countries (EASO, 2005), and

socioeconomic disparities are also observed (Allman et al., 2004; Christelis et al., 2009; Olshansky, 2011). This suggests that one-size-fits-all transport policies are unlikely to adequately or effectively address the mobility needs and expectations of the elderly in the future.

The importance of mobility for independence and well-being is widely recognised (Whelan et al., 2006); life satisfaction increases with a high level of mobility and participation in social and physical activities (Banister & Bowling, 2004; Gagliardi et al., 2010). Driving cessation, on the other hand, has been associated with an increase in depressive symptoms (Marottoli et al., 1997), again emphasising the vital importance of the ability to drive for autonomy and well-being.

Whilst urbanisation, increasing congestion levels and environmental challenges are gradually leading to a shift of focus in European transport policies away from individual motorised transport towards alternative transport modes, the private car retains its importance as the most dominant form of transport for older people (OECD, 2001; Whelan et al., 2006; TRIP, 2012; Staplin et al., 2003a). British Travel Survey data indicates that increased car use has replaced public transport use and walking for older people, partly because age-related health difficulties tend to affect the ability to make use of these latter transport modes earlier than driving, but probably also because of the lack of age-attuned alternative transport options and distance from available vital services such as health care or shopping facilities (Box et al., 2010; Whelan et al., 2006). Research also shows that private car use is a relatively safe mobility option for older people in terms of the risk of injury they face, compared, for example, to travelling as pedestrians, bus users or cyclists (Box et al., 2010; Hakamies-Blomqvist & O'Neill, 2004; Palacio et al., 2009; Siren & Meng, 2012). To enable older people to satisfy their mobility needs whilst at the same time minimising risk of injury to the group, maintaining the safe mobility of older drivers remains a focal topic for researchers and transport policymakers alike (Heikkinen et al., 2010; TRIP, 2012).

2.5 Collision risk

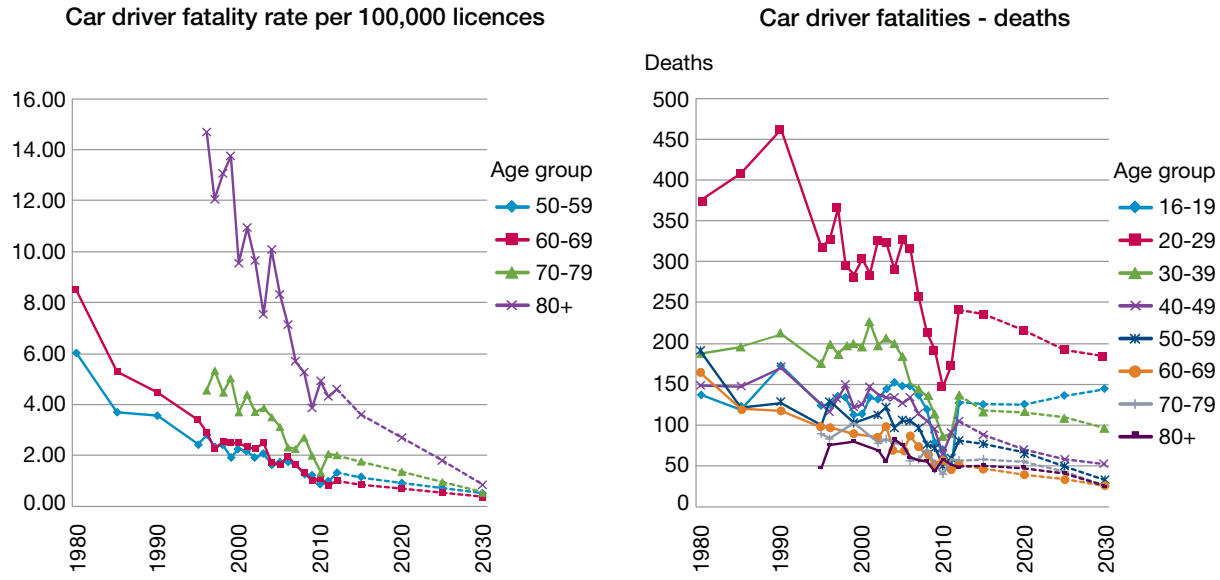
There is a great deal of public concern about age-related cognitive, sensory and physical decline, and its impact on older driver collision rates (Li et al., 2003). This has also resulted in a considerable body of research in recent years, which has compared relative collision rates of older drivers to those of other age groups, either per licensed driver or per vehicle mile travelled (OECD, 2001; Baldock & McLean, 2005; Lyman et al., 2002). However, evidence of causal relationships between the decline in specific abilities or age-related medical conditions on the one hand, and reduced driving performance or increased crash risk on the other, is limited, partly because of the differential effects of medical conditions on functional abilities (Langford & Koppel, 2006; Marottoli & Richardson, 1998). Fildes et al. (2008) emphasise that the older

driver population is heterogeneous, and that individual people's capabilities in relation to safe driving may thus differ considerably.

Comparisons of collision rates in several countries indicate that, when all severity collision rates are compared on a per-licensed-driver basis, older drivers up to the age of 80 have collision rates that are comparable to those of middle-aged drivers. The comparatively greater fatality rates of older drivers can be accounted for by their greater frailty and lower resilience to injury (Ryan et al., 1998; Li et al., 2003; Baldock & McLean, 2005). It is also accepted that the risk of injury which older drivers pose is predominantly to themselves rather than to other road users (Dellinger et al., 2004; Mitchell, 2008; Box et al., 2010).

Projections of older driver fatality rates in Britain up to 2030, based on the road safety performance in previous years, have been presented by Mitchell (2011) (see Figure 2.2). They suggest that, despite the growing numbers of older drivers, their fatality rates are decreasing and will continue to decrease.

Figure 2.2: Projections of older road driver fatality rates (left) and fatality numbers (right) up to 2030



Source: Mitchell (2011), slides 33 & 34

2.6 Self-regulation

Older drivers' safe driving performance has been repeatedly attributed to 'self-regulation', which describes the voluntary adaptation or cessation of driving to match changing cognitive, sensory and motor capacities adequately to the requirements of the driving task (Janke, 1994; Charlton et al., 2006; Lyman et al., 2001; Rimmö & Hakamies-Blomqvist, 2002; Oxley et al., 2003; Charlton & Molnar, 2011).

The importance ascribed to studies that explore self-regulation in the older driver arises from the premise that older drivers' willingness to undergo interventions aimed at maintaining their safe mobility depends on their ability to recognise age-related deteriorations and to appropriately adjust their own ratings of, and confidence in, their driving ability. Marottoli and Richardson (1998) differentiate between 'confidence', which they describe as a belief in one's ability, and 'awareness', which constitutes an individual's ability to perceive their own limitations. However, in terms of a behavioural outcome, both lack of confidence and lack of awareness should ultimately lead drivers to adjust their driving patterns.

Several studies have demonstrated that older drivers are generally sensitive to the effects of their ageing and general health on driving competence, and adjust their driving patterns accordingly to avoid travel under conditions which are perceived to be threatening or cause discomfort (Holland & Rabbitt, 1992; Evans, 1988; Eberhard, 1996; Smiley, 2004; Preusser et al., 1998; McGwin & Brown, 1999; Meng & Siren, 2012). The proportion of older drivers who report self-regulatory avoidance of certain driving situations, however, varies considerably between studies, and is likely to reflect differences in study samples (Charlton & Molnar, 2011). Females are reported to self-regulate more than men. Significant associations have been found between self-ratings of confidence, health status, previous collision performance, performance in an on-road driving test on the one hand, and reported avoidance of difficult driving situations on the other (Marottoli & Richardson, 1998; Lyman et al., 2001; Baldock et al., 2006). Whilst many studies have explored self-reported driving behaviour, a recent study commissioned by the British Institute of Advanced Motorists (IAM) compared the driving behaviour, reaction times, visual ability, visual behaviour, physical abilities and driving-related attitudes of young (17–26 years), middle-aged (34–55 years), young old (64–74 years) and older old (75+ years) drivers in a driving simulator (IAM, 2012). The research found significant associations between deteriorating vision and age. However, this did not translate into less safe driving, as older drivers appeared to compensate for reductions in visual acuity and reaction time through generally slower speeds and through maintaining greater safety margins. Older drivers were also found to display safer attitudes to overtaking and close following, and were less likely to commit driving violations.

Charlton et al. (2003) have argued that the behavioural adaptation observed in many older drivers does not necessarily result from compensation, and suggest that reduced driving could equally be explained as more mature judgements about road use, lifestyle choices, and personal preferences brought about by changes in employment status, place of residence and proximity of services. The authors suggest that the greater flexibility of older drivers compared to younger age groups with regard to mobility decisions allows them to avoid driving in situations in which other drivers are required to drive as a result of their circumstances (e.g. their employment), but that they may prefer to avoid undertaking journeys, too, if given the choice. A similar argument has been

presented by Siren and Kjær (2011), who found in a series of focus groups that older drivers attributed their changes in driving style to their preference of increased comfort and the wish to control external risk in traffic, arising from the behaviour of other road users. In a subsequent telephone study with 840 Danish drivers aged 75–95, Meng and Siren (2012) found a linear relationship between discomfort and avoidance of driving situations, which was stronger for drivers who recognised problems with cognitive function. The authors concluded that perceived discomfort served as an indirect self-monitoring of driving ability, and contributed to the successful self-regulation of older drivers.

Eby et al. (2000) have linked compensatory driving behaviours to the increased frequency of negative driving experiences (such as crashes or near-crashes, negative feedback from other drivers, getting lost, difficulties with reading signs, and difficulties with handling the vehicle) and negative self-appraisals of driving (loss of confidence, or feelings of distress about driving). According to their older driver model, age is associated with declining health and a deterioration of cognitive, perceptual and psychomotor abilities relevant to driving. These, in turn, impact older people's driving skills and lead to an increase in negative driving experiences and negative self-appraisals of driving. To compensate, older drivers may drive less, avoid driving at night, avoid busy traffic or certain driving manoeuvres, and may eventually stop driving altogether.

Whilst there is evidence to suggest that many older drivers successfully self-regulate, research also indicates that there is also a small proportion of drivers who do not adopt protective driving strategies to match the demands of the task to their capabilities, particularly older drivers with cognitive difficulties (Charlton et al., 2006). Whelan et al. (2006) estimate that approximately 10% of older drivers may have unacceptable levels of driving fitness, which may put them at an increased risk of collisions.

Self-regulation and driving cessation decisions are clearly linked. The cessation process, described as a 'cessation continuum' by Dellinger et al. (2001), occurs in stages as a gradual progression of self-imposed restrictions on driving that culminate in complete withdrawal from driving. Gilley et al. (1991: 944) noted that "Likewise, cessation of driving is not likely to be an all-or-none phenomenon, but rather the eventual end point of a gradual reduction of driving activity". If the decision to cease driving is described as the ultimate stage of self-regulation, then correct timing of this regulation measure is obviously important in the context of maintaining the safe mobility of the older driver.

A study by Stutts et al. (2001) including focus groups and a national telephone survey with 2,510 current or previous drivers aged 65 years and over explored the notion of the correct timing of cessation decisions. Cessation decisions were found to be extremely difficult for older drivers and their families. Approximately 72% of drivers stopped driving abruptly, whereas the others reduced their driving gradually. For those who stopped abruptly, crash involvement, health problems and licence cancellation were the most frequently reported reasons for doing so. Those who gradually reduced their driving mentioned their dislike of the driving environment and poor reflexes as deciding factors. Whilst one third of the respondents believed that they had stopped earlier than they should have, 9% felt that they had stopped too late. The majority of respondents believed that they had stopped at the right time. Older adults who stopped driving prematurely were typically younger women in good health who had never enjoyed driving, did not feel comfortable driving, and had someone available to drive them when necessary.

Whilst the process of self-regulation is not yet fully understood, the evidence indicates that age-associated changes in driving patterns help to maintain safe driving in the majority of older drivers. Research by Holland and Rabbitt (1992) indicates that older drivers are receptive to feedback in relation to their driving capabilities, and make compensatory changes to their travel patterns. The authors examined how changes in subjectively perceived and objectively measured sensory efficiency affected older drivers' perceptions of their own driving safety, and how the self-reported compensatory changes in driving were reflected in self-reported collision rates. The study included 54 current drivers in their fifties, sixties and seventies who completed a questionnaire on self-reported vision and hearing abilities, avoidance of potentially difficult driving situations, and their crash rates over the previous three-year period. Subsequently, vision and hearing tests were carried out and results fed back to

the participants. After two months, a second questionnaire measured whether drivers had made any changes to their driving on the basis of the feedback they had received. Participants who reported having difficulties seeing in the dark or at dusk were more likely to say they now avoided driving in the dark ($r=.43$, $p<.005$). Older drivers who reported having difficulties seeing in bright light or glare were more likely to say that they avoided driving in the dark ($r=.47$, $p<.001$) or at dusk ($r=.51$, $p<.001$). The authors also found evidence for a link between compensatory behaviour and crash involvement, in that those drivers who reported avoiding more of the six potentially difficult driving situations were significantly less likely to have been involved in an accident in the previous three years ($r=-.26$, $p<.05$). In response to the feedback received on the vision and hearing test, 36 of the 59 reported intentional changes to their driving patterns. The authors concluded that drivers aged 60 and over displayed a lack of awareness with regard to the age-related changes in visual abilities. Given that the majority of drivers reported sensible changes to their driving patterns in response to the feedback received on sensory deteriorations, the authors concluded that self-initiated compensatory behaviour could contribute considerably to the safety of elderly drivers. Enabling better self-regulation through self-assessment and provision of information is also an avenue that has been advocated by several other authors, including Husband (2010), Molnar et al. (2010), the IAM (2012) and Baster (2012).

Possible limits to the potential effectiveness of self-assessment tools, however, have also been raised. Parker et al. (2003) showed in their questionnaire survey with 1,932 drivers aged between 50 and 90 that, whilst self-assessments and the provision of DIY kits to older drivers received higher acceptability ratings than mandatory age-based testing, the respondents also expressed a concern that self-assessment measures may not be effective if the responsibility for implementing provided recommendations lay solely with the driver.

Similarly, Fildes (2008: 389) argues that "whilst older drivers will prefer self-regulation when it comes to mitigating driving risk, it is not a sufficient process alone to ensure their safety", and that there is a need to further explore the potential and limitations of self-regulation.

Critical voices regarding the potential negative impact of negative feedback on self-regulation have been raised by a group of French researchers (Moták et al., 2012b). The authors argued that providing older drivers with information on presumable age-related cognitive declines and associated driving-related concerns may provoke a stereotype threat which may result in an actual impairment of performance. They hypothesised that this impairment would be due to an increased effort to contradict the stereotype and the associated depletion of available working memory resources and of the resources required for self-regulation. These assumptions were tested in a driving simulator study with 67 drivers aged 65 years and over, half of whom received a stereotype threat ("Older drivers aged 65 years and older are more at risk of a traffic collision than younger drivers, because they hesitate too much before engaging in left turns") whereas the other half did not. The study sample included healthy older current drivers without cognitive impairment.

Participants were required to complete working memory tests before and after driving in the simulator, as well as four circuits of increasing difficulty. To observe self-regulation patterns, they were subsequently asked to train themselves on the same four circuits in the simulator for six minutes. Self-regulation was measured as the percentage of self-paced training time allocated to each circuit. Driving performance was measured as the mean speed in left-turn driving situations, while working memory was measured as the percentage of correctly answered mathematical equations pre- and post-test.

The analysis of the percentage of time spent on different circuits showed that in the control group, younger old drivers targeted predominantly the more difficult circuit 3, whereas the older old preferred the easier circuits (circuits 1 and 2). The experimental group that had received the stereotype threat showed no differences between younger old and older old, and showed no clear pattern of preference. The authors interpreted this as evidence that the control group participants were able to target a difficulty level corresponding to their region of proximal learning, but the experimental group participants were not. Regarding driving performance, drivers in the experimental group drove significantly faster than control group participants on all four circuits and irrespective of age. Whilst no differences were found in working memory performance before the drive in the simulator, participants in the stereotype condition performed significantly worse than the control group after the drive. On the basis of the findings, the authors suggested that the inclusion of a test of self-regulatory abilities could enhance the predictive validity of medical checks and could be a better predictor of driver's safety than evidence of cognitive decline per se. Furthermore, the authors emphasised the importance of providing highly personalised information on age-related changes as part

of any intervention aimed at improving older driver safety, in order to avoid potential counter-productive effects of negative stereotyping associated with non-tailored information.

2.7 Facilitating better self-regulation

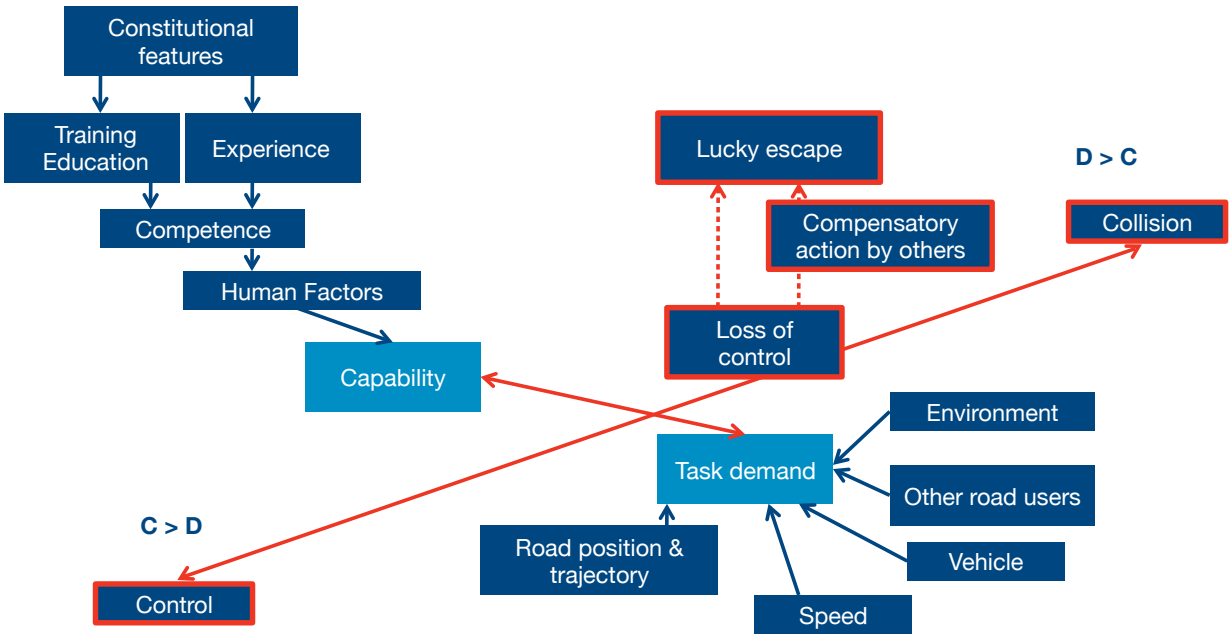
The driver psychology domain can provide pointers as to how better self-regulation may be facilitated, and develops our understanding of the concept of self-regulation and its constituent components.

In modelling driver behaviour, so-called 'motivational models' of the driving task emerged in the early 1980s. In these models, driving is described as a self-paced task, in which the driver purposefully creates the demands of the driving task in interaction with a dynamic road environment. Fuller's Task-Capability Interface model (Fuller, 2000; Fuller et al., 2008) falls into this category of motivational models (see Figure 2.3). It comprises two main components that together make up the difficulty of the driving task:

- the capability of the driver (C) and
- the demand of the driving task (D).

Simply put, if the capability of the driver exceeds the demands of the driving task (C>D), progress will be safe; if the demands of the task exceed available capability (D>C), the driver may lose control over the vehicle and (partly depending on other road users' actions) a collision may occur.

