Investigating Fitness to Drive in Older Drivers with Cognitive Impairment

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Abstract

The assessment of fitness to drive in older individuals is controversial, with some remaining safe and others presenting at a substantially increased risk. There is a need to explore the nature of any deficits in driving performance in individuals with mild cognitive impairment (MCI), whether they engage in self-regulatory behaviours, and the extent to which they have insight into their driving behaviour. This thesis is comprised of two experimental studies and a systematic literature review. The aim of Study 1 was to establish brake profiles of older adults with and without mild cognitive impairment at intersections using a portable driving simulator. An experimental case-control study was conducted whereby 14 drivers with MCI and 14 age-matched healthy controls completed a simulator drive consisting of stop-sign controlled and signal-controlled intersections. Findings partially supported the hypothesis that compared to healthy older adult drivers, drivers with cognitive impairment would engage in higher risk brake response patterns. Preliminary evidence suggested that drivers with MCI may be less likely to stop at stop-sign controlled, and possibly also at critical light change intersections. The systematic literature review was conducted to identify existing literature on the topic of self-regulation in older drivers with cognitive impairment. Current evidence suggests that many drivers with cognitive impairment do self-regulate by restricting their driving and avoiding certain driving situations.

The aim of Study 2 was to investigate the extent to which cognitive status impacts on the decision to self-regulate driving behaviour and to determine whether drivers who self-regulate demonstrate insight into a decline in their driving skills. Older drivers were recruited from the general population in Victoria, Australia.
Findings are presented with respect to cognitive status. Where available, passengers provided an informant view of driver behaviour and an indicator of insight. The findings are discussed in terms of implications for policy and practice regarding older drivers and particularly those with MCI.
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CANDIDATE DECLARATION

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“Logic will get you from A to B. Imagination will take you everywhere.” - Albert Einstein
List of Publications

Publications by the candidate included in the thesis:


Conference Presentation

Terminology and Definitions

ABS – Australian Bureau of Statistics

AIHW – Australian Institute of Health and Welfare

CDR – Clinical Dementia Rating scale

Fitness to Drive – standards for driver licensing

GDS – Geriatric Depression Scale

GEE – Generalised Estimate Equation

MCI – Mild cognitive impairment

MMSE – Mini Mental Status Examination

Older driver – a driver aged 65 years and over

On-road test – on-road assessment procedure

TMT – Trail Making Test

TICS-m – Telephone Interview for Cognitive Status - modified

UFOV – Useful Field of View

WHO – World Health Organisation
Thesis Overview

This thesis commences with two introductory chapters. In the first, the difficulties and the extent of safety risk for older drivers, and particularly those with cognitive impairment are explored. Consideration is also given to the impact of the problem on licensing authorities, health professionals and the community at large. In Chapter 2 an overview of cognitive impairment is presented with respect to prevalence, key definitions and assessment tools. Following these chapters, the thesis is divided into two parts: driver performance and driver self-regulation.

The first part of the thesis, which focuses on driver performance, begins with a review of older driver performance at intersections with respect to data from on-road studies, crash data and driving simulator studies. Based on the review in Chapter 3, and the information outlined in the introduction, Chapter 4 provides an overview of the thesis rationale, research aims and the objectives of the first experimental study.

The first experimental study is presented as a paper in Chapter 4. The study methodology, results and discussion are explained to determine the brake patterns of older drivers when approaching intersections using a portable driving simulator.

Chapter 5 presents the second part of the thesis which focuses on driver self-regulation, cognition and insight. Two theoretical models of self-regulation are presented, with respect to internal and external contributing factors. Chapter 6 consists of a systematic review of self-regulatory behaviour of older drivers with cognitive impairment. Based on the findings of the systematic review and the literature outlined in Chapter 5, the rationale, aims, objectives and design of the second experimental study are described in Chapter 7. The remainder of Chapter 7 consists of the second experimental paper which focuses on the association between
self-regulation, cognitive status and insight. Following this, Chapter 8 consists of a secondary component of the second experimental paper and addresses the factors that potentially influence retirement from driving from a qualitative perspective.