Figure 2.3: The Task-Capability Interface model



Source: Fuller (2000: 51)

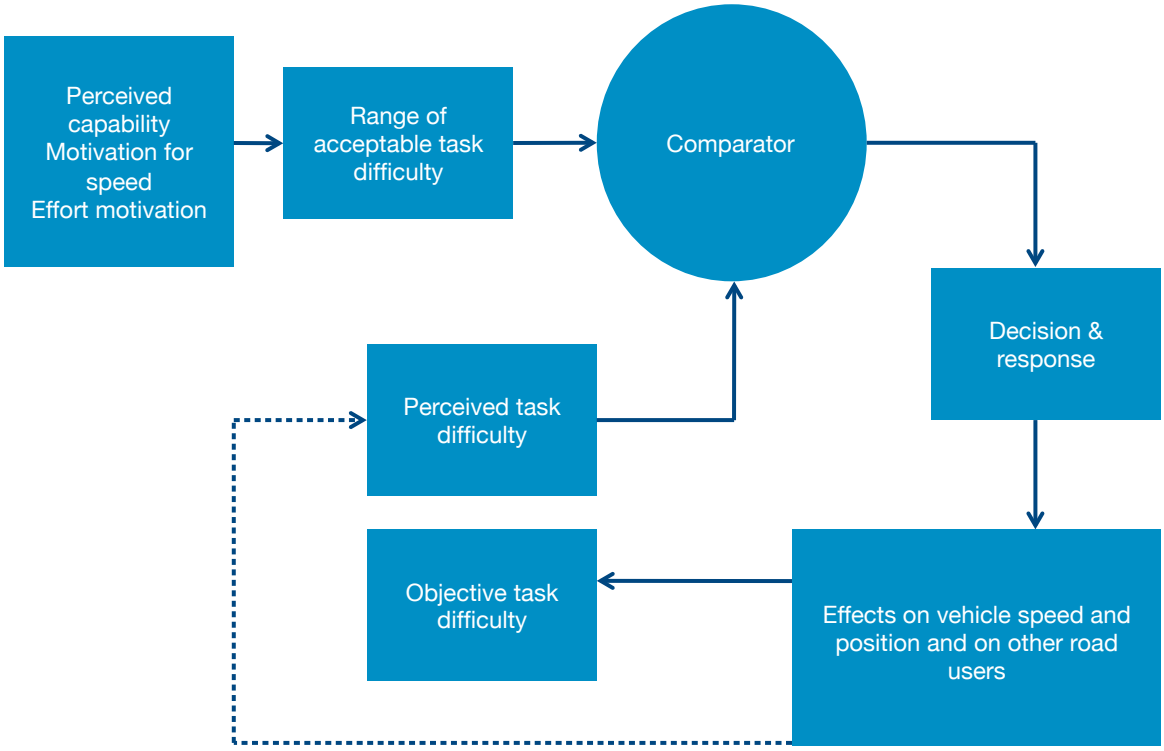
A closer look at the components of capability in Figure 2.3 shows that its upper limit is determined by biological characteristics of the driver, the so-called constitutional features, which comprise, for example, information processing capacity and speed, reaction time, physical reach, motor coordination, flexibility and strength (Fuller, 2005). Built on top are training/education and experience which determines the driver's competence, including knowledge (rules of the road, procedural knowledge defining what to do under what circumstances, and a mental representation of the road and of traffic scenarios which enable a prediction of how these scenarios will develop), and skills (basic vehicle control, and handling skills in challenging circumstances).

Capability according to Fuller can be (temporarily) modified by human factor influences (including age, attitudes, motivation, effort, fatigue, drowsiness, time of day, drugs, distraction, emotion and stress), which determine the momentary capability of the driver. Capability is also influenced by experience: based on their superior mental representations of the road environment, more experienced drivers can use top-down and feed-forward control decisions which become manifest in a more anticipatory driving style, including greater safety margins, quicker neutralisation of threats and a greater potential to recover from error (Fuller, 2009).

Whilst Fuller includes both age and experience in his model, he does, however, not specify how age-related changes of cognitive, perceptual and motor capabilities and simultaneous increases in driving experience relate to each other in determining a driver's actual capability.

Fuller's task-capability interface model introduces a differentiation between the 'actual' (or objective) and the 'perceived' (or subjective), which is of importance for the idea of calibration and the notion of self-assessment. Figure 2.4 illustrates how perceived capability and perceived task difficulty enter a comparator and ultimately inform driver decisions and responses in traffic. It is noteworthy that according to the model, the actual or objective difficulty of the driving task does not enter the driver's decision-making process. Instead driving decisions are always the result of the mental representation of task difficulty.

Figure 2.4: Perceived and objective task difficulty in the task-capability interface model



Source: Fuller (2005: 467)

In the interplay of capability and task demand, drivers can tackle the avoidance of collisions either by increasing capability, for example by increasing vigilance, or by reducing task demands, for example by reducing speed, avoiding complex manoeuvres or avoiding busy travelling times. Fuller (2005) suggested that his model also allowed the integration of taxonomies of the driving task, such as the GDE (Goals for Driver Education) matrix (Hatakka et al., 1999). A condensed version of the matrix is shown in Figure 2.5. The matrix breaks the driving task down into tasks on the control, manoeuvring and journey-related level, but also comprises the more global level of life goals and skills.

Figure 2.5: The Goals for Driver Education matrix

Source: Christ et al. (1999: 40)

Applying the Task-Capability Interface model in this context, one can differentiate between long- and short-term processes of decision-making. As an illustration, drivers can manipulate task difficulty momentarily – for example, by reducing the driving speed (which relates to decisions made on the GDE matrix's control or manoeuvring level); or they can do so long-term – for example by purchasing a car with good safety features (which relates to decisions made on the GDE matrix's planning or strategic level). Other examples of manipulation of the difficulty of the driving task include:

- choosing an easy driving route;
- allowing more time for the journey;
- avoiding driving in high traffic densities;
- avoiding driving in bad weather;
- increasing driver effort;
- increasing driving competence.

Irrespective of the time frame (long- or short-term) of the adjustments that ultimately aim to increase the safety margin that the driver has, the actual (or objective) difficulty and the perceived (or subjective) difficulty of the driving task should match as closely as possible. If perceived and actual difficulty do not match, the chosen solution to reduce task difficulty may not lead to the desired outcome. This is where the notion of 'correct calibration' comes in.

The so-called ‘calibration’ of a driver is a concept that emerged in the context of research into young driver collisions and the fact that young novice drivers frequently overestimate their driving skills, leading to age-specific collision patterns (Kuiken & Twisk, 2001). The authors described calibration as “the ability of drivers to recognise the relationship between the demands of the driving task and their own abilities, including error recovery. At any moment in time, a driver needs to be actively engaged in assessing what the driving task requires in terms of actions or the avoidance of actions, and the potential difficulties involved.” (Kuiken & Twisk, 2001: 14).

If it is accepted that correct calibration is an essential element of safe driving for young novice drivers, it can be argued that it should also apply to older drivers, and indeed to drivers of all ages. Good calibration for the older driver would mean that a driver has a correct understanding of any age-related deterioration of cognitive, perceptual and psychomotor skills, and would allow for these through processes of reducing the difficulty of the driving tasks elaborated on earlier, by taking steps such as a reduction of speed, avoidance of particularly difficult driving situations or, eventually, the replacement of driving by alternative forms of transportation. Evidence from a recent driving simulation study with young and older healthy and unimpaired current drivers presented evidence that older drivers accurately self-regulate when allowed to self-pace training of circuits of varying difficulties in a driving simulator (Moták et al., 2012a).

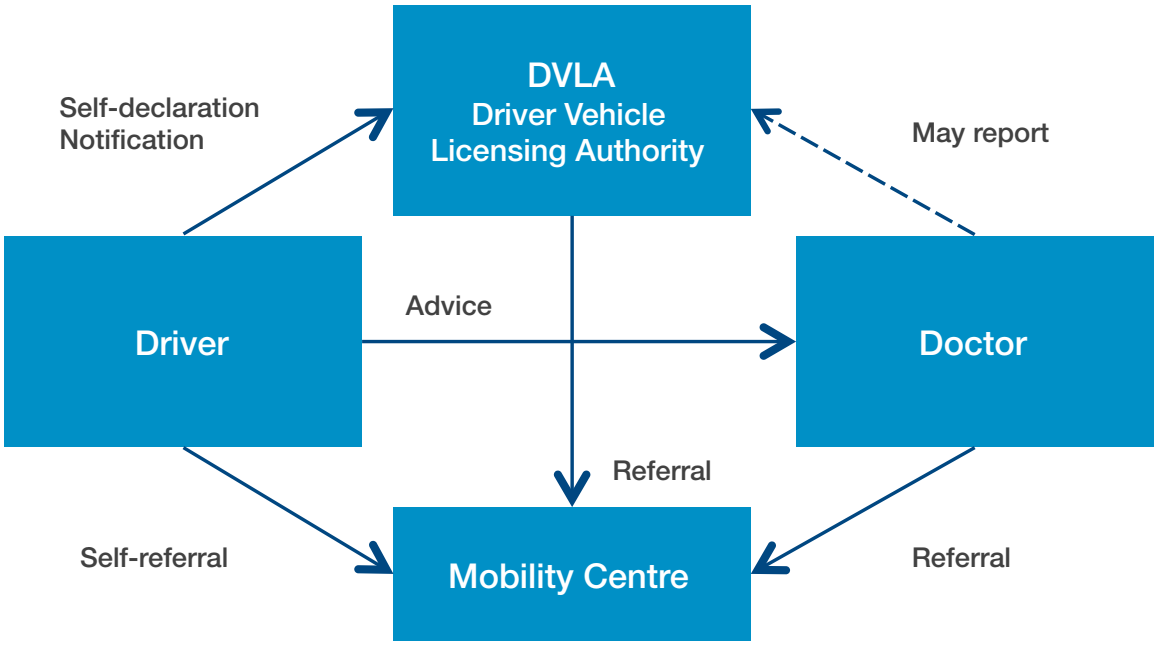
Self-assessment of capabilities essential to safe driving could, therefore, have the potential to inform and improve the calibration of drivers by identifying and quantifying the areas of age-related deteriorations that need to be compensated for by self-regulatory adjustments of the difficulty of the driving task. The possible contribution of self-assessments to the safety of young drivers has already been recognised, and has found its expression in so-called driver records, or driver logbooks, for learner and novice drivers which accompany the learning-to-drive process in several countries, such as Australia or Germany, and, in the past, also Britain. The role of comparable self-assessments of driving ability for older drivers, to facilitate compensatory adjustments of their driving styles and patterns and thus their safety on the road, have been highlighted by several experts, such as Staplin et al. (1999), Eby et al. (2008), Heikkinen et al. (2010), Husband (2010), and Baster (2012), and has stimulated the development of the self-assessment tools reviewed later in this report. Whilst these tools have been developed with the older driver in mind, and therefore typically comprise assessment categories relevant to this particular population, self-assessment of driving ability to improve calibration and compensatory action should be regarded as beneficial for drivers of all age groups from a lifelong learning perspective.

2.8 Age-related testing

Several European countries, as well as states in Australia and the USA, have some form of age-related controls or limitations on driver licensing (Hakamies-Blomqvist & Peters, 2000; Mitchell, 2008; Fildes et al., 2008), but practices vary considerably. Several overviews of licence renewal arrangements in different countries have been produced (OECD 2001; Fildes et al., 2000, 2008; Mitchell, 2008; Langford et al., 2009).

In the UK, driving licences for non-professional drivers are valid up to the age of 70. To maintain the licence after this point, drivers must submit a self-declaration of medical fitness to the Driver and Vehicle Licensing Agency (DVLA) at three-yearly intervals. Drivers, irrespective of age, are also legally required to notify the Drivers Medical Branch at the DVLA of any disability (be it a physical or a medical condition) which affects, or may become likely to affect, their fitness as a driver; the relevant medical standards are subsumed in a guidance document for medical practitioners (DVLA, 2012). The DVLA can subsequently revoke the licence (completely or temporarily)or refer the driver to one of 17 accredited Mobility Centres in the UK to undergo a comprehensive fitness-to-drive assessment (see Figure 2.6).

Figure 2.6: Medical fitness assessments in the UK



Source: Authors' own

The Mobility Centres in the UK were established to provide information, advice and assessment to people wishing to begin, or continue, using personal transport following injury, illness or, disability. Included in this provision are fitness-to-drive assessments for older drivers. The range of assessment services provided by the Centres varies, but always includes a functional examination of fitness to drive, and advice on vehicle and control adaptations where necessary. Following the assessment, Mobility Centres provide a recommendation to the DVLA of whether the examinee is considered fit to drive, unfit to drive, or whether further monitoring and examination is required before a decision can be made. It is for the DVLA to make the final decision on the extension or curtailment of the driving licence.

As illustrated in Figure 2.6, drivers can consult with their GP (General Practitioner) if in doubt over their fitness to drive, and can be referred to a Mobility Centre by their GP for an assessment; or they may self-refer there. GPs may also report a driver to the DVLA if in doubt over their fitness to drive, and when there is a concern that the driver may pose a risk to other road users. As the "GP's primary role is to provide for the patient's health rather than to police licensing" (Fildes et al., 2000: 21), this optional notification of the DVLA aims to protect doctor-patient confidentiality and avoid the potential damage to the doctor-patient relationship that may arise from the notification of the licensing agency without the older driver's consent. Fildes et al. (2000) have argued that – particularly for chronic, long-term illnesses –the reaction of patients to losing their licence may jeopardise their treatment. They also reported that GPs are often uncertain as to what constitutes an acceptable crash risk with regard to presented conditions and disabilities. Similarly,

the Breen et al. (2007) report provides evidence that psychiatrists also have poor knowledge of the guidelines issued by the DVLA, and that relatively few patients are advised that they should not drive. Thus it is also possible that fitness-to-drive issues are not at the forefront of GPs' minds when seeing patients. A recent DfT study into GPs' knowledge and attitudes to giving advice on fitness to drive indicated that they would benefit from computer-prompts and would welcome information materials that could be distributed to patients and the general public (Hawley, 2011). Whilst not included in the figure above, the family, friends and social network of the older driver are an important trigger for decisions to adapt or cease driving, or to seek a specialist fitness-to-drive assessment. Research presented by Musselwhite (2011) indicates that older drivers who made the decision to cease driving themselves were more accepting and happier with the outcome. They also reported a higher quality of life than those who were pressured to give up driving by family members or medical professionals.

Despite the fact that many countries have some form of age-related controls in place, evaluations of their safety impacts indicate consistently that they are ineffective in identifying older drivers with a heightened crash risk attributable to functional impairment. An OECD expert group concluded in 2001 that age-based mandatory assessments to identify drivers who were no longer fit to drive were neither cost-effective nor beneficial" (OECD, 2001). A range of international studies have corroborated this conclusion.

A comprehensive study carried out by Grabowski et al. (2004) in the USA used a regression approach to assess how licensing arrangements in different states – such as in-person licence renewal, vision tests, road tests and frequency of licence renewal – impacted on the fatality risk of drivers aged 25–64 and older (subdivided as 65–74, 75–84, and 85+). The regression approach at the same time controlled for state-level differences, such as different seat belt laws, speed limits, drink-driving laws and the number of licensed older drivers. The authors found that the only policy that related to older drivers and was significantly associated with a lower fatality risk (incident rate ratio 0.83; 95% confidence interval 0.72–0.96) was the requirement for in-person licence renewals; however, this only held true for drivers aged 85 and over. None of the other state-mandated assessment measures, including vision tests, road tests, more frequent licence renewals and in-person renewal (for drivers aged 65 to 84) were significantly associated with the fatality rate of older drivers, and thus with additional road safety benefits for older drivers.

Similar findings were reported for the comparison of older driver collision rates in Australia – in Sydney (where there is mandatory assessment from 80 years onwards) and Melbourne (in which there are no age-based controls) (Langford et al., 2004). Arguing that differences in driving activity between drivers may disguise actual differences in collision risk, the authors compared collision rates on four exposure measures: (1) per population, (2) per licensed driver, (3) per distance driven and (4) per time spent driving. Significant differences

in collision risk were only found for two of the exposure measures (per licence and per time spent driving) and suggested that, contrary to expectation, the older drivers in Sydney (with age-based controls) had higher collision risks than those in Melbourne (who had no controls). A subsequent study compared fatality rates of older drivers in the two Australian states: Victoria (where there are no age-based controls) and New South Wales (in which there is mandatory submission of a medical certificate from 80 onwards, and completion of an on-road test from 85 years onwards), spanning a period from 1988 to 2001. The authors found no significant differences between the fatality rates of older drivers in the two jurisdictions. Similarly, no significant differences were found for the fatality rates of all other road users, including road users not in the older drivers' vehicle, and older drivers' passengers (Langford et al., 2008).

A comparative study between Finland (where a compulsory system of medical checks starts at age 70) and Sweden (where there is no age-related screening) indicated that the age-related collision trends of older private car drivers in Finland were similar to those in Sweden (Hakamies-Blomqvist et al., 1996). No demonstrable safety benefit for car driving in Finland was found, even though Hakamies-Blomqvist and Peters (2000) suggested that this may be due to methodological limitations. Finland's comparatively higher pedestrian fatality rate for people of 70 years and over raised the question of whether the age-based screening may have led to a modal shift towards less safe forms of transport such as walking. Further research into this question was undertaken by Siren and Meng (2012), who investigated the safety impacts of the introduction of age-based cognitive screening starting from the age of 70 in Denmark in May 2006, in a population-based study. The research compared the per-capita collision rates for drivers and vulnerable road users aged 18–69 and 70+ before (2003–6) and after (2006–8) the introduction of the screening. Whilst collision rates for car drivers did not significantly change for either age group in the post-implementation period, the collision rate for older vulnerable road users in the post-implementation period increased significantly: by 38%. The authors suggested this indicated that the new screening procedure has produced a modal shift for older people from the comparatively safe activity of driving to less protected forms of mobility.

Similar conclusions are drawn by Mitchell (2008) in his comparison of the fatality rates of drivers aged 65 and over in three European countries (France, the Netherlands and the UK) which had relaxed licence renewal procedures with those of older drivers in four European countries with more demanding processes (Denmark, Finland, Norway and Sweden). He interprets the finding that the lowest fatality rates for this age group occur in two of the countries (UK and the Netherlands) with more relaxed procedures as evidence that stringent licensing procedures have no effect on the overall road safety of drivers aged 65 and over. Mitchell also suggests that more stringent procedures reduce the level of car driving licences among older people and tend to expose older people to greater fatality risks as pedestrians.

In their review of the literature on traffic safety measures for older drivers, Heikkinen et al. (2010) found gender effects of restrictive licensing policies, suggesting that it is predominantly older females who cease driving if such measures are implemented – however, usually not for medical reasons (see also Siren, Heikkinen & Hakamies-Blomqvist., 2001). Reasons for giving up driving were also shown to differ between the sexes by Hakamies-Blomqvist and Wahlström (1998). For men, deteriorating health was the most frequent reason to cease driving; women reported, in equal proportions, that they either did not need a car or that it was expensive to run.

The consistent findings of the ineffectiveness of a wide variety of age-based licensing practices around the world have led to a change in thinking and the promotion of a more targeted approach to licence reassessments for older drivers, with the aim of identifying those most at risk instead of subjecting all drivers to costly and inefficient age-based controls (Fildes et al. 2008; Langford et al., 2009). The debate has shifted in recent years away from chronological age as a determinant of fitness to drive, towards a functional definition of age and towards procedures that can most successfully differentiate between 'unsafe' and 'safe' drivers, and towards a focus on the link between age-related declines and collisions, in order to maintain the mobility of the 'safe' drivers for as long as possible (Dobbs et al., 1998; Stutts, Stewart & Martell, 1998; Eby et al., 2008; Selander et al., 2011). Large research programmes into age-related changes in driving capabilities, and developments of models for multi-tiered assessments in California, Maryland and Australia, have been the logical consequence of this development (Eby et al., 2003). Implicit in the development of multi-tiered assessment systems is the need to define multiple cut-off points for each functional test used as a predictor variable for older driver safety: one to differentiate unimpaired drivers from those who are mildly impaired, and who should receive education and awareness measures to enable them to compensate for the observed impairment; and another to trigger specialist in-depth assessment after severe impairment is identified (Staplin et al., 2003c).

Early work was carried out by the American NHTSA in conjunction with the California Department of Motor Vehicles to develop a model for a three-tiered assessment procedure that could identify drivers who may be at an increased risk of being involved in an a collision (Janke & Eberhard, 1998). The first tier was to comprise brief and inexpensive screening tests, carried out by trained staff in a licensing agency field office that would identify impaired licence applicants whose driving was likely to be affected. The second-tier assessment, to be carried out by qualified agency staff and involving more elaborate tests, was aimed at identifying those drivers who would perform badly on the third-tier assessment, an on-road test. The selection of tests to be included in the assessment process was informed by a comprehensive review of the literature (Janke, 1994); an initial pilot study with 75 older drivers with medical conditions and 31 healthy controls of the same age (65 years and over) served to provide indicative findings regarding the tests' abilities to discriminate between impaired and non-impaired drivers (Janke, 2001).

A similar research project, the 'Model Driver Screening and Evaluation Program', was initiated by NHTSA in 1996 with the aim of updating the guidelines for screening and evaluating medical fitness to drive, published in association with the American Association of Motor Vehicle Administrators (Staplin et al., 2003a, 2003b) and including the production of the self-awareness checklist 'How is your driving health?' (available at www.nhtsa.gov/people/injury/olddrive/modeldriver/3_app_g.htm).

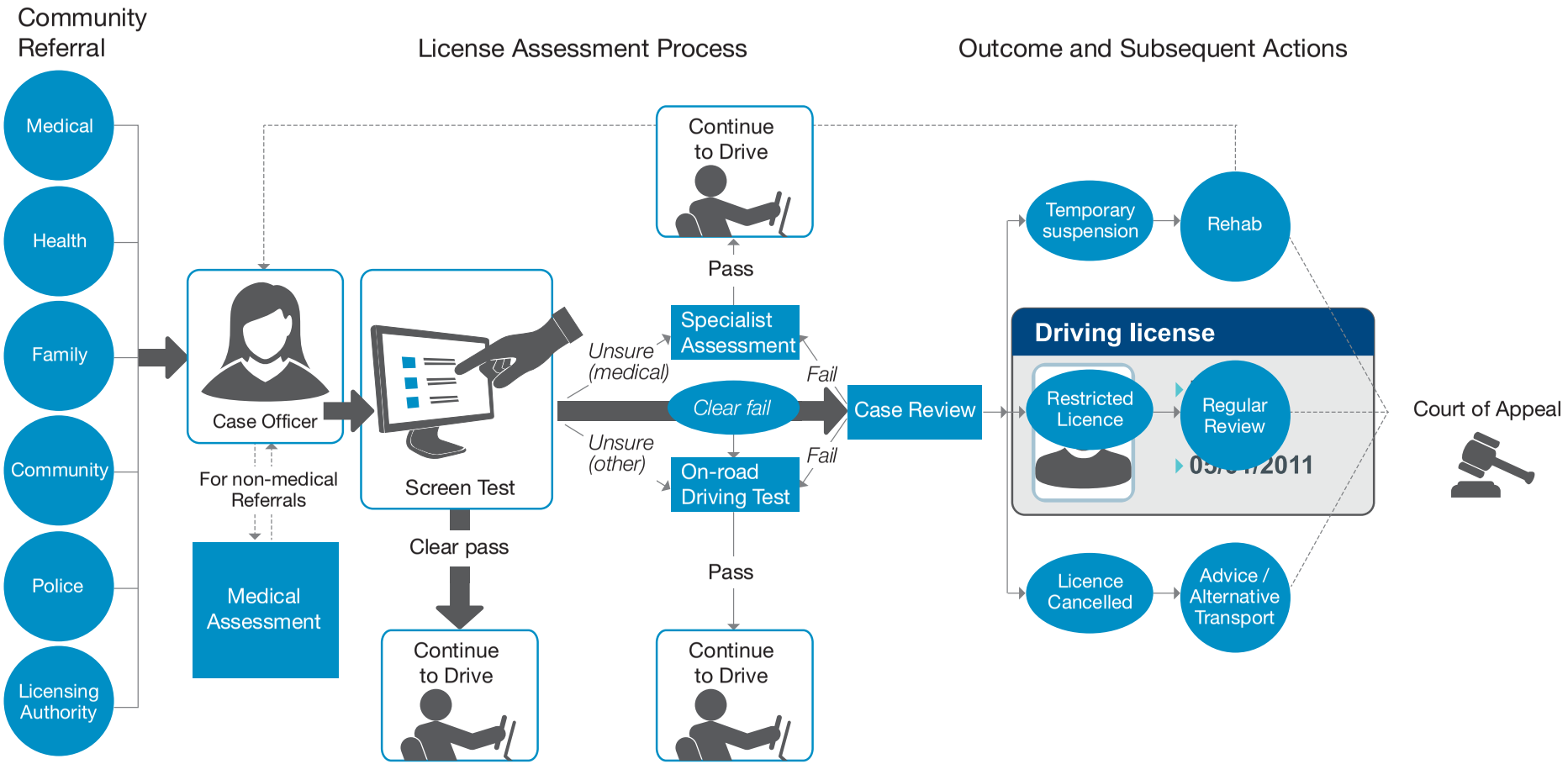
Part of the project was the large Maryland Pilot Older Driver Study (MaryPODS), which investigated the relationships between functional ability as measured by a screening battery, the so-called Gross Impairments Screening. Five visuo-cognitive tests and four physical ability tests were included. The focus on "gross" impairment in the research reflected the interest of developing a scientifically valid, but also practical, tool that could be easily, inexpensively and briefly administered without requiring significant amounts of training. MaryPODS linked the test results to violations and collisions with 1,876 impaired and healthy drivers. Statistically significantly higher risks of collision involvement (based on peak valid odds ratios[2]) for those drivers who failed the tests, as compared with those who passed, were found for retrospective and prospective at-fault collision involvement. For at-fault crashes, the odds ratios ranged from 2.48 to 4.96. The authors concluded that there was scientifically robust evidence for the potential of quick, office-based functional capacity screening to predict risk of driver impairment, which could be made available to specialists at a cost of US$5. They suggested that the use of such assessments in combination with education, counselling of those no longer fit to drive, and planning of alternative transport options, could benefit individuals and also society as a whole.

2 Odds Ratios describe the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. An odds ratio of 1 means that the odds of the event occurring is the same for both groups, an odds ratio greater 1 means that the odds of the event occurring are greater in the group under observation than the reference group.

The original odds ratios calculated in MaryPODS – to characterise the relationship between functional status and accident involvement of those drivers who failed on each of the subtests and those of drivers who passed – were subsequently updated with an additional year's data on collision involvement of the sample, provided by the Maryland Motor Vehicle Administration (Staplin et al., 2003). The comparison of the peak valid odds ratios from the original with those of the new study confirmed previously identified relationships, but suggested that the predictive value of functional tests for involvement in at-fault collisions decreased over time, particularly for the visuo-cognitive measures. The authors concluded that for functional capacity screening to be effective, assessment intervals should be no more than two years apart.

The American research served as a basis for the development of the 'Australasian model licence assessment procedure', developed by the Monash University Accident Research Center on behalf of Austroads, (see Figure 2.7) with an intended implementation by all jurisdictions in Australia and New Zealand. The model includes a range of community referral mechanisms, multi-level assessment of a driver's functional ability, the use of valid and reliable assessment tools, the provision of a range of outcome options for referred and assessed drivers, the establishment of a case officer position, and the option for assessments to be conducted by both government and non-government agencies (Fildes et al. 2000, 2008).

Figure 2.7: The Australasian model licence assessment procedure



Source: Fildes et al. (2000: 22)

An initial research programme to examine the screening tests' capacity to predict driving performance (but not crash risk) `on a specifically designed on-road driving test was carried out in Wellington, New Zealand, with a sample of approximately 1,000 current drivers aged 79 or older. A subsequent evaluation of the effectiveness of the selected 16 assessment protocols covering all three levels of the assessment in the model included 62 potentially impaired participants and 62 healthy controls. The authors found no evidence that the screening tests were able to distinguish between safe and unsafe drivers, and recommended that the tests were therefore unlikely to be useful to licensing authorities, leaving the Austroads models currently inoperable and necessitating further research (Langford et al., 2009).

2.9 Summary of evidence and its impact on the current policy context

The previous sections of this report have provided an overview of current developments and practices in Britain and abroad in relation to older drivers. The main findings are as follows:

- The older population is growing, heterogeneous and increasingly mobile.
- Mobility is an important aspect of independence, autonomy and well-being.
- Driving provides comparatively safe mobility for older people (and the road users around them), and fatality rates of older drivers in Britain are decreasing.
- The majority of older people successfully adapt their driving styles and patterns, and maintain safe driving records; this adaptation to age-related deterioration in cognitive, sensory and motor function is referred to as self-regulation, even though greater flexibility with regard to driving times and situations and a greater prioritisation of driving comfort may account for some of the observed changes, too.
- There is evidence that a small proportion of older drivers do not self-regulate, and research on driving cessation (the endpoint of self-regulation) suggests that a small proportion of former drivers feel that they have surrendered their licences too early.
- Self-regulation alone is unlikely to be sufficient to maintain the safety of older drivers. There is also evidence to suggest that older drivers welcome feedback on cognitive and perceptual capabilities, and use it to adapt their driving styles accordingly. However, there is also evidence to suggest that such information should be highly personalised if it is to be of benefit to the driver.
- Existing age-based licensing procedures are not cost-effective and do not provide road safety benefits, but may actually put older people at risk by reducing licensure rates and triggering modal shift towards less safe forms of transport.
- Alternative approaches towards identifying the small proportion of potentially unsafe drivers comprise multi-tiered assessments whereby older drivers whose safety may be at risk undergo cost-effective office-based

screening tests before more specialised assessments are carried out.
- Despite a growing body of evidence, there is currently no international agreement on a standardised battery of easy-to-use and cost-effective diagnostic tools with good reliability and predictive value for road safety outcomes.

The majority of older drivers do not represent a significant safety problem in Britain at present, nor, arguably, will they do so in future. Countries with more stringent relicensing procedures do not achieve significantly greater road benefits, but have to shoulder the costs of these procedures. The growing acknowledgement of the diversity of the ageing process, and the associated shift in thinking away from testing that is based on chronological age and towards assessments that focus on functional age, represent significant progress. However, alternative and standardised approaches that can reliably differentiate between the fit and unfit driver are still at the development stage, and far from reaching consensus. Current policies in Britain in relation to older drivers are therefore unlikely to change in the near future.

These findings should not lead to the conclusion that no further effort needs to be directed at maintaining older drivers' safety. Given the likely increase in the number of older drivers over the coming decades, safety is most likely to be improved by strategies that are aimed at the entire driving population but which bear older drivers in mind (Gandolfi, 2009). The summary overview of present knowledge indicates that many older drivers welcome, and are willing to engage in, interventions that help them maintain mobility by enabling them to self-regulate better. Providing opportunities and tools to older drivers to self-assess their driving-related capabilities has the potential to enhance self-regulation of those using them and, with that, the decisions that older drivers make about when, where and how they drive.

Research studies indicate that the prospect of stringent obligatory relicensing procedures causes older drivers considerable concern, and that their perceived acceptability is low (Parker et al., 2003). In contrast, self-assessment tools afford older drivers the opportunity to assess their driving-related capabilities in private and without stress potentially affecting their performance. The feedback provided by the tool can then enable them to take appropriate action to address any issues flagged; can facilitate discussions with family members, the social network and medical practitioners; and can, ultimately, enable better planning of alternative transport options for when they eventually cease to drive.

Several researchers have advocated self-assessment tools as a cost-effective way of screening for age-related deteriorations of driving capability. For the success of a screening tool, it is important to assess those components of driving capability that are relevant to safe driving and deteriorate with age. The following chapter reviews evidence of the age-related changes to cognitive, perceptual and motor capabilities, and their potential link to road safety outcomes, in order to provide the reader with an evidence base against which existing self-assessment tools for older drivers are subsequently described and considered in more detail.

3. Age-Related Changes in Cognitive, Sensory and Psychomotor Driving Capabilities

Ageing brings about eventual deteriorations in the ability to gather appropriate and accurate information through sight, hearing and balance; to move correctly or effectively; and to make successful, timely decisions. These reductions vary markedly between individuals, and the rate of decline of a particular ability is not necessarily accompanied by similar declines in others. It is commonly agreed that chronological age, or a particular medical diagnosis, is a poor predictor of this sensory, motor and cognitive functioning in a general sense, and does not of itself determine an individual's specific fitness to drive (Folkerts, 1993).

General reviews in this area include Koppel et al. (2009), Reger et al. (2004), Parasuraman and Nestor (1991), McGwin et al. (2000); they all point to a complicated picture of variable rates of decline and associations with important real-life tasks.

In order to understand how the maturing process affects these capabilities, studies of brain structure and functioning have focused on identifying the key areas that show age-related changes. As we age, particularly during adolescence and early adulthood, the brain undergoes a series of developments which result in the specialisation of brain function and faster communication between brain regions. This facilitates improvement in information processing, as the network of areas used for particular tasks becomes more specialised, and thus more effective.

With older age come observable physical changes in the brain in terms of volumes of grey and white matter, dopaminergic dysfunction[3] and decline, and a reduction in the asymmetry (localisation) of brain function, particularly after the age of 50, but declining more sharply after age 70 (for a review refer to Dennis & Cabeza, 2008; Sun et al., 2012). These changes are related to the speed and accuracy of message transmission within the brain and, consequently, age-related differences in how the information is processed.[4]

3 Dopamine is a neurotransmitter which is produced in several areas of the brain, including the substantia nigra and the ventral tegmental area. Dopamine has many functions in the brain and is involved in reward-driven learning, voluntary movement control, and motivation. Dopamine dysfunction in the frontal lobes of the brain has been linked to declines in cognition, especially memory, attention and problem-solving.

4 In terms of brain function, reduction in occipital lobe activity (related to vision) is accompanied by an increase in activity in the prefrontal cortex, the centre for higher-order cognitive processes. This pattern is known as posterior-anterior shifting in ageing (PASA) and it means that as people age, brain functioning becomes more diffuse, and less specialized. This compensatory mechanism is believed to mediate the ability to continue to perform tasks correctly even at advanced ages, but may result in decreased response times. Nonetheless, this compensation mechanism is only a buffer, as PFC function itself is also vulnerable to age-related declines. This includes executive functioning, which is understood as the mechanisms in charge of regulating, controlling and managing other cognitive processes and functions, such as task-switching, problem-solving, working memory, and so on.

Executive functioning has been identified as a key capacity that is affected by age. One study by MacPherson and colleagues (2002) compared three groups of adults of different ages (the oldest group being aged 61–80) to assess the role of the prefrontal cortex (PFC) on performance on tasks involving working memory (which controls movement of information between long-term and temporary memory storage) and executive functioning. Results showed an age-related effect on all tasks, with older participants having the worst performance.

Similarly, a review of the biology of ageing (Hedden & Gabrieli, 2004) highlighted findings that associated the PFC with cognitive functions such as task-switching, fluid intelligence, attention, and working memory. The authors found the general results as being indicative that older adults experienced greater difficulty in performing executive functions, and that this was strongly related to changes in PFC function.

So, as a generalisation, we can say that starting at around the age of 50, and accelerating from around the age of 70, we are all likely to experience some physical and cognitive deterioration. This general reduction in prior performance may lead to an increase in difficulty experienced in some tasks, though whether that difficulty is a cause for concern will depend on the precise combination of abilities required, and the consequences of error or slowed responses. For many tasks, an age-related deterioration in performance can be frustrating, but not necessarily catastrophic. For other tasks, such as driving, a point might inevitability be reached where continued activity may provide a significant risk for the individual concerned and also for others around them.

3.1 Cognitive, sensory and psychomotor abilities relevant to driving

Of the sensory, motor and cognitive abilities that are likely to decline with age, it is important to understand which are related to driving performance or behaviour, and whether any firm criteria exist which link capability to risk of crash and injury. Stutts and Wilkins (2003: 431) summarise their view of the relationship between capability and crash risk in older drivers as follows:

> "The reality of ageing… is that many of the sensory, physical, and mental skills needed to safely operate a motor vehicle deteriorate. As a group, older adults have poorer visual acuity, reduced night time vision, poorer depth perception, and greater sensitivity to glare; they have reduced muscle strength, decreased flexibility in the neck and trunk, and slower reaction times; they also are less able to divide their attention among tasks, filter out unimportant stimuli, and make quick judgements."

Older adults are also more likely to suffer from chronic medical conditions and to require medications for their treatment, which can further compromise their ability to drive (Dobbs, 2002; Janke, 1994).

However, it is important to recognise that though a deterioration can be detected, and the control of the vehicle – or coping with the traffic situation – might become more difficult or effortful for the driver, a direct link to increases in accident risk can be difficult to establish. Determining performance criteria that have valid relationships with notions of safe driving is even more challenging.

It should also be remembered in this context that successful driving is a function not only of underlying abilities and understanding, but also of tactics, beliefs and attitudes. Older drivers may develop compensatory driving styles over time that, whilst effective, may not be completely in line with normal test standards. This will be especially evident when that decline is gradual. For example, there is a general reduction in total binocular sensory field of view with age. When the reduction in the area that can be seen is modest and slow, the driver is likely to be unaware of the extent, or even existence, of the decline unless involved in some form of performance test. Subtle changes in scanning pattern can accompany the decline, and small increases in head movement can ameliorate the reduced range of vision. In these cases the driver may not even be aware that more effort is being devoted to driving.

3.1.1 Sensory deficits

Vision is central to performing the driving task, as this function mediates higher-order processes such as attention allocation, hazard perception, and decision-making. Studies on ageing have shown an age-related decrease in occipital lobe activity which is believed to relate to deficits in visual perception (Dennis & Cabeza, 2008). Earlier, Janke (1994) stated that a high proportion of elderly drivers will show serious limitations in their visual performance under typical driving conditions. Visual acuity, both static and dynamic, have been implicated in driving, although poor dynamic acuity (the ability to perceive a moving target) has shown a stronger relationship to driving errors than a decline in static acuity. Visual acuity follows an inverted U-shaped curve over the course of life, with adults over 50 starting to show declines. However, Janke (1994) is careful to assert that there is great variability in acuity at older ages, and that age alone cannot determine deteriorations in functioning.

Contrast sensitivity,[5] the ability of the visual system to distinguish between an object and its background, has also shown age-related declines and is considered important for driving safely. A person with low contrast sensitivity may have driving difficulties such as:

- trouble seeing traffic lights or vehicles at night;
- missing facial gestures;
- experience tired eyes in low light conditions;
- inability to see small objects unless contrast is high.

5 Contrast sensitivity is typically measured as the ability to see a shade of grey against a white background.

Surprisingly, in a review by NHTSA (2008), it was clear that findings regarding its association with crash risk were only weak to moderate. As Ball et al. (1993) affirm, an approach limited to visual sensory factors is, by itself, inadequate in identifying factors that place older adults at risk of driving problems.