Chapter 9 presents the general discussion. The main findings of Study 1 and Study 2 are discussed here and are related back to the Driving as an Everyday Competence Model (Lindstrom-Forneri, Tuokko, Garrett, & Molnar, 2010). Strengths and limitations of each study are discussed combined with implications of the findings for Australian policy makers, licensing authorities and older drivers.
Chapter 1: Introduction

The Older Driver Problem

Retirement from driving presents for many as a major life event which can be a daunting prospect for both the individual and members of their immediate family. Driving authorities are faced with the challenge of balancing the need for maintaining the mobility and the independence of the older driver for as long as possible, with concern for the safety of the driver and the public at large. Older drivers who experience age-related changes in physical and sensory functioning as well as age-related medical conditions can be at a heightened risk for motor vehicle crash involvement (Charlton et al., 2010). Although distinct from the normal ageing process, cognitive impairment becomes more prevalent with age. It thus presents as a growing concern in conjunction with the increase in the proportion of older individuals in the community (Lopez et al., 2003). Extensive reviews of literature, focusing on older drivers with moderate and severe forms of cognitive impairment, have indicated a moderately high crash risk in comparison to healthy controls (Adler, Rottunda, & Dysken, 2005; Brown & Ott, 2004; Charlton et al., 2010; Dubinsky, Stein, & Lyons, 2000; Lloyd et al., 2001; Man-Son-Hing, Marshall, Molnar, & Wilson, 2007; Marshall, 2008). This increased crash risk is partly due to a lack of insight into a decline in functional abilities by the driver (Okonkwo et al., 2009; Pachana & Petriwskyj, 2006), and is largely due to the influence of cognitive changes on driving performance (Anstey, Wood, Lord, & Walker, 2005; Lafont, Laumon, Helmer, Dartigues, & Fabrigoule, 2008; Uc & Rizzo, 2008).

To date, very few studies have examined the relationship between mild cognitive impairment, driving performance and crash risk (Fritelli et al., 2009; Herrmann et al., 2006; Hunt, Morris, Edwards, & Wilson, 1993; Snellgrove, 2005).
While the need to monitor drivers in the initial stages of cognitive impairment has been increasingly highlighted in research, findings do not universally suggest that all drivers with a formal diagnosis of cognitive impairment should automatically have their licences revoked (Friedland et al. 1988). Rather, it has been argued that the severity of the illness and the driving competence of the individual should be taken into account in the decision as to whether individuals forfeit or are able to retain their licence to drive (Molnar, Patel, Marshall, Man-Son-Hing, & Wilson, 2006). There is therefore an urgent need to determine and understand the key characteristics of driving performance and especially the trigger points relevant to the reliable identification of drivers who are potentially unsafe.

While the American Academy of Neurology Quality Standards Subcommittee recommends that all drivers with moderate or severe stages of cognitive impairment should refrain from driving (Iverson et al. 2010) a significant proportion of drivers with cognitive impairment continue to drive (Freund & Petrakos, 2008). According to estimates derived from a survey of a large Australian sample of older drivers (n = 5026), 42% of males with probable dementia, and 63% of males with mild cognitive impairment were current drivers (Ross et al., 2009). These estimates were lower for females at 11% and 19% respectfully. These results were obtained via self-report of driving status by adults living in New South Wales, Victoria and South Australia, with cognition measured by the Mini Mental Status Exam. This data was collected between 1991 and 2000, and therefore current and future estimates are likely to be much higher on the basis of predictions that the prevalence of dementia in Australia is expected to increase by approximately 254% from 2011 to 2050 (Access Economics, 2011). The anticipated escalation in numbers of older adults with dementia, poses many challenges. In particular, it places a demand on health care providers, governments and licensing authorities who are
faced with providing sound and timely assessments for drivers. It also demands that the future design of roads and vehicles takes older drivers into account.

**The extent of safety risk for older drivers.**

While older drivers typically have lower risk in terms of absolute number of crashes compared to younger drivers, older drivers are more likely to sustain greater injuries or fatalities once involved in a crash (Lee, Lee & Cameron, 2003). In Australia, for example, drivers aged 65 years and above comprised 16.7% of all driver fatalities from July 2010 to July 2011, while accounting for only 13.5% of the Australian population in 2010 (Australian Bureau of Statistics, 2012). Furthermore, ageing is associated with deteriorating health and an increase in a range of neurodegenerative diseases that may increase driving risk. A large body of research now demonstrates that those individuals with Parkinson’s disease, Alzheimer’s disease and stroke demonstrate a greater number of driver errors than their healthy counterparts (Dobbs, Heller, & Schopflocher, 1998; Lafont et al., 2008; Rizzo, McGehee, Dawon, & Anderson, 2001; Stolwyk, Charlton, Triggs, Iansek, & Bradshaw, 2006). In particular, older drivers with cognitive impairment have been found to engage in a number of hazardous behaviours in challenging driving situations, such as approaching intersections, merging and changing lanes (Dobbs et al., 1998). There is general agreement that drivers at the moderate and particularly severe stages of dementia ought to cease driving. It remains unknown, however, as to whether individuals who experience mild cognitive impairment remain safe drivers, or are at a substantial increased safety risk (Iverson et al., 2010).

It has been previously suggested that all drivers with cognitive impairment were unsafe and should not drive (e.g., Friedland et al., 1988). Some researchers in the field maintain this view (e.g., Perkinson et al., 2005); even though there is
evidence to suggest that premature cessation of driving can lead to social isolation and a decreased quality of life (Marottoli, Mendes de Leon, Glass, Williams, & Conney et al., 2000). Conversely, other researchers argue that not all drivers with cognitive impairment are unsafe and therefore each driver should be assessed on a case by case basis (Berndt, Clark, & May, 2008; Eby, Silverstein, Molnar, LeBlanc, & Adler, 2012; Molnar et al., 2006). Nonetheless, evidence from a two year longitudinal study by Duchek et al. (2003) suggests that drivers with mild cognitive impairment (MCI) do experience a decline in on-road driving performance to a greater extent than healthy controls (Duchek et al., 2003). The key point is that this rate of decline may vary depending on the individual and may not translate into a substantial crash risk.

The crash patterns of older drivers with cognitive impairment.

Older drivers are over represented in intersection crashes compared to other age groups (Clarke, Ward, Bartle, & Truman, 2010). Intersections are challenging driving situations with many conflict points that require the driver to simultaneously attend to and adequately respond to multiple sources of information. Intersections often require the driver to select a gap in oncoming traffic before turning - a manoeuvre that has been found to be especially problematic for older drivers (Braitman, Kirley, Ferguson, & Chaudhary, 2007). The difficulty has been attributed to problems judging speed and distance of the oncoming vehicles (Yang & Najm, 2007) as well as visual search problems (Bao & Boyle, 2009), scanning for hazards (Romoser, Pollatsek, Fisher, & Williams, 2013), and failure to give-way (Braitman, Kirley, Ferguson, & Chaudhary, 2007; Preusser, Williams, Ferguson, Ulmer, & Weinstein, 1998). The subset of drivers most at-risk for crashes at intersections are aged above 80 years of age (Rakotonirainy, Steinhardt, Delhomme, Darvell, &
Schramm, 2012), and examination of responsibility according to police reports demonstrate that drivers in the “old-old” age group (i.e., 80 years and above) are more likely to be at-fault in these crashes (Rakotonirainy et al., 2012; Viitanen et al., 1998). In Australia, approximately 21% of males and 24% of females aged 85-89 years suffer from dementia (Access Economics, 2009), with rates rising to 37% of males and 47% of females aged 95 years and above. Therefore, the likelihood that this subgroup of at-risk “old-old” drivers has cognitive impairment is high.

Driving patterns and crash statistics differ according to the road infrastructure and environment. For example, although younger driver fatalities are high in rural areas, a pattern is emerging whereby older drivers are also over-represented in fatal and serious crashes in rural compared to urban areas (Thompson, Baldock, Mathias, & Wundersitz, 2012; Travis, Clark, Haskins, & Kilch, 2012). Over-representation of older drivers in rural crashes has been attributed to limited alternate transport options (Corcoran, James, & Ellis, 2005), limited access to medical facilities (Gonzalez, Cummings, Mulekar, & Rodning, 2006), and excessive speed on high speed roads (Thompson et al., 2012). It is important to account for these differences when researching older driver behaviour in order to understand unique patterns of driving behaviour, identify key crash types and to develop appropriate countermeasures.