The evidence of the influence of deterioration of both proprioception (sense of touch and position) and of balance was reviewed by Carter (2008), who found no strong relation to driving.

Hearing provides all-round information – unlike vision, which is restricted to direction of gaze and field of view. It enables the driver to benefit from perception of warnings and alarms in the traffic environment, and will also better calibrate their perception of speed and vehicle performance. Nevertheless, Dobbs (2005), in a meta-analysis of existing research, showed that deafness, even when profound, is not a barrier to car driving, and reviewed evidence of a relationship with driving performance. It was seen to be variable across studies, and there was no strong association with increased crash risk.

3.1.2 Motor decline

Motor abilities, in terms of range of movement, speed of execution and strength, are necessary for the safe operation of vehicles and for turning to view mirrors and oncoming traffic, amongst other driving-related activities. Though modern vehicles with power-assisted braking and steering functions, automatic transmissions and comprehensive mirrors, are much less demanding of the physical capabilities of the driver than in the past, the driver is still required to exert forces through arms and legs, and to make movements of the trunk and head to drive successfully.

Two major reviews of the research literature (Janke, 1994; NHTSA, 2008) on age-related decline have identified a number of physical functions that have consistently been found to relate to driving ability. Lower and upper limb mobility, as well as head and neck range of motion, are believed to affect older drivers' ability to drive safely. Lower limb function is needed to shift the foot from the accelerator to the brake in an emergency situation. Research has shown that elderly drivers who commit more pedal errors (failing to stop, or accelerating inappropriately) were at higher risk of crash involvement (Freund et al., 2008).

Similarly, difficulty reaching out and head turning have also been shown to be predictive of crash involvement. The latter is of particular importance, given that older drivers are at higher risk of crashes at intersections, where the ability to assess oncoming traffic from either direction is crucial for merging safely onto the road (Clarke et al., 2010).

3.1.3 Cognitive decline

A prerequisite for driving is the integration of high-level cognitive functions with perception and motor function (Wagner et al., 2011). As research has shown that cognitive abilities decline with age, it is important to identify which of these are related to driving. A body of research has identified a number of such capabilities, including:

- attention (Lopez-Ramon et al., 2011; Dawson et al., 2010);
- working memory (MacPherson et al., 2002; Grady & Craik, 2000);
- executive function (Wagner et al., 2011; Salthouse, 2010; Dawson et al., 2010; Andrews & Westerman, 2012; Mathias & Lucas, 2009; Selander et al., 2011);
- task-switching (MacPherson et al., 2002);
- hazard perception (Horswill et al., 2010);
- perceptual speed (Salthouse, 2010);
- visual perception (Dennis & Cabeza, 2008).

However, of these capabilities, the ones that have most often been at the centre of research are attention, working memory, and executive function.

Take, for example, intersections, which are the most common road accident environment across all driver age groups, but with older drivers significantly overrepresented. Close to 40% of fatalities and 60% of injuries to drivers over 65 occur at such junctions, and most especially while performing right turns. Turning at intersections involves several tasks likely to be affected by attention decline:

- braking to a specific point;
- time-to-contact (TTC) judgements (concerning oncoming cars);
- time gap judgements.

Previously, the greater rate of accidents at intersections has been attributed to misjudgements of distance or speed of an oncoming vehicle, or misjudgement of gaps. So far, the effects of visual distractions in real road scenes, in particular with reference to attentional decline in older drivers, have not been addressed fully.

It is interesting to note that there appears to be little or no age-related decline in motion perception; however, clear age-related deficits have been found in more complex tasks, such as judgement of TTC with oncoming vehicles. Several studies have found little or no age-related decline in the perception of radial motion (involving image expansion or contraction), which is the motion pattern that underpins TTC judgements, but declines have been found on tasks such as distinguishing forward from backward movement, direction of self-motion, or TTC itself. There is a discrepancy between results from driving-related tasks (which are shown to be age-impaired) and simple motion discriminations (shown to be not impaired).

Age-related decline in attentional control is one possible explanation for this difference. When there are multiple items heading towards the observer, each must be inspected in turn to decide whether it will collide, which strongly suggests that the perception of heading or TTC requires attention. Also, poor heading discrimination is correlated with attentional deficits rather than perceptual deficits in older adults. This suggests that older adults may rely increasingly on attention to aid motion judgements whilst driving. When tested in the laboratory on simple tasks, without distraction, performance might be maintained; but when distracters are added, older adults are impaired by their poorer ability to exclude distractions, leading in turn to impairments in motion judgements. So, the more realistically representative of real-world demands the task is, the greater the extent to which the age-related deficit is revealed.

The picture that emerges is not surprising. The functional capabilities, changes in which are regarded in the literature to be of importance, and decreases in which have an association with increased crash risk are:

- static and dynamic acuity;
- contrast sensitivity;
- upper and lower limb movement and head turning;
- judgement of speed and distance;
- the ability to ignore distractions.

3.2 How are functional abilities measured?

The driving task is a dynamic psychomotor control task with a continuous set of adjustments necessary for altering the speed and direction of the vehicle and manoeuvring in relation to emerging hazards.

- Safe driving requires of drivers (Carter, 2008):
- effective and reliable control of the vehicle;
- the ability to respond to the road and traffic around them;
- knowledge of and willingness to follow rules of the road.

The UK driving test has three main components: a test of knowledge of driving theory, a test of hazard perception, and an on-road basic practical skills test. In the UK the licensing of a car driver is entirely dependent on the driver's self-declaration of any disability, with the exception of a simple vision test and any observations made by a driving examiner at the time of the test for new drivers. Medical information is only used where there is an indication of a problem, normally after a declaration by the driver or because of a notification to the DVLA from someone else, such as a relative or health professional. There is thus, at the time of licence acquisition, no requirement for a quantitative test of many basic sensory, motor or cognitive abilities. Driving competence is assessed largely through the output measure of errors in the practical element of the driving test.

This is a fundamentally different approach to that needed by the elderly for self-assessment of future crash potential. In order to quantify the relationship between cognitive abilities and the risk for crash in older and medically impaired drivers, as well as to provide a systematic and reliable assessment of such abilities, standardised tests have been developed. These have been subject to extensive review by Janke (1994), Carter (2008), NHTSA (2008) and Langford et al. (2009), and fall into two general categories: neurophysiological tests and self-report questionnaires.

3.2.1 Motor ability

Reviews have identified that tests of motor ability, such as the *Rapid-Pace Walk* and *Alternating Foot-Tap Test*, were good predictors of the likelihood of being involved in a crash. The Rapid-Pace Walk is a measure of lower limb strength, endurance, range of motion, balance and proprioception, in which participants are asked to walk a 20-foot path as quickly as possible. The foot-tap test is an alternative measure of lower limb mobility, and requires participants to touch the floor with their right foot ten times at two different distances (chosen to simulate movement between accelerator and brake).

3.2.2 Visual attention

Assessments based solely on vision and perception have proved to be of limited value in predicting crash risk. An alternative proposed by Ball et al. (1993) is to examine the role of attention factors in driving performance. The *Useful Field of View* (UFOV) test is a computer-based measure of processing speed and attention that has been used consistently in mobility research. It is based on the measurement of the visual area over which information can be

acquired in a brief glance without eye or head movements (Ball et al., 2002). The test is divided into three subtests: the first section measures processing speed alone, while the second and third subtests measure processing speed for divided attention and selective attention tasks respectively (Selander et al., 2011).

The first subtest requires participants to identify a target (a silhouette) presented in a central fixation box, while the second involves the identification of a central and a peripheral target simultaneously (Clay et al., 2005). The third level requires central and peripheral target identification within a background of distractor shapes. Its use with elderly populations has been generally supported, and normative data has been provided (Edwards et al., 2006).

The UFOV test is widely used in mobility research, as well as for driver-relicensing processes in several countries. Studies varying in methodology and sample size have been able to identify a relationship between UFOV test scores and different driving performance measures. More recently, a study by Selander et al. (2011) investigating driving errors characteristic of older drivers assessed 85 volunteers between the ages of 65 and 85 on a number of measures including UFOV. Results showed correlations between the second (divided attention) and third (selective attention) subtests and both on-road and off-road tests. Another recent study by Bélanger et al. (2010) also found that older participants (mean age=73.4) who crashed in a driving simulator task had lower scores on the divided attention and selective attention subtests than those of non-crashers.

The study by Edwards et al. (2006) in the USA used a large community sample of older adults (n=2,759) in order to provide normative data, and explored performance by age, gender and level of education. Results identified that although the UFOV test relies on visual function, it also taps into higher-order cognitive abilities, and older age was a significant predictor of UFOV task performance. These findings are important, as it supports the construct validity of the UFOV test with a large community-based sample.

A cumulative meta-analysis study by Clay et al. (2005) sought to examine the relationship between UFOV and a number of commonly used objective measures of driving performance, including accident records, and both off-road and simulator driving. They identified eight studies between 1985 and 2003 that met the study criteria and were included in the analysis. Results showed that the relationship between UFOV test performance and driving was robust across studies, and hence across different measures of driving performance.

Although UFOV has been found to relate to measures such as crash involvement and driving performance, results of studies have not always been straightforward. For example, the study by Selander et al. (2011) showed only weak correlation between UFOV (subsets 2 and 3) and two on-road driving tests. The authors of the 2005 meta-analysis identified only eight studies, five

of which included older drivers with known mild impairments such as early Alzheimer disease and drivers referred to a driving programme. Similarly, a study in Australia based on data from 39 participants (mean age=81.67) failed to identify an association between participants' pass or fail status on the UFOV test and prior crash involvement (Bohensky, Martin, Charlton & Langford, 2007). These studies show the UFOV test to be highly promising, but not definitive.

3.2.3 Decision making ability

While attention as a whole is regarded as an important capability necessary for safe driving, more subtle processes such as detecting small changes in the environment may also have a role to play. *Change blindness* is understood as the inability of drivers to effectively detect changes in a dynamic environment (Caird et al., 2005). It has been studied in the context of driving, and has been shown to correlate with UFOV (Rizzo et al., 2009; Lees et al., 2007). A study by Rizzo et al. (2009) looked into changes in change blindness across age groups from 20 to 84. Regression analysis found that hit rate (correct responses) decline and reaction times on change blindness increased with age. They also found that there were different age thresholds at which change blindness accelerated; hit rate decline was first observed at age 54 and reaction time slowing followed at age 68. In comparison, the threshold for the UFOV test was 64. This may reflect the differences in what the tasks measure, as the UFOV test relates primarily to, visual spatial ability, whilst change blindness relates to attention and evaluation (Lees et al., 2007).

The *Trail Making Test* (TMT) (NHTSA, 2003) has been used to measure executive function. It consists of two parts, A and B, and it is believed to tap into a number of abilities such as visual search, perceptual motor speed, speed of processing, working memory and general intelligence (Sánchez-Cubillo et al., 2009). In TMT A, participants are required to draw lines to sequentially connect numbered circles as quickly as possible, without lifting the pencil from the page; part B of the test involves connecting encircled numbers and letters (1–A–2–B–3 etc.) randomly arranged on a page. Specifically, TMT A measures visual search capability, TMT B primarily reflects working memory and task-switching ability, whilst the TMT (A-B) difference score reflects executive control abilities.

Studies have aimed to assess the relationship between TMT task performance and driving ability. One study found that both the UFOV test and TMT were predictive of performance on a rural highway course, with a sample of 26 participants (mean age=63) (Mullen et al., 2008). Following this and similar findings, a recent study aimed to develop a predictive model for at-risk older drivers using a number of variables (cognitive, visual, and motor) to predict driving cessation and crash risk in a sample of 100 drivers aged 65–89. They found that poorer scores on TMT B or TMT (A-B), and serious on-road errors, predicted crashes (Emerson et al., 2012). Interestingly, this study did not identify a relationship between the UFOV test and crashes. Similarly, Rozzini

and colleagues found that executive skills, as measured by TMT A-B, were independently associated with an increased risk of crash (Rozzini et al., 2012).

One study failed to find a relationship between mean time to complete TMT A & B and pass/fail status on two different driving examinations for 98 participants aged over 65 (Selander et al., 2011). In spite of this, general results show that the TMT B is a strong predictor of at-risk drivers, and therefore a good candidate for transferability to self-assessments.

Sometimes, because of lack of time or training resources, clinicians and trained professionals need assessment tools that can identify deficiencies in a number of capabilities important to driving. Two measures of cognitive ability that are currently used are the *Mini-Mental State Examination* (MMSE) and the *Clock-Drawing Test* (CDT).

The MMSE is a validated measure that screens for general cognitive impairment and dementia, and contains items that measure attention, orientation, recall, language, and visuo-spatial perception (Crizzle et al., 2012). Examinees are required to state time and space (from broad to narrow, i.e. year, month, day, time), to repeat name prompts and recall these prompts at a later point in time, to spell words backwards, to name objects and to draw figures. A maximum score of 30 points is achievable, and although there is some debate as to what the appropriate cut-off point should be (Nishiwaki et al., 2004; Crizzle et al., 2012), in general, scores under 24 are considered indicative of cognitive impairment.

In the Clock Drawing Test the examinee is given a sheet of paper with a large pre-drawn circle on it. After the examiner has indicated the top of the page, the examinee is asked to draw numbers in the circle to make it look like a clock and then to draw the hands of the clock to read '10 after 11'. A score of 1 indicates a perfect clock, a score of 6 is given if there is no reasonable representation of a clock. Although the reviews by NHTSA (2008) and Janke (1994) show that the MMSE was consistently found to relate to driving ability and crash risk, this was mostly so for clinical populations. No research could be identified that looked into the reliability and validity of the MMSE as a predictor of driving problems or crash involvement in healthy ageing populations. In fact, most studies identified related to the use of the MMSE in combination with a number of assessment tools.

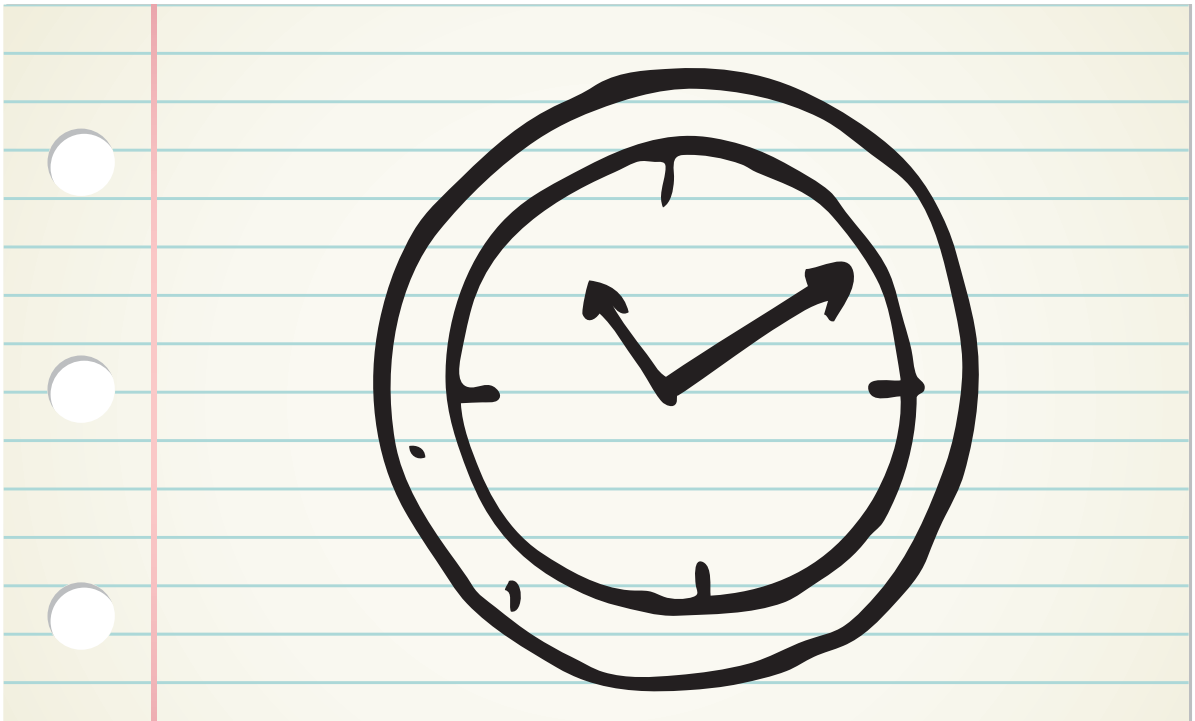
The CDT is another measure of cognitive function that is believed to draw primarily on visuo-spatial and executive function (Peters & Pinto, 2008). It has been found to have good discriminative properties in clinical populations (Carr et al., 2011; Agrell & Dehlin, 1998), and as a screening tool for driving competency in older populations (Freund et al., 2005). The latter study by Freund and colleagues evaluated a sample of 119 community-dwelling drivers between the ages of 61 and 96 who had been referred for driving evaluation. All subjects completed the CDT and were measured on the number of self-

reported hazardous errors (e.g. crashing and running red traffic lights), traffic violations (e.g. speeding or driving too slowly), and rule violations (e.g. failing to turn and turning in the wrong direction). All correlations between driving performance and the CDT were negatively correlated; that is, worse performance on the CDT was reflective of more driving errors. Some research has shown that the CDT has the ability to detect cognitive dysfunction in populations with normal MMSE scores (Juby et al., 2002).

3.2.4 Comparative studies

A recent meta-analysis by Mathias and Lucas (2009) sought to provide an evidence-based method for screening at-risk drivers by systematically analysing the research into cognitive predictors of driving. On-road driving, simulator driving assessments, and studies using driving problems were included. The UFOV test was the only test that served as a good predictor on all three types of study. However, in simulator studies, clock drawing was found to have “very good” discriminative ability, whilst the MMSE showed “good” discriminative validity. Among the tasks that best predicted on-road driving performance were a complex reaction time task, and a computerised visual attention task. Finally, trail making was among the best predictors of driving problems. However, it is noteworthy that only eight studies were included in this analysis, and that the only study to use the CDT was the previously mentioned study by Freund et al. (2005). Because of the limited data, findings must be interpreted with caution.

In contrast to the findings of Juby et al. (2002), it has been proposed that the CDT may not be a reliable tool for the assessment of capabilities in healthy elderly drivers. A study by Nishiwaki et al. (2004) compared performance on both the MMSE and the CDT in a very large sample (n=13,557) of participants aged over 75. Although the CDT had good sensitivity and specificity, it was useful only in detecting moderate to severe cognitive impairment. It is noteworthy that this study was not related to driving performance; however, its results require consideration, especially in view of the large sample size.



Other research has looked into particular components of driving, for example pedal errors. This was defined in practical terms as inappropriate acceleration or failure to decelerate when required, and could be considered to be a measure of at-risk drivers, as it represents a hazard in terms of road safety. In this study, 180 subjects aged 65 and over were assessed on three cognitive tests – MMSE, CDT, and TMT A & B – on a simulator. The authors found that clock drawing was the best predictor of pedal errors, followed by age (Freund et al., 2008). This study mirrors the research by Mathias and Lucas (2009) somewhat, as neither TMT A nor TMT B was related to pedal errors, although the MMSE was not found to predict pedal errors in this study.

One possible explanation is that the test procedure used in Freund et al. (2008) was a more complex test scenario (than that in Mathias and Lucas), where participants were scored on a more global measure of ability to execute manoeuvres and make decisions. Alternatively, authors mention that 70% of participants who experienced pedal errors reported an inability to slow or stop the vehicle, thus highlighting that they were aware of the required action needed.

Recent research has identified a number of promising measures that can be used as alternative to the MMSE and the CDT. Staplin et al. (2013), proposed the use of the *Maze Test* as an alternative measure of executive function. In this test, participants trace a path (with finger or pencil, depending on the test format) through a number of mazes presented. Scores are derived from completion time, planning time, and errors committed. In their study, authors examined the relationship between performance on the Maze Test and prospective crash and moving violations from local authority records for 692 participants aged 70–93. Results showed that simple and complex mazes could identify drivers at higher risk of crash involvement. Although this study used a large, community-based sample of older drivers, there was no comparison between performance on the Maze Test and the CDT. Therefore, conclusions regarding its added value as an assessment tool over and above that of the CDT cannot be drawn.

Another test that has been proposed is the 'Addenbrooke's Cognitive Examination – Revised' (ACE-R). This screening test – believed to assess attention, perception, memory and executive function – was recently examined as a possible predictor of driving ability in Portugal. Overall results showed that ACE-R had higher classification accuracy than the MMSE in detecting unsafe drivers (Ferreira et al., 2012). Although both of these alternatives seem promising, more research is needed to confirm their reliability and validity in mobility research.

Hazard perception is another capability that decreases with age and is important in driving. One recent study by Horswill and colleagues (2010), has sought to understand its relationship to crash involvement. They measured hazard perception and UFOV performance in a sample of 271 older drivers (mean age= 74.84). Using a hazard perception test developed for the study (though based on an existing measure), they found that individuals with slower response times to traffic hazards were more likely to have been involved in a crash in the previous five years. In the same way, drivers who failed the UFOV test were also more likely to have crashed recently.

However, another study by Borowsky et al. (2010) used six different hazard avoidance movies, and measured participants' eye movements with an eye-tracking device. Their results showed that older drivers (aged 65–72) were as sensitive to potential hazards as younger experienced drivers (aged 22–30), though it should be noted that the participants in the Horswill et al. study were older.

3.2.5 Problems with predicting driving performance

Neither chronological age nor diagnosis of a medical condition is a strong predictor of driving ability. Nor is performance on a single psychomotor test a fail-safe predictor of crash risk. It is apparent from the literature that driving is a dynamic activity drawing on a range of sensory, motor and cognitive abilities. In view of this, it is not surprising that there is no assessment tool which can serve as a strong predictor of driving competence that is focused on just one ability.

It is worth looking at how detailed assessments of competence are currently conducted at UK Mobility Centres. To gain a comprehensive view of driving ability and safety, clients undertake an assessment lasting between two and four hours. The assessment will include vision screening; a health questionnaire; psychometric testing; performance on a static rig to determine reaction time, strength and flexibility; an escorted drive on a private road; and, if deemed appropriate, a drive on public roads for around 40 minutes. This standardised route will incorporate elements of car control, both selective and sustained attention, and the ability to deal with complex situations. Assessors report that the range of activities and the degree of interaction with the client over the session give a clear picture of competence and potential safety. The assessment is comprehensive, includes elements of real driving, and relies heavily on the subjective interpretation of the assessor.

In contrast, The American Medical Association and NHTSA have developed ADReS – Assessment of Driving-Related Skills, as a starting point for health professional engagement in assessment of fitness to drive, without recourse to on-road trials.

The battery of tests includes:

- visual acuity, as measured by means of a Snellen chart or by the Donders confrontation test (a technique of requiring the participant to correctly identify the number of fingers held in view at a distance of around three feet);
- cognition by executive task – trail making B;
- visual spatial attention – clock drawing;
- physical endurance – Rapid-Pace Walk;
- range of joint motion – neck, fingers, shoulder, elbow and ankle;
- motor strength – shoulder, hip, wrist, ankle and hand grip;
- a self-assessment questionnaire of around 20 items, highlighting problems in traffic.

The health professional is also encouraged to enquire about coping strategies for driving in low light levels, and driving in situations where there is glare from other vehicles' headlights.

Neither of these approaches uses advanced technology such as driving simulation, or interactive tests of hazard perception or change blindness.

In summary, although there is not complete agreement on the level of association between the results of the tests and future driving ability, there is a degree of agreement on the most promising components of an appropriate assessment. However, it should be noted that the research to date has not incorporated the most recent thinking about how to develop tests that tap into the important aspects of risk-taking, situation awareness and resistance to distraction.

3.3 Transferability of functional test to self-assessment

There is potential benefit for older drivers in the availability of easy-to-administer, reliable and cost-effective self-assessment tools. Such tools would be only a subset of the total range available to the professional practitioner. As such, self-assessment tools cannot be expected to deliver a comparably detailed insight into competence and safety, but if they tap into important underlying abilities, they could serve a useful function in alerting the driver to potential problem areas, and give advice on suitable next steps.

From the review above, it seems possible to transfer several valid tests to a computer-based environment for self-assessment:

- visual performance – static acuity (and, possibly, contrast sensitivity);
- executive function – trail making or maze following;
- cognition – UFOV;
- hazard perception and change blindness (though this would need further development and validation);
- driving style – through questionnaire;
- driving problems – through questionnaire;
- range of motion – through questionnaire.

4. Self-Assessment Tools

Self-assessment tools in the older driver domain generally target older drivers who are motivated to take a test because they feel unsafe in traffic or have concerns regarding their driving abilities (Heikkinen et al., 2010). Such tools aim to alert drivers to the presence of age-related impairments, risks or health concerns that may put them at a greater risk of collision if adequate compensatory action is not taken, and are therefore conceived to be educational tools (Charlton & Molnar, 2011). Possible compensatory actions in response to issues detected may include changes to driving patterns such as: the reduction or cessation of driving, avoidance of difficult driving situations, adoption of greater safety margins, and changes to journey planning. They may also include advice to seek support from medical practitioners (e.g. for vision or cognitive testing), changes to the vehicle used (such as the purchase of assistance systems), or the use of alternative modes of transport.

The ultimate aim of self-assessment tools is to provide older drivers with feedback on their current driving capabilities and advice on how their mobility may be safely prolonged. The (tacit) expectation is that both will translate into appropriate self-regulatory and voluntary modification of driving-related behaviour.

Whilst self-assessment tools are generally promoted to older drivers without any stated restrictions, several researchers have argued that self-assessments may not be feasible for the entire population of older drivers. Staplin et al. (1999), for example, have suggested that individuals can only self-assess if they are sufficiently cognitively intact to be able to effectively engage in self-screening, understand feedback, and act appropriately on that feedback. Since cognitive impairment is associated with an increased collision risk, some people in need of assessment may not be able to self-assess. Similar concerns have been echoed throughout the literature (Eby et al., 2003; Molnar et al., 2007).

Until comparatively recently, the assessments of cognitive capabilities relevant to safe driving relied on paper-and-pencil-based tests, typically with the assistance of someone trained in the use of the group of tests in question. In such clinical assessments, specialists would guide older drivers through the assessment process, calculate performance scores, compare them with norm data, provide feedback on the results, and discuss the implications of the assessment outcome with the person under review.

Paper-and-pencil-based tools that are developed for the purpose of self-assessment of older drivers have to be simple enough to allow an untrained user to complete and to correctly score performance. The emergence of the PC and fast, stable Internet connections has brought with it the potential for automated, computer-based or Web-based self-assessments which use automated and standardised test instructions, assessment/scoring algorithms and feedback, and can therefore handle more complex question sets and associated scoring without undue challenges to the user.

Web-based or computer-based assessments have already been used in other domains, for example in the driver-profiling domain, and lessons learned in these areas can inform the implementation of Web- or computer-based self-assessments for older drivers. Experiences from driver profiling indicate that both careful piloting of the Web-based tool and observation of behaviour are necessary to ensure that navigation through the tools is clear and simple. Tools that rely on written questions only can present a challenge to respondents of low reading age, and should therefore limit the number of questions included to avoid excessive completion times and loss of motivation in the respondent. It has also been found that automatic saving of scores in case of an unexpected breakdown of the Internet connection considerably reduces the frustration experienced by the user when having to input the information all over again. Tests that rely on fast and accurate responses, either by key press or by using the mouse, must provide a sufficient number of practice runs to ensure that the respondent can use the equipment appropriately. The inclusion of tutorials, for example to build up mouse proficiency, should be considered.

Whilst older peoples' access and use of the Internet and information technology may at present still be limited, estimates indicate that Internet use among older adults is increasing. An American telephone survey with a weighted, representative sample of n=2,254 adults aged 18 and above suggested that, in April 2012, 53% of American adults aged 65 years and over used the Internet or email at least occasionally, compared to 83% of adult Americans of all ages (Zickuhr & Madden, 2012). At 34%, Internet usage was found to be less prevalent for adults aged 76 and over. However, the comparison of Internet use over time (2000–12) showed clear trends for increased usage, particularly for adults aged 65 years and over.

In Britain, Internet usage levels are comparatively lower, but also on the increase. The number of households with an Internet connection is growing: 77% of households (19 million) had an Internet connection in 2011, compared to 73% in 2010. Nevertheless, in 2011, 60% of those aged 65 and over reported that they had never used the Internet. This compared with 22% of those aged between 55 and 64, and just 1% of the 16–24 year olds (Office for National Statistics, 2011).

This review indicates that many of the currently available self-assessment tools for older drivers are paper-and-pencil based, even if they are hosted on a website, and that comparatively few tools have been implemented as interactive, Web- or computer-based self-assessment resources. However, for several of the identified paper-and-pencil-based self-assessment tools, implementation as an interactive tool was anticipated or planned. Because the development of most paper-and-pencil-based tools preceded available interactive tools, a review of these tools is provided initially, detailing the development process and laying the foundation for the subsequent review of interactive, Web-based tools in this report. The provided overview of existing tools does not claim to be exhaustive, but integrates information provided by experts in the older driver domain with the review of the scientific literature.

Generally, two different approaches characterise tools available for self-assessment.

- tools that aim to increase self-awareness, typically by requiring the respondent to reflect on and self-report problems experienced and concerns related to safe driving;
- tools that measure the driver's maximum performance on a test (or tests), to screen for functional impairment of abilities relevant to driving.

Tools developed under both approaches provide feedback and advice to older drivers as to how adjustments to driving patterns and medical support can help to prolong safe mobility.

4.1 Benefits and limitations of self-assessments

Unlike mandatory assessments of fitness to drive, self-assessments are voluntary measures and leave the adoption of the recommendations made in the feedback section to the initiative of the driver. Self-assessment tools, particularly Web-based ones, can be easily and cheaply distributed and can thus potentially reach large numbers of older drivers. They can be completed in an environment chosen by individuals at their own pace, and provide a repeatable, confidential and non-threatening source of information about driving capability (Eby et al., 2003; Heikkinen et al., 2010). As such, self-assessment measures are likely to be associated with fewer feelings of stress and anxiety than mandatory age-based testing, and may therefore be associated with increased motivation for completion (Heikkinen et al., 2010). Because of the ease of access of feedback on driving abilities, self-assessment tools may have the capability to identify potential problems earlier than they would otherwise be detected, and can facilitate timely action to prolong safe mobility. Focus groups with older drivers and their adult children have also indicated that self-assessment tools can facilitate the discussion of older driver mobility with family members (Eby et al., 2003).

However, several limitations of self-assessment tools have also been raised, such as the self-selective nature of such tools: as with any self-selected measure, those drivers who decide to complete them are more likely to be motivated and to have a safety-conscious, proactive approach, whilst drivers with existing driving-related problems who are afraid of losing their licence may choose not to use the tool (Dunn, 2012).

Self-assessment tools that rely on self-report are susceptible to self-report and self-enhancement bias. Respondents may be inclined to engage in 'socially desirable responding', which describes the tendency to provide answers that make the respondent look good. According to Lajunen et al. (1997), socially desirable responding comprises two components: 'impression management', which describes the tendency to give favourable self-impressions to others; and 'self-deception', which comprises "a positively-biased, but subjectively honest self-description" (Lajunen et al., 1997: 342). In the context of self-assessment tools, self-deception is of particular importance as it may lead respondents to under-report on existing problems, which in turn leads to the provision of inappropriate positive feedback on driving capability and a potentially false sense of security. The difficulties associated with self-evaluation led Bédard et al. (2011) to conclude that the development of tools that relied on self-report was more challenging than those that were based on performance measures, and they found that this explained the comparatively low associations found with the outcomes of on-road assessments. Further evidence that questions the accuracy of older drivers' self-assessment of driving-related performance has recently been produced by Horswill et al. (2013), who found significant enhancement bias in drivers aged 65 years and over, and showed that the self-rated performance on a hazard perception test did not correlate with older drivers' actual performance on the test.

It is generally acknowledged that whilst self-assessments may be successful at increasing awareness and knowledge of age-related changes in driving abilities, they cannot replace more stringent assessment procedures in relation to licensure decisions.

As discussed earlier, self-assessment tools that provide general, rather than individualised, feedback may lead to counter-productive impairment rather than improvement of driving (Moták et al., 2012b). Whilst more evidence is required to corroborate this effect, adopting the recommendation to tailor advice to the specific capability of an individual would certainly be good practice, given the considerable variability of the ageing process.

4.2 Non-interactive self-assessment tools

4.2.1 The Driving Decisions Workbook

Significant amounts of work on the development of two self-assessment tools

– the first paper-and-pencil-based, the second Web-based and interactive – has been undertaken by a group of researchers based at the University of Michigan Transportation Research Institute over the last ten years.

The initial work, which commenced in 1998, comprised the development of a paper-and-pencil-based self-screening tool, the so-called 'Driving Decisions Workbook (DDW)' (Eby et al., 2000; Eby et al., 2003), with sponsorship by General Motors Corporation and pursuant to an agreement between General Motors and the US Department of Transportation. Against the backdrop of an ageing and increasingly mobile population, the work aimed to develop an instrument that would provide people who started to experience age-related declines in their driving abilities, or loss of confidence in certain driving situations, with a source of feedback and information that could enhance their driving decisions. The stated aims of the tool were therefore to:

1. provide feedback to facilitate good driving decisions by increasing self-awareness and general knowledge;
2. increase general awareness of age-related declines in driving abilities, to facilitate discussion with family members and the social network.

The development process of the tool comprised the following elements:

- a review of the literature on abilities (cognitive, perceptual, psychomotor) relevant to safe driving and their age-related change; a review of health factors (common medical conditions, prevalence of prescription drugs and effects of drugs on driving ability); and a review of the literature on older driver education and skill enhancement;
- conducting 16 focus groups with current and former older drivers and adult children, to explore perceived changes in driving ability, perceived value of a self-evaluation tool, and future plans for driving;
- an expert panel workshop to decide what abilities to assess, how to assess them, to decide whether they could be self-assessed, and what format and length would best suit the tool.

The integration of the information led to the development of a theoretical framework (discussed in section 2.7 of this report). Three domains were selected to be included in the self-assessment instrument: (1) health & medication use (i.e. medical status); (2) driving abilities (vision, cognition and psychomotor) and (3) experiences/attitudes and behaviours (i.e. general driving fitness). Driving skills were not included because the researchers argued that these were related to practice rather than age. Assessment areas that did not lend themselves to inclusion in a paper-and-pencil-based tool (e.g. visual field under divided attention) were also excluded. Thirty-seven assessment areas remained for inclusion in the tool, broken down as follows:

1. Health and medication use:

    - conditions: seven assessment areas;
    - medications: eight assessment areas.

2. Driving abilities:

    - vision: seven assessment areas;
    - cognition: four assessment areas;
    - psychomotor: three assessment areas.

3. Experiences/attitudes/behaviours: eight assessment areas.

The question set covering the 37 assessment areas was developed on the basis of existing items that were adapted for self-completion. Item response categories were either dichotomous (yes/no) or included four-point Likert scales (e.g. “none”, “a little”, “some”, “a lot”). Feedback provided to drivers in response to their answers was developed on the basis of the literature review conducted and expert input. It covered four types of advice to the driver:

1. suggesting further evaluation: driving evaluation, vision examination, medical examination;
2. provision of general information: increasing respondent knowledge by providing description of the issue, prevalence in the older population, and its effect on safe driving;
3. increasing self-awareness: by flagging problems, in particular areas relevant to safe driving;
4. driving compensation: changing users’ driving decisions to maintain safe and effective mobility.

In the graphic layout of the workbook, one to five questions relating to an assessment area are presented on the right-hand side of the page, with the feedback presented on the left. Arrows from the response categories that flag a concern connect them to relevant feedback on the left-hand side of the page. Where possible, all types of feedback were included for each assessment area, so as to give comprehensive advice to the respondent in

relation to any potential concern. Feedback commences with a self-awareness statement, followed by a set of bulleted items suggesting further evaluation and behavioural compensation strategies (where appropriate).

The question set and feedback were piloted with the target group through structured interviews, and adapted as necessary. This also comprised an assessment of the reading age (7th and 8th grade).

The finalised DDW is divided into three sections:

1. Introduction: this comprises a brief discussion of older person mobility and the need for self-awareness in making good driving decisions; instructions on how to complete the workbook; discussion of how the workbook may be used in future and to facilitate discussion with family members.

2. Self-evaluation, including five sections:

    - on the road (experiences/attitudes/behaviours);
    - seeing (driving abilities domain);
    - thinking (driving abilities domain);
    - getting around (driving abilities domain);
    - health (health and medication use domain).

3. Q&A section: this section provided more general advice for safe driving than the specific assessment areas, covering:

    - general driving safety;
    - how to use the information from the driving workbook to optimise a visit with a doctor;
    - where and how to get a driving evaluation carried out;
    - mobility options;
    - planning for effective mobility in the future;
    - how to use the workbook with someone else who may be experiencing driving difficulties.

An evaluation and validation study of the workbook was undertaken with an opportunity sample of n=99 current drivers aged 65 and over to identify whether:

- the instrument increased self-awareness and general knowledge of age-related declines in driving abilities, and was perceived as useful;
- the questions accurately identified selected abilities and driving problems.

The measures applied to answer these questions included:

- self-reported increases in self-awareness, general knowledge and perceived usefulness of the instrument (questionnaire);
- the MMSE (testing general orientation, learning and memory, attention, language and spatial relationships);
- the Gross Impairments Screening (GRIMPS) battery, which comprises a collection of tests to assess cognitive, perceptual and psychomotor abilities;
- a standardised driving course of seven miles in length, including 28 manoeuvres at specific locations and 17 performance tasks, each with a fixed number of possible errors and objective scoring criteria, including critical driving errors; the completion time for the course was approximately 15 minutes.

The results of the evaluation indicated that 94% of respondents found the workbook at least “somewhat useful”. All respondents felt that it would facilitate discussions with family members, and 14% of the drivers reported greater awareness of changes they had not noticed before, and intended to follow up with a refresher course or visit to a doctor. A gender effect was found, in that females rated the workbook more positively than male drivers. The mean completion time for the workbook was approximately 30 minutes.

The validation of the workbook comprised the comparison of the workbook scores (overall score, domain score and subdomain scores) with those obtained through the on-road driving test.

Spearman correlations were calculated between the scores for the DDW and the on-road test. A significant but modest positive correlation (r=.30) between the overall scores for the workbook and the on-road test was found, indicating that as problems measured by the workbook increased, so did problems in the on-road test.

Additionally, both, the driving ability (cognition and psychomotor, but not vision) and the experiences/ attitudes/behaviours domain correlated significantly with on-road performance. The correlation with the health domain was not significant, but the correlation with the health subdomain was.

Clear gender differences emerged for all but the medication subdomain; for men, the correlations were positive and highly significant; by comparison, only the subdomains cognition and psychomotor were significant for women.

The differentiation between younger old (65–74-year olds) and older old (75+ year olds) showed that correlations between workbook scores and the on-road test were only significant for the 65–74-year old group (r=.31*), but not for the 75+ year olds.