The problem for licensing authorities.

The extensive literature, focusing on ageing and functional capabilities has consistently shown a decline in physical health with age. Consistent with this finding, a number of licensing authorities have introduced age-based medical examinations to assess fitness to drive. However, the use of age-based assessments has not translated into a decreased crash risk for older drivers (Langford, Fitzharris,
Koppel, & Newstead, 2004). Licensing procedures vary considerably between countries, and between jurisdictions within the same country. For example, while some jurisdictions require medical assessments, others also require older drivers to participate in on-road driving assessments at defined ages. In Australia, only Victoria and the Northern Territory refrain from age-based testing, all the other states and territories require the driver to produce a medical certificate once the driver reaches a certain age. However, if the driver suffers from a medication condition it is now mandatory to notify the driver licensing authority in all Australian states and territories (Austroads, 2012). More specifically, the guidelines state that the drivers themselves are responsible for “reporting to the driver licensing authority any long-term or permanent injury or illness that may affect their ability to drive safely”. If for some reason the driver cannot or will not report their condition to the authorities, and there is potential danger to other road users, the onus falls upon the medical practitioner to report the condition to the authorities. The physician is also required to advise the person about their responsibility to report, to ensure patients are adhering to their medication, and to ensure patients are complying with any conditional licence restrictions.

According to the Australian guidelines, all drivers with dementia are required to hold a conditional licence (Austroads, 2012). The conditions may involve, limiting driving to non-peak hours, daylight hours only, within 20 kilometres of the house, to name a few. This licence is subject to annual review, based on the results of a driving assessment, if required, and the results of a medical assessment. The medical assessment focuses on capabilities related to driving such as; attention, memory, visuo-spatial perception and insight. The physician can propose conditions of a conditional licence to the driver licensing authority based on the medical assessment,
which may consist of a radius restriction from the driver’s home. Ultimately, the
driver licensing authority has the final authority on the specifications of the
conditional licence. While a conditional licence arrangement may assist with a
smooth transition for the driver and their family into driving cessation, the process
presents a challenge for physicians who rely on assessment results, which do not
always equate with fitness to drive. For example, drivers may compensate for
degrees in functional performance and limit their own driving (Anstey et al., 2005;
Baldock, Mathias, McLean, & Berndt, 2006; Janke, 2001). In addition, the extent of
deterioration can vary between individuals, highlighting the importance of
monitoring patient progress over time. The assessment of dementia and cognitive
decline is particularly challenging (Odell, 2009). As a result, solutions for identifying
drivers who are medically at-risk to drive have been developed. Currently, however,
there are no agreed upon clinical screening tools that accurately predict on-road
driving performance (Martin, Marottoli, & O'Neil, 2009; Molnar et al., 2006; Wilson
& Kirby, 2008).

In summary, the assessment of fitness to drive is a controversial issue due to
the lack of specific assessment criteria and the wide differences in fitness to drive
guidelines (Austroads, 2012; White & O'Neill, 2000). This is most particularly the
case with respect to drivers with cognitive impairments. These guidelines rarely
specify cut off criteria according to the degree or severity of cognitive impairment.
As a result, greater responsibility for determining risk is placed on the health
physician who may consequently make the decision on the basis of subjective
criteria. Rather, than a determination of whether one should or should not be driving,
the current dominant research issue relates to gaining an understanding of the
progressive changes in driving ability that could enable a determination of the
predictors of unsafe drivers. These changes can be identified through investigations of older drivers who may be in the transition phase between mild cognitive impairment and dementia.

The problem for health professionals.

The physician is in an ideal position to monitor changes in medical fitness to drive, educate the patient about their health condition and how it impacts on driving, and notify the driver licensing authority if the driver is at a potential safety risk. Despite this responsibility, physicians may refuse to report drivers who are unfit to drive due a number of potential barriers. According to the Australian Medical Association (2008), physicians are opposed to the responsibility of judging fitness to drive for a number of reasons. First, it may jeopardise the doctor-patient relationship. Continuing care and monitoring of health conditions, confidentiality and patient quality of life can be a higher priority for some physicians compared to road safety. Second, the medico-legal liability and legal liability of medical decisions is a contentious issue for physicians (Odell, 2009). Finally, lack of education about the association between medical conditions, crash risk and appropriate assessment tools can leave doctors feeling ill equipped to make a judgment on fitness to drive (Marshall & Gilbert, 1999). There are thus a number of uncertainties and challenges associated with determining driving risk via this process.