On the basis of the findings from the self-report data, the authors concluded that the workbook was a well-received and effective first-tier assessment tool. Regarding the validity of the tool, the authors suggested that the preliminary study had shown positive, albeit only modest, correlations with on on-road performance, which were limited to the 65–74-year old age group and did not include the health and medication use domain. They suggested that the study sample was small and not representative of the older driver population, and they indicated that further research was necessary to ensure that the workbook was valid for the older old (75 years and over), and that it would successfully incorporate the health and medication use domain.

Conclusion

The DDW is based on comprehensive development work and a review of the literature. Its layout means that it is easy to complete and provides a clear link between areas of concern and associated feedback. Heikkinen et al. (2010) have commented that whilst the DDW provides feedback for each assessment area, it does not include a summary conclusion about an individual's ability to drive safely.

Initial evaluation results on user acceptance are clearly positive, and significant associations with on-road assessment outcomes have been established – albeit of moderate size and only for drivers aged 65 to 74.

To date, no research on the link between increased self-awareness and self-regulation – that is, the impact of the DDW on driving patterns – has been undertaken. No evidence is currently available on its impact on the road safety of older drivers.

4.2.2 The adapted Devon Driving Decisions Workbook

The original DDW produced by Eby et al. (2000) provided the basis for the Driving Decisions Workbook published by Devon County Council (referred to as the UK DDW) in 2011, in partnership with Cornwall, Plymouth and Torbay councils.

An analysis of injury accident data for Devon (from police STATS19 data records) had indicated that older drivers represented a considerable proportion of collision-involved drivers. Devon's demographic profile and a subsequent marketing study with n=96 older drivers in the county made the case for the development of a programme aimed at older drivers by Devon County Council. The development was informed by a literature review on the effectiveness of education and training interventions undertaken by Husband in 2010. This review also included the recommendation of, and the adaptation of, a self-assessment tool for older drivers.

Together with Devon and Cornwall Constabulary, Devon County Council launched a comprehensive programme for older drivers, 'Driving Safer For Longer' (DSFL) in June 2007. It is now delivered as part of the Devon Road Casualty Reduction Partnership, and includes workshops for older drivers, refresher trainings, practical driving training and on-road assessment programmes.

Its self-assessment component, the UK DDW, was completed in 2012 and is currently in a paper-and-pencil format. It is a reduced and slightly adapted version of the DDW published by Eby et al. in 2000, and can be completed by the older driver either alone or together with a family member.

In contrast to the American version of the tool with three main assessment domains and six subdomains, the UK DDW comprises four sections and a smaller number of assessment areas:

1. On the road:
    - friends and family;
    - collisions;
    - unfamiliar places;
    - night driving;
    - bad weather.
2. Thinking:
    - divided attention;
    - speed of decision-making;
    - memory.

3. Getting around:

    - flexibility;
    - muscle strength;
    - reaction time.

4. Health:

- physical fitness;
- eyesight;
- prescription drugs;
- health conditions.

'Vision' in the UK DDW is not treated as a separate section with a considerable number of assessment areas, but is subsumed under the heading 'health', and comprises only questions on vision aids and the minimum sight distance required in the British driving test. Additionally, the section on health does not include detailed questions about different medical conditions and drugs, but subsumes them into one question.

The wording of the questions included is generally the same as in the American tool, but some of the questions are shortened. The visual presentation of the questions and the feedback, depending on the response category, are the same as for the American version. The completion time for the tool is stated to be 15 minutes.

The Devon DSFL scheme, including both workbook and older driver workshops, was evaluated as part of an undergraduate degree at Plymouth University (Dunn, 2012). The evaluation aimed to assess via questionnaire study whether the workbook or the workshop increased:

- topical support knowledge;
- self-awareness;
- self-reported (compensatory) behaviour.

The sample included n=195 current drivers aged 50 years and over in Devon (n=79 males; n=101 females; n=15 gender unknown). Participants were recruited through the Devon Drivers' Centre (DDC) and therefore self-selected for participation. Older drivers who had agreed to participate were randomly allocated to either the workbook condition or the control group. Drivers who had specifically contacted Devon County Council to participate in the workshop were allocated to the workshop group. This implies another self-selection effect for the workshops, with only the control conditions and the workbook using random allocation to the experimental group. Ninety-seven older drivers formed the control group, 31 participated in a workshop and 67 completed the workbook.

Older drivers in the experimental condition were asked to complete questionnaires at three time points: (1) before receiving the intervention, (2) immediately after completing the intervention, and (3) two to four months after receiving the intervention. The control group only received questionnaires at time points (1) and (3).

In addition to demographic data, the survey questionnaire comprised four items which asked the respondent to list medical conditions, medicinal drugs and vision problems relevant to safe driving. Ten items comprised five-point Likert scale statements on driving ability, knowledge of possible sources of support, and self-reported changes in driving behaviour. Whilst the questionnaires for time points (1) and (2) asked about intentions to change behaviour, at time point (3) it asked whether participants had actually realised these intentions. Eleven items asked about the use of compensatory driving strategies, and the final free response item asked about events or developments that would lead the driver to cease driving. Seven items in the questionnaire issued at time point (2) asked participants about the perceived usefulness of the intervention, the appropriateness of the content, and changes in self-perception resulting from the participation.

Results of the analysis of the questionnaire data were only available for selected parts of the questionnaire and are briefly summarised. Ratings of the perceived usefulness of the workbook and the workshop, their appropriateness and their effect on self-perception, indicated that the two interventions were perceived similarly positively. The only significant difference between the interventions indicated that the workshop led more drivers to report that they had noticed a change in their driving as a result of participation.

The comparison of the three groups' recall of topical support information indicated that the number of medical conditions, drugs and risks relevant to driving increased significantly at every time point. Compared to the control condition and the workshop, the workbook resulted in the highest numbers of generated responses. Whilst this could be evidence for its greater effectiveness at improving topical knowledge, no information is provided by Dunn as to whether the responses listed actually mapped onto the information provided by the workbook or may have been derived from other sources.

No significant differences between groups or time points were found for self-awareness items (feeling able to drive safely, knowing when to stop driving and when to see a doctor to check abilities).

For the self-report items on intended (time points (1) and (2)) and actual (time point (3)) changes of behaviour, no significant differences were found between the three groups with regard to starting discussions with friends and family; however, significantly lower scores at time point (3), compared to time point (1) and (2), marked the transition from intention to actual behaviour, suggesting that participants did not talk to family within two to four months of participating in the intervention. Similarly, lower scores at time point (3) for undergoing a driving assessment offered by the Devon DSFL scheme meant that participants had not undergone a driving assessment within two to four months of the intervention.

Overall, the author concluded that the workbook, in particular, was associated with an increase in knowledge of driving-related risk factors including medical conditions and medicinal drugs. Both interventions led to an increase in participants' intention to engage in further support measures (e.g. talking to friends and family) at time point (2), but drops in scores at time point (3) (two to four months after participation in the intervention) suggested that these support measures had not been sought at this point. Whilst the author interpreted this as evidence that initial intentions to engage in behaviour change did not translate into action, it is possible that the participants merely did not have a strong intention to change in the first place. Mean scores for the intention to talk to family or seek support tended to be close to m=3.0, with those for the actual behaviour being closer to m=2.5. The five-point Likert scale ranged from "strongly disagree" to "strongly agree", with the mean response category being "neither agree nor disagree". Depending on how the scale was scored, a mean response of m=3.0 for items asking about an intention to take action may have meant that participants did not feel that such action was required, and reported at time point (3) not to have taken action accordingly.

Several limitations of the study might have compromised the findings. Self-selection for participation suggests that the participants may not have been a representative sample of Devon's older driver population. Additionally, randomisation was incomplete, with participants in the workshop self-selecting. According to the author, response rates declined over the course

of the study, particularly for time point (3), reducing the sample sizes, and thus the statistical power of the analysis. As the study relied on self-report, no information is available on the actual functional status or the driving performance of the participant group, which would have allowed a validation of the interventions. The author concluded that further research was necessary to address these points.

According to DCC (Husband, personal communication, 5 November 2012) the intention is to transform the workbook into an interactive, Web-based tool in the future. Recommendations for the distribution of the paper-and-pencil version of the workbook were put forward by Dunn (2012), and included posting it to older drivers, distributing it at an older driver event, and dissemination through GP surgeries.

Conclusion

The UK DDW shares the theoretical underpinning of its original American version. Given that previous evaluation work by Eby et al. (2003) did not find health and vision to correlate with on-road performance, the reduction of health- and vision-related items in the Devon version are appropriate, and have the advantage of reducing the length of the tool.

Evaluation results again showed evidence of positive user acceptance, albeit from a self-selected sample who had actively sought to engage in an older driver safety intervention. The inclusion of a two-to-four- months follow-up in the evaluation indicated that participants tended to not engage in further actions to ensure their safety within this timeframe. However, it is possible that this is due to a lack of perceived need by the older driver. Without objective data on performance level in the sample, it is impossible to draw conclusions on the necessity of further actions recommended by the tool.

The UK DDW shares with its predecessor the lack of evaluation data on its impact on changes to driving patterns and road safety outcomes.

4.2.3 'Driving Safely While Aging Gracefully'

The non-interactive booklet *Driving Safely While Aging Gracefully* was developed by the USAA (United Services Automobile Association) Educational Foundation, the American Association of Retired Persons (AARP), and NHTSA in 1999 as a freely available self-assessment tool. No details could be obtained on the development or evaluation of the tool. The booklet is hosted on NHTSA's website (www.nhtsa.gov/people/injury/olddrive/Driving%20Safely%20Aging%20Web/) and is also promoted by the AAA (Australian Automobile Association) Foundation, through a weblink to the tool. Similarly to the DDW, the stated aim of the tool is to increase self-awareness of the older driver by requesting respondents to reflect on changes in their vision, physical fitness, attention and reaction time that may put them at risk of collisions.

In contrast to the DDW, however, the self-assessment does not require participants to rate the frequency or severity of problems experienced, but merely asks for the experience of problems – alongside the question "Do you have these symptoms of…?" or "Has this happened to you?", three to seven brief statements are listed for each assessment section describing potential difficulties (for example: "A friend or family member has expressed concern about your driving"). The second half of the page then provides advice, summarised in bullet points under the heading "What you can do". There are four areas of self-assessment: (1) vision, including three items; (2) physical fitness, including six items; (3) attention and reaction time, including seven items; and (4) keeping alert to changes, including five items.

Two subsequent information sections discuss alternative transport options and the importance of self-awareness in adjusting driving patterns to observed deteriorations in function. The final page of the booklet provides useful links to organisations that can assist with driving decisions.

Conclusion

The absence of a need to score responses means the tool is easy to use; however, the absence of scoring also means that all behavioural problems included are given the same weight, and any one "yes" answer triggers the provision of feedback; this means that no direction is provided to older drivers as to which feedback bullet point(s) may be particularly pertinent to them.

No information was found on the development of the tool or any evaluation carried out in relation to it. It is therefore not possible to ascertain its impact on self-regulation and safety outcomes.

4.2.4 Information brochures including elements of self-assessment

A ten-page brochure called *Autofahren im Alter – Flott unterwegs* [Driving in old age – buzzing around], targeting older drivers, was published by the Swiss BFU (Swiss Council for Accident Prevention) in collaboration with the Swiss Association of Vehicle Licensing Offices (ASA) in 2012. The document combines information provision with self-assessment, and is available at www.bfu.ch/PDFLib/1037_42.pdf. The brochure is introduced as an aid for older drivers to self-assess their health in relation to the driving task. It provides, in the first part, high-level information on age-related deterioration of vision, hearing, memory, movement, reaction times, coordination, medical conditions (of the heart, and diabetes) and the effects of medical drugs. Subsequently, readers are invited to self-assess their driving-related health using six statements describing the avoidance of difficult driving situations (dense traffic, intersections and overtaking), experiences of fail-to-see situations, slowing of reactions, slowing of driving speed, and encouragement by others to cease driving.

The tool does not include scoring; if readers experience any of the problems outlined in the six statements, it is suggested that they should discuss these with a doctor, a driving instructor or with their friends and family.

Outlined on subsequent pages are advice on age-related licensing procedures for Switzerland, and tips for safe driving, such as avoiding rush hour, planning breaks, cleaning car lights, using assistance systems and signing up for refresher training. The last page of the brochure proposes using alternative modes of transport or relinquishing the licence, and reiterates the three most important tips: (1) increasing self-awareness, (2) undergoing yearly voluntary medicals and (3) ceasing to drive if need be.

A similarly structured but more extensive (25-page) brochure was published by the Touring Club of Switzerland, a motoring club, in 1996. The document *Älter – Aber Sicher! Wissenswertes für Senioren am Steuer* [Older – but safe! Useful facts for seniors on the road] aims to support older drivers' mobility by providing information on age-related changes in driving ability and recommendations for the maintenance of safe mobility. The brochure is available at www.fvsfsrfss.ch/uploads/tx_userdownloads/pub_05.09.06_IP_aelterabersicher_d.pdf. It comprises detailed information on age-related changes in performance and medical conditions, and on legal processes in relation to driving licences and fitness-to-drive assessments. Ten questions allow the reader to self-assess driving performance in difficult situations (intersections, dense traffic and reversing), incidents of failing to see other road users, experience of fatigue and vision problems when driving, slowing of reactions in critical situations, and negative feedback from the driver's friends and family, or from other road users. The question set does not require scoring; respondents are recommended to visit the doctor if they experience any of the listed problems, and to undergo a detailed assessment of their fitness to drive.

Resources for older drivers have also been published by the Australian Capital Territory (ACT) Government. This includes the *ACT Older Drivers' Handbook*, a 54-page document which provides advice on safe driving practices and is posted to all ACT drivers on their 70th birthday, and *Retiring from Driving*, a 42-page booklet aimed at older drivers and family members who have concerns about the safety of an older driver. The handbook (which can be accessed at www.seniorsmovingsafely.org.au/download_documents/older_drivers_hbook_web_0703.pdf) comprises a paper-and-pencil-based self-assessment which is a slightly reworded version of the 'Drivers 65 Plus – Check Your Performance' tool described in section 4.3.5, including the same scoring rationale. Feedback is provided for each of the items comprised in the assessment.

The *Retiring from Driving* booklet was developed by Monash University Accident Research Centre and can be accessed at: www.seniorsmovingsafely.org.au/download_documents/retiring_from_driving.pdf. It includes six assessment areas:

1. vision: five items;
2. movement: three items;
3. reaction and fatigue: six items;
4. medications: two items;
5. driving: nine items;
6. feedback: five items.

For all items, older drivers have to rate the frequency of occurrence of concerns on a three-point scale ("often"/"sometimes"/"never").

The scoring rationale is that older drivers who have answered "often" more than five times are recommended to seek alternatives to driving themselves, as they may pose a risk to themselves and others. Those who answer "sometimes" more than five times are advised to start planning alternative means of transport. Drivers who answer "never" more than ten times receive feedback that whilst they may be safe to drive at present, they should consider early planning for retirement from driving. The structure of the booklet is such that scoring outcomes are disclosed to the driver at the end of the document rather than directly after the assessment. This means that all drivers, irrespective of their assessment outcomes, are presented with information about warning signs of age-related deteriorations and advice on adjustments to their driving patterns and styles.

Conclusion

Whilst the tools described in the previous sections combined self-assessment with feedback and educational materials, the emphasis of the five tools in this section was on increasing knowledge about age-related changes with brief checklists enabling self-assessment for older drivers. Only the last two of these checklists required scoring. For the first three tools, any "yes" answer

triggered the need for further action. The feedback sections for all five tools were not tailored to the individual, and mean that readers have to select those recommendations which they feel to be most relevant to them.

No information was found on the development of the tools or any evaluation carried out in relation to them.

4.3 Interactive self-assessment tools

4.3.1 The Enhanced Driving Decisions Workbook

The intention to improve on the previously developed DDW described in section 4.2.1 was carried out in the development of the Enhanced DDW (Eby et al., 2008; Molnar et al., 2010). Because the DDW had not shown significant correlations between health and on-road performance, the Enhanced Workbook focused on health concerns, namely the symptoms people experience as a result of medical conditions associated with ageing, and the medications used to treat these conditions. The researchers argued that whilst the number of possible medical conditions and associated treatments was large, they did not necessarily affect driving performance. The number of health concerns that impacted critical driving skills, on the other hand, was comparatively small and allowed targeted assessment. To enable individualised feedback, the researchers decided to implement the Enhanced Workbook as a Web-based tool that could compile specific feedback to older drivers in response to their self-reported health concerns.

The identification of health concerns, and of critical driving skills that may be affected by these health concerns, was underpinned by a literature review and a two-day workshop with an expert panel. Panel members initially discussed the list of health concerns and the list of critical driving skills identified by the literature, and considered the feasibility of their inclusion in a self-assessment tool. Subsequently, the panel discussed the severity level at which each health concern might affect driving safety. Four severity levels were chosen (“none”, “low”, “medium”, “high”) to characterise health concerns.

Once the linkages between health concern, severity and driving skill had been established, the panel developed specific recommendations that could be provided as feedback for the self-screening instrument, covering:

1. general awareness;
2. self-awareness;
3. recommendations for behavioural changes;
4. further evaluations (e.g. through a healthcare specialist);
5. vehicle modifications.

Twenty-seven health concerns and 15 critical driving skills were identified for

inclusion in the Enhanced Workbook. Health concerns broadly covered:

- visual problems;
- attention deficits;
- slowed information processing;
- memory and orientation problems;
- depression and anxiety;
- pain and neuropathy;
- fatigue and endurance problems;
- motor problems.

Driving skills broadly comprised:

- planning and orientation;
- accelerating, decelerating and maintaining speed;
- manoeuvring;
- observing and responding;
- communicating driving intentions.

For each health concern, three to five questions were chosen from a larger set of validated self-report questionnaire items that had been identified by the previous literature review. Item response categories were either dichotomous (yes/no) or comprised five-point Likert scales ("none", "a little", "some", "a lot", "extreme"; and "never", "rarely", "sometimes", "often", "always"). The response categories of both items were mapped onto the four severity categories, on the basis of expert opinion.

To enable the selection and compilation of individualised feedback by the Web-based tool, feedback was prepared for all health concerns / driving skills. This included a short description of each health concern and what it may mean for safe driving, as well as recommendations (relating to general awareness, self-awareness, recommendations for behavioural changes, further evaluations, and vehicle modifications) for safer driving. A scoring algorithm was developed which estimated the respondents' level of severity with regard to each health concern, based on the responses to the questions, and its link to critical driving skills that may be affected. The feedback output to the driver comprised individualised lists of potential health concerns reported, potential critical driving skills affected, and tips for safe mobility given these health concerns / potential driving problems.

All materials were piloted with older drivers (aged 65+) and adapted to ensure that they were easy to understand and appropriate, before they were uploaded onto a purpose-designed website (http://um-saferdriving.org). Completion time for the question set was stated to range between 15 and 30 minutes. The Enhanced DDW was the only tool reviewed which permitted increasing the font size, a feature of no small importance given the association between age and deteriorating visual acuity.

An evaluation and validation study with n=68 current older drivers aged 65 and over was undertaken to:

assess whether the instrument increased self-awareness of age-related declines in driving abilities, and whether it was perceived as useful;

assess the extent to which the instrument accurately identified health concerns and potential driving difficulties.

The evaluation involved obtaining questionnaire data from participants after they had completed the self-screening instrument, to ascertain their understanding of and ability to use the instrument, their intentions to change their driving as a result of completing the instrument, and the perceived usefulness of the instrument for facilitating discussions between older drivers and their families about the former's driving concerns.

Similarly to the previous paper-and-pencil workbook, the results indicated that older drivers felt that the tool increased self-awareness, with approximately three quarters suggesting that it made them more aware of changes in their driving. About a third of the sample stated that the tool had helped them discover changes of which they had previously been unaware; 40% reported an intention to change their driving; 50% of respondents intended to discuss health concerns with their doctor in future. When asked whether they would recommend the tool to friends and family, over 90% of the respondents stated that they would do so, and 94% thought that the tool would facilitate discussions with friends and family.

For the validation of the Enhanced Workbook, the researchers compared the scores from the tool with participants' scores in a 45-minute on-road assessment by a driving instructor car fitted with dual controls. Additionally, participants were also assessed on a range of clinical tests, including:

- their medical and driving history;
- vision;
- perception;
- physical abilities;
- cognitive skills;
- driving knowledge.

Scores for the workbook, the clinical assessment and the on-road test were standardised to range from 0 to 100 for ease of comparison. Spearman correlations between the Enhanced Workbook scores, the on-road test and the clinical evaluation were performed.

Correlations between the self-screening tool and on-road performance and between the self-screening tool and clinical evaluation were significant and in the right direction, but small ($r=|.26|$; $p< .05$ for both correlations). Further

differentiation by age showed them to be significant only for the 75+ age group, not the 65–74 age group. For this age group, correlations between the workbook and on-road driving were higher ($r = -.44$; $p < .001$). Similarly, larger correlations between the workbook and the clinical evaluation were observed ($r = .54$; $p < .001$).

Whilst the workbook did not correlate with the on-road assessment for women's driving performance, it did correlate with the clinical assessment scores ($r = .35$; $p < .05$). When clinical evaluation scores and on-road driving scores were correlated ($r = -.59$, $p < .001$), this gender effect disappeared, suggesting that it may have been due to some feature of the tool or possibly to self-reporting. For men, the workbook correlated significantly with on-road driving ($r = -.34$, $p < .05$), but not with clinical assessment scores. Correlations between clinical evaluation and on-road driving were, however, again significant ($r = .63$, $p < .001$).

On the basis of the results, the authors recommended that the use of the tool was appropriate as a first-tier assessment for drivers over the age of 74 years only, and that further validation with a representative sample of older drivers was needed. The authors suggested that the lack of a significant correlation between the clinical evaluation and the on-road test for the 65–74 age group meant that the lack of a correlation between the Enhanced Workbook and the on-road test was not caused merely by limitations of the self-assessment tool, but by a factor yet to be understood. Validation of the tool with a representative sample of the older driver population was also recommended.

The tool is freely accessible (see above) and acknowledges the support of the US Department of Transportation's NHTSA. There was no information available about how, by whom, or by how many older drivers the Enhanced Workbook has been used to date, or how it has been marketed since its launch.

Conclusion

In a manner similar to the paper-and-pencil-based DDW, the development of the Enhanced Workbook has been underpinned by comprehensive research and a theoretical foundation. The question set is extensive and, when the provision of feedback is taken into account, completion time can be considerable, particularly if the older driver reports several problems (Heikkinen et al., 2010).

Like the DDW, the Enhanced DDW does not include a summary score associated with an indication of the level of impairment experienced. As pointed out by Heikkinen et al. (2010) this means that older drivers who report several health concerns will receive detailed feedback on how to maintain mobility, but will never receive feedback that they should consider stopping driving altogether .

User acceptability of the tool was high, and the evidence suggested that, in the perception of its users, it was successful in increasing self-awareness and discussion with family members. Additionally, significant correlations of the workbook scores with on-road performance were found for drivers aged 74 and over. Further evaluation studies on road safety outcomes and self-regulation patterns are required.

4.3.2 RACQ Older Drivers' Self-Assessment Questionnaire

In Australia, the Royal Automobile Club of Queensland Limited (RACQ), a motoring club and member of the AAA, introduced an interactive Web-based questionnaire 'RACQ Older Driver's Self-Assessment Questionnaire'(ODSAQ) in 2005 as one element of its older driver programme "Years Ahead", which was launched in 2000 (AAA, 2010). Other programme components comprised a discussion-based presentation, a refresher handbook, an on-road *assessment* drive with a qualified driving instructor, an on-road *refresher* drive with a qualified driving instructor, and a fitness-to-drive factsheet. The RACQ Older Driver's Self-Assessment Questionnaire, which can be accessed online at www.racq.com.au/motoring/driving/road_safety/older_road_users/older_driver_self_assessment, is also promoted by Queensland Department of Transport and Main Roads through a weblink on its website (www.tmr.qld.gov.au/Licensing/Medical-condition-reporting/Older-drivers/How-age-affects-your-driving.aspx).

The ODSAQ begins with a brief introductory paragraph which defines the aim of the tool as providing feedback on the respondent's ability to continue driving safely based on their responses to 31 self-assessment questions. No information could be found as to how the question set had been developed. The tool also advises respondents that it is intended as guidance only, and not as a replacement for a thorough assessment of driving ability by a qualified medical practitioner.

Three areas are covered by the questionnaire: (1) health, including 13 items; (2) driving, including 12 items; and (3) other factors to consider, comprising six items. Each item is presented as a short question with a dichotomous yes/no response option, for example “Do you get tired or feel sleepy on long trips?” Responses to the questionnaire are not recorded on the system, and completion of the tool is free of charge and anonymous.

The scoring of the questionnaire follows a traffic light system, marking respondents as green (no concerns), yellow (some concerns) or red (serious concerns) in each of the three assessment areas, and also for their overall score. Each “yes” response to a question is awarded a score of 1, and score ranges for the tools are as shown in Table 4.2. Completion of the tool for the purpose of the current review indicated inconsistencies in the scoring as it is presently set up in all three assessment areas, with “yes” responses to all items (which results in the maximum possible score) only leading to 26 out of 31 possible points for the overall score.

Table 4.1: Scoring rationale for the ODSAQ

Health-risk points	Driving-risk points	Other factors risk points	Total score
0–3 green	0–3 green	0–1 green	0–7 green
4–7 yellow	4–7 yellow	2–3 yellow	8–17 yellow
8–13 red	8–12 red	4–6 red	18–31 red

Source: RACQ (2005: www.racq.com.au/motoring/driving/road_safety/older_road_users/older_driver_self_assessment).

After respondents have received their scores and traffic light banding, they can chose to receive feedback and advice only for their areas of concern, or for the complete set of questions. Feedback is subsequently displayed in small text boxes below each question, with a brief description of age-related changes in relation to the question, accompanied by advice on how adaptations to driving patterns, or seeking health provisions, can maintain the safe mobility of the older driver.

Conclusion

Whilst it was not possible to find information on the development process of the ODSAQ, the items included seem to derive from the literature on likely risk factors and age-related performance deteriorations. For each question, “yes” responses were awarded a score of 1, suggesting an equal weighting for all driving concerns included.

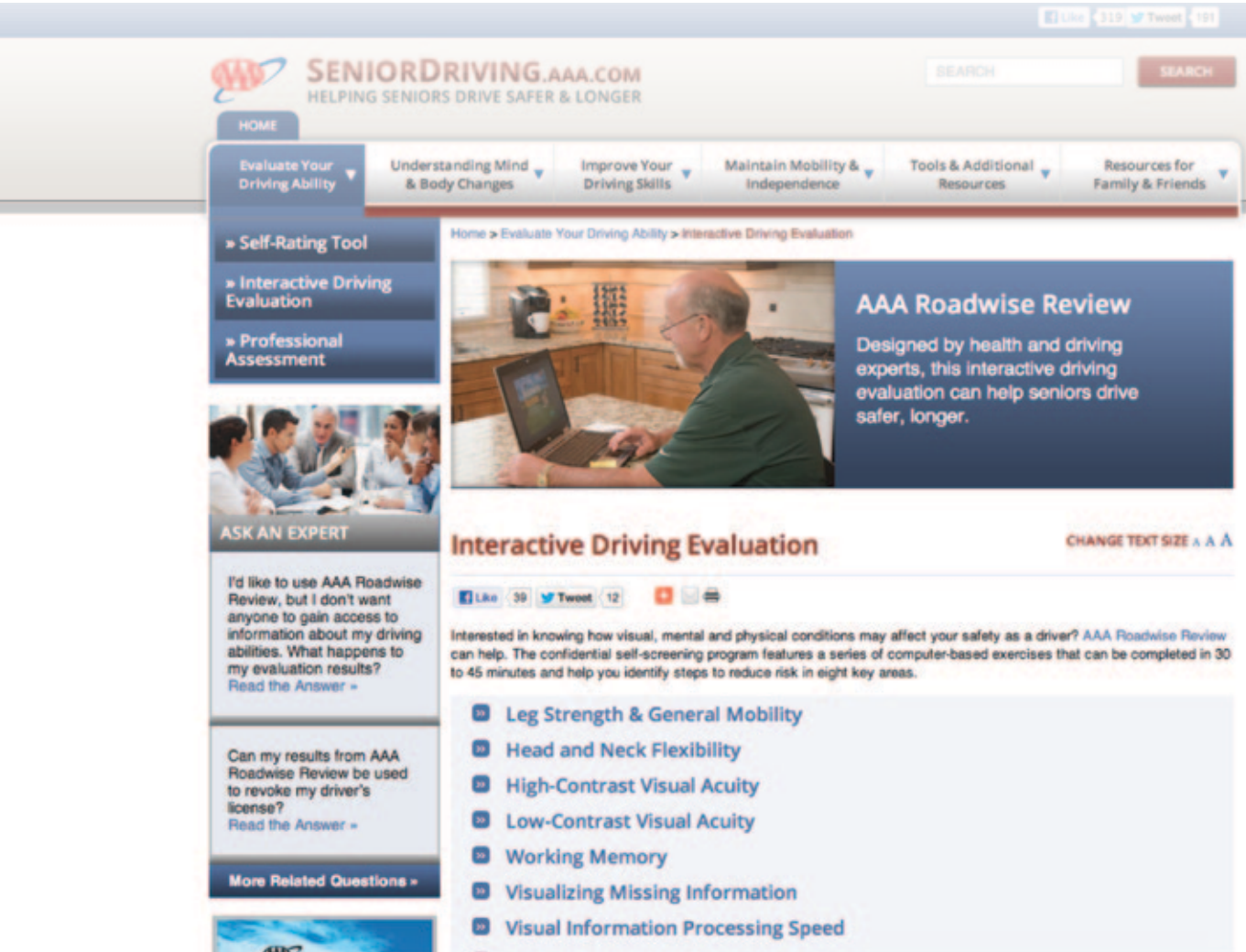
The question set is simple and easy to understand. Feedback was available in relation to each question answered positively, thus providing tailored advice to drivers.

No information was found in relation to the evaluation of the tool.

4.3.3 The AAA Roadwise Review: A Tool to Help Seniors Drive Safely Longer

A different approach to driver self-assessment was used in the development of the Web-based tool Roadwise which is hosted on the American Automobile Association's website (http://seniordriving.aaa.com/evaluate-your-driving-ability/interactive-driving-evaluation) and which was originally promoted as a CD-ROM. The Web-based version is available to drivers free of charge, whilst the CD-ROM version can be purchased from the AAA at cost. In addition to the Roadwise Review, the AAA also offers a brochure enabling older drivers to self-assess their driving performance through the completion of 15 screening questions, and receive feedback and recommendations. The booklet with the title *Drivers 65 Plus: Check Your Performance* can be downloaded on the AAA website free of charge (https://www.aaafoundation.org/sites/default/files/driver65.pdf).

The Roadwise Review comprises a range of tests of functional abilities that have been related to collision involvement in prior research, and aims to enable older drivers to identify areas of concern. The tool was jointly developed by the American Automobile Association and researchers at TransAnalytics LLC, and is based on the DrivingHealth® Inventory (Edwards et al., 2008), a clinical assessment tool.



The DrivingHealth® Inventory, in turn, is the software adaption of the GRIMPS Battery of General Physical and Mental Abilities which emerged from the research undertaken as part of NHTSA's Model Driver Screening and Evaluation Program discussed earlier (Staplin et al., 2003a, 2003b), and includes five visuo-cognitive and four physical ability measures. In combination with the UFOV test developed by researchers based at the University of Birmingham, Alabama, in the USA (and its business spin-off, Visual Awareness Incorporated), the DrivingHealth® Inventory, including the UFOV test, is offered as a Web-based or portable (USB flash drive) first-tier screening tool by TransAnalytics Health and Safety Services, the sister organisation of TransAnalytics LLC. The tool is targeted at rehabilitation professionals and others working in clinical settings, and promises a standardised procedure that under controlled conditions provides reliable indication of whether an older driver has no, a mild, or a serious deficit in a range of functional abilities relevant to an individual's medical fitness to drive. It is available at a price of US$10 per screening.

A demonstration of the tool is available at http://drivinghealth.com/phpBB3/viewtopic.php?f=7&t=5.

The DrivingHealth® Inventory including UFOV comprises measures of:

- high- and low-contrast visual acuity: participants are required to differentiate different-sized characters on the computer screen at a distance of 10 feet (3m), under conditions of high or low contrast;
- visualisation of missing information (subtest of UFOV);
- visual information processing speed (subtest of UFOV);
- divided visual search: Trail Making Test (TMT) A & B[6];
- short-term and working memory: delayed recall test from the MMSE;
- leg strength and general mobility: Rapid-Pace Walk Test;
- head and neck flexibility: participants are required to see an object on the computer screen which is 3m directly behind them; they turn from a seated position to look at a computer directly behind them by rotating, using their neck and trunk, without lifting their hips while their hands hold onto the seat beneath them.

The adaptation of the DrivingHealth® Inventory in the Roadwise Review comprises the same eight tests of visuo-cognitive and physical abilities, and measures the speed and accuracy of a driver's responses for each of the assessment dimensions. However, certain test procedures were modified to enable self-completion by the driver.

Sixteen focus groups with older drivers in the USA and Canada were set up to inform these modifications and to ensure that the contents of the tool were clear and easy to understand.

6 As a reminder to the reader: In TMT A, participants are required to draw lines to sequentially connect numbered circles as quickly as possible, without lifting the pencil from the page; part B of the test involves connecting encircled numbers and letters (1–A–2–B–3 etc.) randomly arranged on a page.

Older drivers can use the Roadwise Review to self-assess driving capabilities at home. The system requirements are modest for today's standards. Completion time is stated as 30–45 minutes. Each test, and its relevance to driving, is briefly described and instructions are given. Upon completion, a rating ("no impairment", "mild impairment" or "serious impairment") is provided for each of the eight performance areas, and advice is made available to the driver on safe driving strategies and options for further information and testing, if appropriate. Depending on the measure and the level of impairment, the older drivers may be referred to a health professional or fitness-to-drive assessment specialist. If no impairment of skill is detected, the driver is asked to use the assessment outcomes as a comparison baseline for future assessments, and is advised that the absence of impairment should not lead to diminished vigilance.

Available evaluation results for the Roadwise Review are briefly summarised in the following literature.

Porter (2010) suggested that some of the normative data used on the computer-based assessment had been derived from the paper-and-pencil version of the test, and that this normative data may be inappropriate for the computer-based scoring. Her study with an opportunity sample of 28 older (70+ years) drivers compared the performance on the CD-ROM version of the Roadwise Review with the following conventional tests:

- brake response time (movement time and reaction time);
- flexibility tests;
- vision testing (visual acuity: distance and near; peripheral vision: left and right);
- TMT A & B.

The analysis found no relationship between leg strength and general mobility on the one hand, and the components of brake response time on the other. Additionally, findings suggested that the Rapid-Pace Walk Test had little face validity, i.e. drivers did not readily accept the applicability of the test to driving.

Participants took significantly longer to complete the TMT B test of the Roadwise Review than the paper-and-pencil-based version, leading to a classification of being severely impaired on the former compared to mildly impaired on the latter. Over 60% of participants failed the Roadwise Review head/neck flexibility test. Neck rotation was found to be a significant predictor of failing, and no other independent variables – including vision, and field tests of trunk and neck flexibility – added significantly to the prediction. However, the case-by-case evaluation of those who had failed the test suggested that they may not have been able to perform components of it, including meeting the necessary vision criteria, which may have led them to perform poorly. The author suggested several improvements to the Roadwise Review, include a threshold test for mouse proficiency, increasing its face validity, and making the feedback more specific.

An evaluation study carried out by Bédard et al. (2011), with a convenience sample of n=51 drivers aged 50 and over who had a score of less than 24 on the Standardised MMSE, compared the Roadwise Review to the outcomes of clinical tests of driving fitness and to an on-road driving assessment. The on-road driving assessment was carried out in the participant's own car and lasted approximately 40 minutes. A trained evaluator scored participants' driving errors, with 50 points being the threshold for failing the test. In addition to the overall score, subscores were calculated for:

1. starting, stopping and backing;
2. signal violations, failure to give right of way, and inattention;
3. moving on the roadway;
4. speed and passing;
5. turning.

Correlations between the Roadwise Review and the clinical tests (TMT A & B and subtest 2 of the UFOV test), as well as between the Roadwise Review and driving performance, were calculated. To allow the detection of as many significant associations as possible, the alpha-level for the multiple (75) Pearson Correlations performed was not adjusted. Additionally, the researchers tested the congruence of the assessment outcomes for the Roadwise Review and the on-road assessment, comparing the pass and fail patterns for both assessment procedures. Reported correlations between the subtests of the Roadwise Review and their clinical counterparts ranged between r=.61 for TMT A and the visual search section of the Roadwise Review, and r=.46 for TMT B and visual search. The correlation between subtest 2 of the UFOV test and the visual information processing speed of the Roadwise Review was r=.48. Whilst the correlations between the Roadwise Review and the on-road performance should all have been positive (as greater impairment is associated with more driving errors), several negative correlations were found. Comparing the drivers who had passed or failed the Roadwise Review and the on-road test, the authors found no evidence for a relationship between the assessment outcomes. On the basis of their findings, Bédard et al. (2011) concluded that the Roadwise Review was not able to identify unsafe drivers in their sample.

Quoting results from two more evaluation studies, Langford (2012) concludes in his doctoral thesis on licence authorities' options for assessing and managing older driver safety that it remains to be seen whether currently available evaluation results, derived from tests of the DrivingHealth® Inventory, are applicable to the Roadwise Review in its self-administered electronic format.

Conclusion

In contrast to previously reviewed self-assessment tools which rely on older drivers' reflection and self-report of changes experienced in driving-related capabilities, the Roadwise Review comprises a series of performance tests to capture the maximum performance of older drivers, and to quantify any impairment which may adversely affect driving. The tool derives from clinical assessment of drivers and is based on extensive research into predictors of collision involvement.

Whilst performance-based measures do not have to deal with the biases that are voluntarily or involuntarily caused by self-report, the accuracy of self-application of the performance test depends on the adherence of the respondent to standardised testing conditions. It is not surprising that the reduced rigour of self-assessment compared to clinical assessment leads to somewhat different outcomes, as shown in the evaluation work reported by Porter (2010) and Bédard et al. (2011). Evaluation studies that establish norm data for the self-completion of the eight tests included in the Roadwise Review are therefore required. Given the erratic pattern of correlations, reported by Bédard et al. (2011), between the scores of the Roadwise Review and an on-road assessment, further work into validating the Roadwise Review is necessary.

To what degree the Roadwise Review impacts older drivers' self-regulatory decision-making remains to be demonstrated.

4.3.4 Suffolk County Council's Grand Driver Scheme: The Older Driver Risk Index

Suffolk County Council (SCC) commissioned Driving Research Limited to undertake research to inform the development of its Grand Driver Project scheme with input from Cranfield University in the UK. The programme targets drivers aged 60 years and over, and aims to provide appropriate assessment and training in order to reduce their risk on the road by providing a framework of assessment sessions, information seminars and in-car training at a total cost of £10. At the scheme's outset, older drivers who chose to participate in the Grand Driver Project scheme were also enrolled as participants in the development of the Older Driver Risk Index (ODRI), a Web-based profiling tool that was launched in 2009. The aim of the tool was to establish the relative attitudinal and behavioural risk of older drivers with reference to their peer group and to investigate the specific issues that they face on the road (Gandolfi, 2009).