Physicians treating individuals who are 65 years and above are commonly faced with the challenge of treating chronic diseases, which are the leading cause of illness and disability in this population (Australian Bureau of Statistics, 2006). An
association between crash risk and drivers who suffer from age-related conditions such as; diabetes, sleep apnea, epilepsy, alcohol abuse and dependence, cataracts, schizophrenia, multiple sclerosis and dementia (Charlton et al., 2010; Vaa, 2003) has been identified. To date, the research has typically involved an investigation of crash risk for each condition separately rather than accounting for multiple health conditions. In a study by Langford, Dow and Turmel (2011), an analysis of 2,639,281 drivers in Quebec, Canada was conducted by relating prescription medication records with crash data. When analysed by age, 80% of drivers aged above 80 years had one health condition, while 64% had two or more conditions. Therefore, it is likely that older drivers with cognitive impairment may have more than one health condition. It is not yet known how multiple health conditions impact on fitness to drive, however multiple health conditions are likely to augment crash risk for drivers with dementia.

Adults aged over 65 years are frequently prescribed medication for chronic illness and for psychological conditions. Furthermore, the prevalence of polypharmacy use is high for Australians aged 75 years and above (Morgan et al., 2012). Prescription medication such as benzodiazepines and anti-depressants have been found to impair driving performance although the few studies that have investigated this relationship typically comprise small samples of adult drivers of all ages, without specifically focusing on older drivers (Cooper, Meuleners, Duke, Jancey, & Hildebrand, 2011). A population based study conducted by Meulners and colleagues (2011) explored the association between 616 older drivers admitted to hospital from 2002 to 2008 in terms of their prescribed medication, and crash outcomes. Increased crash risk was found for those prescribed benzodiazepines and anti-depressants. Physicians therefore have a role to inform their patients about the potential impact of prescription medication on driving performance. While it is more
common for prescription medications to have effects that impair driving performance, research is starting to emerge in favour of treatments for Alzheimer’s disease such as cholinesterase inhibitors, which may improve attention and consequently improve driving performance (Daiello et al., 2010).

The importance of maintaining mobility.

Motor vehicle crashes have obvious negative implications for the drivers and passengers such as loss of mobility, a decline in general health and wellbeing, as well as ongoing costs associated with medical treatment and insurance. It has been estimated that the economic cost of road crashes is around 18 billion per annum in Australia (Australian Government, 2010). A motor vehicle crash is often associated with significant stress and emotional responses which can contribute to the onset of psychological disorders such as post-traumatic stress disorder, acute stress disorder, anxiety and depression (Blanchard, Hickling, Taylor, Loos, & Gerardi, 1994). Furthermore, a substantial number of people also suffer from chronic pain syndromes after experiencing a motor vehicle crash (McLean, Clauw, Abelson, & Liberzon, 2005). Road traffic injuries not only impact those directly injured, but can also negatively impact on family members, who may be required to take on the role of a caregiver.

As driving is for many individuals an instrumental everyday activity, it is an essential part of remaining involved in social activities and is an integral component of self-esteem and well-being (Edwards, Lunsman, Perkins, Rebok, & Roth, 2009). When the driver ceases driving after a motor vehicle crash, the individual becomes at an increased risk for developing depression due to reduced mobility and increased social isolation (Marottoli et al., 2000). For many, the loss of a licence can be likened to a loss of identity, particularly for older males who may lack the ability to continue
to independently participate in daily activities. Once a driver has been involved in a crash, they often rely upon family and friends for support and the family members can play an integral role in promoting and maintain driver safety particularly when the driver lacks insight into their behavior. This can result in communication difficulties, frustration on part of the care giver when the driver lacks insight about the family members concerns for their safety. Family members can often act as co-pilots and provide the ‘eyes’ for drivers who suffer from dementia (Taylor & Tripodes, 2001). For family members who rely on the driver for transport, they may be less likely to discuss or encourage driver cessation (Adler, Rottunda, Bauer, & Kuskowski, 2000). Consequently, it is essential to include family members in any interventions aimed at changing driver behavior and enhancing driver safety.