The development of the ODRI was informed by a review of the literature and an analysis of STATS19 at-fault collision data from 2005–7 for drivers aged 60 years and over in Suffolk.

The ODRI is a modification of the previously existing Driver Risk Index™, which was developed by researchers at Cranfield University and which is commercially utilised by its business spin-off, DriverMetrics®. The Driver Risk Index™ is a composite profiling tool, comprising four areas of assessment and using self-report items covering the following areas:

1. situational risk: including age, gender, annual mileage, penalty points on licence and collision involvement; respondents complete 17 multiple choice / free input items;
2. behavioural risk: including scales measuring aggression, thrill seeking, hazard monitoring, dislike of driving and fatigue proneness; respondents rate their agreement with statements on 41 items on visual analogue scales;
3. coping risk: including five coping styles – confrontational coping, task-focused coping, reappraisal coping, emotional coping and avoidance coping; respondents rate their agreement with statements on 35 items on five-point Likert scales;
4. socially desirable responding: including impression management and driver confidence; these scales are included to determine the likely accuracy of the self-reported risk profile; respondents rate their agreement with 12 items on six-point Likert scales.

Twenty-nine new items were developed and included on the basis of the literature review to account for age-specific factors. These items included driving situations of concern for older drivers, self-perceptions as a driver and peer comparison, perceptions about driving cessation, and alternative transportation modes.

Additionally, the researchers included two of the three subscales of the Driver Behaviour Questionnaire (DBQ), the error and the lapses subscale (Parker et al., 1995). The DBQ differentiates between "(…) lapses, [which include] absent-minded behaviours with consequences mainly for the perpetrator, posing no threat to other road users; (…) errors, [which] are typically misjudgements and failures of observation that may be hazardous to others; and (…) violations, [which] involve deliberate contraventions of safe driving practice" (p. 1036). A questionnaire study with 1,600 British drivers found violations to be significant predictors of self-reported collisions; errors and lapses were not found to predict collision involvement. Research has shown that interpersonally aggressive violations are the least-reported behaviour type among older adults, whilst errors and lapses play a more significant role (Parker, McDonald, Rabbitt & Sutcliffe, 2000).

The item set originally implemented as the Older Driver Risk Index comprised, in summary:

- Section A: situational analysis: 17 items; multiple choice or open answers (number of collisions, mileage etc.);
- Section B: behavioural risk analysis: 70 items; 11-point Likert scales;
- Section C: coping styles: 35 items; five-point Likert scales;
- Section D: impression management: 12 items, six-point Likert scales;
- Section E: DBQ: 16 items, five-point Likert scales.

Piloting of the question set included short interviews with older drivers to establish whether the questions were appropriate and easy to understand.

The paper-based version of the questionnaire was completed by n=913 older drivers who had been recruited through the Grand Driver Scheme at SCC, or through motorist associations.

Subsequent work included the testing of the factor structure and internal consistency of the questionnaire. In the final version of the questionnaire, 102 items remained. The emergent factor structure consisted of six behavioural factors, three coping factors, two error factors, and two socially desirable responding factors.

Behavioural factors:

1. Driver confidence;
2. thrill seeking;
3. aggression;
4. hazard monitoring;
5. fatigue and concentration;
6. attitude to public transport.

Coping factors:

7. effective coping;
8. blame-based coping;
9. avoidance coping.

Error factors:

10. careless errors;
11. dangerous errors.

Socially desirable responding factors:

12. impression management;
13. overconfidence.

Research was carried out comparing the collision involvement of different subgroups of the sample (60–69-year olds, 70–79-year olds, 80+ year olds) to validate the question set, with numerous differences emerging. Older Driver Risk Index profiles of those drivers who had been recommended for further training by a driving instructor during on-road assessment were compared to those who had not received such a recommendation. The findings indicated that drivers who had received a recommendation for further training reported significantly lower levels of driving confidence and lower levels of overconfidence, as well as more careless and more dangerous errors than those who had not received such a recommendation.

No information was available that described the development of the risk classification algorithms, of the feedback provided to respondents, or of the implementation of the question set as an interactive, Web-based tool. This probably reflects the fact that the tool is used commercially, through DriverMetrics®.

No research has been carried out to date to test the predictive validity of the tool with regard to road safety outcomes. However, a master's thesis explored the relationships between Older Driver Risk Index profiles and self-reported self-regulation as measured by questionnaires completed by n=191 drivers aged 60 years and over (Haward, 2011). Six factors of the Older Driver Risk

Index were found to be significantly correlated to self-regulatory behaviour, including driver confidence (negative correlation), hazard monitoring, blame-based coping (negative correlation), overconfidence (negative correlation), careless errors and dangerous errors. Volunteer bias and self-report bias were mentioned as the major limitations of the study.

Subscribers to the Grand Driver Project scheme receive single-use log-on codes from DriverMetrics®. Access to the tool is also available to potential users for a one-off fee of £12 through liaison with DriverMetrics®.

Conclusion

Similarly to the UK DDW, the Older Driver Risk Index is embedded in a local authority multi-component programme aimed at maintaining the safe mobility of older drivers in the county. The tool is a modification of the Driver Risk Index™, a commercially used tool that originated from research into stress and coping.

Details on the computation risk prediction algorithms and the feedback provided to drivers were not available. Whilst available evaluation results suggested significant associations, particularly between driver confidence and overconfidence, and instructor assessments of driving performance on the one hand, and self-reported self-regulation behaviour on the other, further evaluation research is necessary to establish the tool's impact on road safety outcomes.

4.3.5 Drivers 65 Plus: Check Your Performance

The 'Drivers 65 Plus' was initially published as *Drivers 55 Plus: Check Your Own Performance* by the American Automobile Association in 1994 as a paper-and-pencil-based self-assessment questionnaire with the aim of providing older drivers with an opportunity to self-assess their driving capability. The development of the tool was based on the results of research conducted by the Safety Research and Education Project at the Teacher's College of Columbia University, with funding from motor clubs associated with the AAA and the insurance industry.

Both the paper-based and Web-based version of the tool include 15 items with three-point item scales as responses (e.g. "always / almost always"; "sometimes"; "never / almost never"). Drivers complete the questionnaire based on the frequency of experiencing concerns or problems in traffic, adherence to safe driving behaviour, health problems, and feedback on their driving from others. Answers that indicate the absence of any concern receive a score of zero, those that indicate a mild concern a score of three, and those that indicate a serious concern a score of five.

Overall scores for respondents are automatically calculated, and the advice given to drivers recommends them

- to continue driving if total scores are in the range 0–15;
- to use caution and to consider improvements to current driving practices if scores are in the range 16–34;
- to stop and urgently consider improvements to driving if scores exceed 35.

Since its initial publication it has been developed into a Web-based self-assessment, with a direct translation of questions and scoring mechanism. The tool is available free of charge on the AAA website at: https://www.aaafoundation.org/drivers-65?button=driver55.

Conclusion

The brevity of Drivers 65 Plus means that the tool can be completed quickly. The implementation of the tool as an interactive, Web-based device has removed the need for the older driver to calculate performance scores.

No information could be found on evaluation of the paper-based or Web-based tool regarding its impact on self-awareness or adoption of the provided advice.

4.4 Web-based assessment resources for family members

Web-based resources for family members of older drivers go beyond the scope of this current review; however, some examples of such tools should be

briefly mentioned, reflecting the importance of the social network and family, in particular for decisions about changes to driving patterns and about driving cessation. Resources that were identified during the search for information included the following:

- An online training course ('We need to talk') for family members on conversations with older drivers, provided by AARP and available free of charge at www.aarp.org/home-garden/transportation/we_need_to_talk/.
- An interactive, Web-based tool for family members to identify potential problems with the driving of an elderly family member (the 'Fitness-to-drive Screening Measure Online'), developed by the University of Florida and available free of charge at: http://fitnesstodrive.phhp.ufl.edu.
- An online checklist ('Aging Parents and Elder Care') to help family members to identify potential issues with health and driving of an elderly family member. It remains unclear who developed the tool, which is available free of charge at: www.aging-parents-and-elder-care.com/Pages/Checklists/Elderly_Drivers.html.
- An information brochure for family members of elderly drivers (*The Way Ahead – a positive driving future*), including a checklist for potential issues with health and driving, and advice on how to approach conversations about driving cessation, developed by the Sussex Safer Roads Partnership and available free of charge at: www.sussexsaferroads.gov.uk/safer-for-older-drivers/advice-for-friends-and-family-members.html.

5. Summary, Critical Discussion and Recommendations

This review has found that the development of self-assessment tools for the older driver has been underpinned by concerns over demographic developments, and the perceived need to make provision for older drivers to maintain their mobility and associated well-being for as long, and as safely, as possible. The potential contribution of self-assessments to the safety of older drivers and their role in future transport policies is generally acknowledged, irrespective of the prevailing licensing arrangements for older drivers in Great Britain. Existing self-assessment tools have frequently been found to be one element in more extensive resource provisions for older drivers and their social network. Providers of tools include academic groups, motoring clubs, local authorities, older people representative groups, government agencies and private business. Unfortunately, neither information on the marketing of the tools (other than through websites), nor use figures, were available.

Existing self-assessment tools fall into one of two categories. They either rely on older drivers' self-report (and quantification) of problems and concerns experienced in their driving, or they were based on tests that measured functional abilities relevant to driving and quantified the impairment on each of these abilities. The majority of the tools had been developed in the USA, and the DDW and the Roadwise Review in particular had been based on substantial research programmes and reviews of the literature which had demonstrated significant correlations of the included assessment dimensions with collision involvement.

For several of the tools identified, no information could be found on the development of the question set, or the derivation of cut-off criteria to separate drivers classified to suffer from "no", "mild" or "severe" impairment. The links between severity and scoring were determined, for the DDW and the Roadwise Review, by expert panels, and informed by the literature review; however, scoring rationales were less clear – or not available – for other tools.

Comparatively few validation studies have been carried out to assess the predictive validity of existing self-assessments for performance on objective tests of function, either in clinical evaluation or in driving performance. Langford (2012) suggests that such studies are critically important. The evaluation and validation results available demonstrated that tools developed under both approaches have their own challenges, as correlations with driving performance in on-road assessment – arguably the most accurate measure of actual driving performance – were in many cases significant, but also far from perfect. There is a variety of explanations that may partly account for these findings, depending on the approach on which the tools were based.

Tools that are based on older drivers' self-report of concerns over their driving performance depend significantly on the accuracy of the self-report. A study by Horswill et al. (2013) indicated that the self-rated hazard perception performance of older drivers, even in situations where there is nothing to gain from a favourable self-presentation, is subject to enhancement bias, and does not correlate with objectively measured hazard perception performance.

The authors argued that "relying on older drivers' self-regulation to offset age-related declines could be problematic, because these drivers (like all drivers) have little insight into their own driving ability" (Horswill et al., 2013: 135).

They suggested that self-regulation instead appeared to be driven by other factors, such as self-efficacy, which describes a person's belief in his or her ability to complete tasks or achieve goals, and driver confidence. This suggestion would appear to concur with the findings reported by Gandolfi (2009) and Haward (2011), who both found links between driver confidence/overconfidence and self-regulation in their evaluation of the Older Driver Risk Index. Support for this notion also comes from the research reviewed in section 2.6. The available research, however, does not permit conclusions about whether self-regulation, based on relatively unspecific feelings of confidence or discomfort, is sufficiently accurate to make compensatory changes to driving styles and patterns, or whether it could be improved by a more accurate insight into actual performance levels delivered by self-assessment tools.

Self-report tools are, additionally, vulnerable to bias caused by intentional misrepresentations by respondents which lead to inaccurate feedback to the driver. Whilst the motivation to intentionally embellish the truth in a voluntarily completed tool that does not impact licensing status should be low, it may yet play a role – for example, when the tool's outcomes are used for discussion with family members over the driver's fitness to drive. No studies could be identified that have attempted the quantification of such biases for self-assessment tools aimed at older drivers.

Tools that measure performance on functional ability tests do not suffer from self-report problems. However, the accuracy of the feedback provided by these tools depends on the participants' adherence to the standardised assessment protocol. The comparatively lower scientific rigour in the completion of the tool in a home environment compared to completion in the clinical setting may be in part responsible for the fact that observed correlations between self-assessment and clinical test application are significant, but not perfect.

A graver concern is the lack of predictive validity for on-road performance observed in the Roadwise Review. It led Bédard et al. (2011) to conclude that tools that lacked validity may impact drivers negatively, as they would end up receiving feedback that was not consistent with their abilities, leading them to worry when they shouldn't, or conversely to experience a false sense of reassurance. The authors identified an unwarranted sense of confidence, costs of additional further evaluation through healthcare specialists, and mobility loss due to premature curtailment of driving as possible negative impacts of incorrect feedback. Similar concerns about the potentially negative impacts of safety interventions aimed at older drivers have been voiced by Davidse and Hoekstra (2010). The findings emphasise the importance of further work on the predictive value of the self-assessment tools available.

It should be noted that that, to date, relatively little attention has been paid to higher-order abilities, such as risk-taking, situational awareness, change blindness and resistance to distraction. It could be argued that test validity could be improved if future tools incorporate effective assessments of these abilities.

Referring back to the theoretical framework provided in section 2.7 of this report and the argument rehearsed in section 3.1, it should also be emphasised that upper performance in functional ability test may never perfectly map onto observed driving performance, given that drivers rarely operate at their upper capability limit. Whilst links between functional impairment and collision involvement have been demonstrated, self-regulation and the notion of self-pacing when driving may offer an explanation as to why the links between performance assessment outcomes and driving performance are not straightforward.

Whilst evaluation work on functional performance assessment tools has focused on their association with clinical assessments and on-road performance, studies that have explored their impact on self-awareness in older drivers are lacking Whilst the study by Holland and Rabbitt (1992) reviewed in section 2.6 indicated that the provision of feedback on functional abilities led to increased self-awareness and subsequent compensatory changes in older drivers' travel patterns, similar studies for functional self-assessment tools targeted at older drivers have not yet been undertaken.

Irrespective of the approach chosen for the self-assessment tool, available evaluation findings suggested that from a user perspective, the reviewed tools were well accepted by older drivers and were perceived as useful. For the DDWs (both the Original and the Enhanced), there was evidence to suggest that the tools led to increased self-awareness and increased topical knowledge. They were also reported to facilitate discussions about driving with family members.

However, current evaluation designs need to be improved. All evaluation and validation studies reviewed relied on opportunity samples of older

drivers which were frequently not representative of the overall older driver population. Several studies reported recruitment through existing driver safety improvement schemes, thus facilitating the self-selection of older drivers with arguably particularly positive attitudes towards safety interventions. In some cases, randomisation for control group and experimental group was not possible. Whilst the difficulties of recruitment are acknowledged, the potential bias to the findings has to be considered (Langford, 2012). It should also be mentioned that several of the evaluation studies were planned and carried out by the developers of the tools. Again, whilst this is frequent practice, replication studies of such evaluations by independent researchers are needed.

The tacit assumption underlying all types of self-assessment measures is that the provision of feedback on a driver's age-related impairments in their driving abilities, and advice on how to address these, will lead to appropriate self-regulatory modifications of driving patterns. The anticipated pathway for the contribution of self-assessment tools to the improved road safety of older drivers is through improved calibration and selection of appropriate actions in response to the corrected understanding of one's own driving capability.

There is currently no robust evidence from evaluation studies of existing tools that has tested this assumption that better calibration leads to changes in self-regulation which are in turn beneficial to older drivers' road safety performance.

Whilst most available evaluation studies have tested for statistical associations between the self-assessment tool and the outcome measure immediately after completion, only one study (Dunn, 2012) explored participants' self-reported intention to change and actual change four months after completion. The findings suggested that many drivers had not made changes to their driving at this time point, possibly because the perceived need for change was low. There is an urgent need for prospective, randomised control studies that investigate the impact of self-assessment tools, and associated feedback, on the objective behaviour of older drivers over time (expressed, for example, by seeking out further assessment and evaluation, participating in driver education/training activities, and/or modifying or perhaps reducing actual driving) (Molnar et al., 2007; Charlton & Molnar, 2011; Langford, 2012).

Involving control groups in these studies is not only good experimental practice, but of particular relevance for research on ageing processes, as increased self-regulatory practices observed over time may not be the result of the self-assessment tool, but of the ageing process itself. Such studies would also help to establish the longevity of the safety benefits of self-assessments (Langford, 2012). Until evaluation studies present evidence of how self-assessment tools impact self-regulation behaviour and compensatory changes to driving patterns and styles, one can only speculate as to whether and how the increased self-awareness of drivers may translate into actual driving-related behaviour.

Once this evidence becomes available, further evaluation will be required to establish the impact of improved calibration and self-regulation on road safety outcomes such as collision involvement and, possibly, quality-of-life measures.

The provision of safety interventions such as training courses or awareness workshops can be associated with significant costs to either the provider (for example, a local authority) or the user (the older driver). Self-assessment tools, on the other hand, can, once validated, provide cost-effective contributions and reach a wide spread of older drivers.

There is evidence to suggest that current barriers to computer- and Web-based tools are likely to disappear with future generations of older drivers becoming increasingly computer-literate. Whilst the age specifications for existing self-assessment tools vary, and often seem to be arbitrarily selected (mirroring the lack of agreement on when older driving starts discussed in section 2.1), evaluation results of current self-assessment tools suggest that differences exist within the older driver age subgroups (e.g. Molnar et al., 2010; Gandolfi, 2009). To maximise the benefits of the tool to the target group, evaluation studies need to explore for which older driver subgroups self-assessments are most effective.

On the basis of this review of existing tools, and the available evidence for their predictive validity, the following recommendations are put forward:

- Self-assessment tools can serve a valuable purpose in raising driver awareness of abilities and problems, but they cannot act as a definitive measure of driving competence, and should not be promoted as such.
- The limitations and benefits of current tools should be acknowledged, so that they can be used appropriately.
- There are components of the driving task that can be self-assessed, and which have been shown to have some predictive value for determining driving abilities, but more research should be conducted to validate them, particularly in the areas of risk-taking and situation awareness.
- Self-assessment tools should include the following features:
  - self-report of medical history and health concerns;
  - self-report of driver experience (including the experience of difficulties) and attitudes;
  - tests of component abilities:
    - vision: static, dynamic and contrast threshold;
    - UFOV;
    - the Clock-Drawing Test and the Maze Test;
    - hazard perception and change blindness.
- Self-assessment tools should be refined by testing with older drivers of different pathologies and experience levels. Randomised controlled trials are needed.
- Self-assessment tools can usefully complement older driver programmes and interventions, and provide a growing number of drivers with quick

and easy-to-access checks of driving ability; self-assessments should not replace clinical assessments of fitness to drive which are carried out to inform decisions on licensure.

- Available self-assessment tools tend to be free of charge, but are likely to suffer from self-selection bias – respondents to such tools are more likely to have a proactive attitude to driving safety; possible solutions to this issue, to encourage their use by all older drivers, should be considered.
- Self-assessment tools are not suitable for older drivers suffering from significant cognitive impairment; this should be stated on the tool and supporting materials.
- Self-assessment tools must avoid creating a sense of false security in drivers, or conversely provide incorrectly negative feedback on driving abilities to the driver, as both outcomes are associated with significant costs to the individual and/or to society.
- Feedback provided by self-assessment tools should be as tailored and individualised as possible.
- Government should acknowledge demographic developments and the perceived need to make provision for older drivers to maintain their mobility and associated well-being for as long, and as safely, as possible.
- Government should encourage research into the potential contribution and predictive validity of self-assessments to the safety of older drivers.

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