Maintaining mobility is an important goal that contributes to older adult independence. According to Stalvey, Owsley, Sloane and Ball (1999); mobility has been defined as the “spatial extent to which one’s travel in their environment”. According to Buys, Snow, van Mengen & Miller (2011) driving is the preferred transport option for maintaining mobility in Australia due to convenience, affordability, availability and the sense of security it provides. As driving is the preferred option, it can be challenging for people to seek out and use other forms of transport, particularly when other psychosocial and environmental factors may act as additional barriers. Geographic location, ease of access to alternative transport options, and financial factors can all act as determinants of mobility for older drivers. Furthermore, drivers in rural areas may be at a disadvantage due to limited health service providers, opportunities to access education about the effects of cognitive impairment on driving, as well as limited opportunities to provide counselling for drivers and family members who may be suffering from grief and loss after driving cessation (Nixon, 2011). It is therefore important to recognise these limitations
specific to rural areas when designing interventions to maximize mobility and promote road safety.

**Addressing the problem of older drivers with cognitive impairment.**

A useful framework for addressing road safety that is frequently cited in the literature is referred to as the Safe Systems Model (Australian Transport Council, 2010). The Safe Systems Model is a holistic view that accounts for the interaction between the road users, the vehicles and the environment. It is useful to address road safety from a holistic perspective, as there are many different facets involved. The aim of the model is to not only reduce the number of fatalities and injuries on the roads but also to minimise the extent of injury when crashes occur. There are four principles that underpin the model: human error, human fragility, a forgiving system, and shared responsibility. This framework takes into consideration that road users make mistakes and errors that contribute to road crashes, through factors such as inattention or driver fatigue. The system acknowledges that people do make mistakes and therefore the road system should be developed to accommodate for this. This system was used to inform the development of Australia’s National Road Safety Strategy (2011-2020) (Australian Transport Council, 2010). Within this strategy priority interventions were recommended relating to the four cornerstone areas: safe people, safe roads, safe speeds and safe vehicles. This thesis will focus on safe road users, and specifically safe drivers.

The knowledge base regarding driving performance of older drivers with mild cognitive impairment and their capacity to self-monitor is still in its infancy. Research is therefore needed to inform practice related to driver assessment, licence restrictions and engineering solutions for vehicles and roads. More specifically, it is
important to explore the nature and extent of the problem including; any deficits in
driving performance in individuals with MCI, whether drivers with MCI engage in
self-regulatory behaviours, and finally whether drivers with MCI have insight into
their driving behaviour. The goal of this thesis was to address these areas specific to
this increasing subsection of older drivers with MCI.
Chapter 2: Age-Related Cognitive Impairment and Driving

Cognitive Impairment Defined

Although there is large variability between individuals, it is well understood that changes in cognition are associated with age. For example, older adults typically demonstrate declines in information processing, reaction time and working memory (Salthouse, 2000). Therefore, older adults typically require more time to complete tasks compared to their younger counterparts, and tend to focus on accuracy rather than speed (Starns & Ratcliff, 2010). It has been suggested that this slowing may be associated with age-related changes in the brain such as atrophy of the frontal lobes (Raz, Gunning-Dixon, Head, Dupuis, & Acker, 1998) or white matter degeneration (Gunning-Dixon & Raz, 2000). Cognitive impairment is distinct from normal ageing as it is underpinned by different neuropathology. Dementia is a term used to describe a range of conditions characterized by cognitive dysfunction, which can include impairments in language, memory, perception, cognitive skills and brain function (Australian Institute of Health & Welfare (AIHW), 2012). There are many different types of dementia, however, the majority of cases (approximately 50-75%) consist of Alzheimer’s disease, followed by vascular dementia (20-30%) and fronto-temporal dementia (5-10%) (AIHW, 2012). Due to the cognitive abilities required for driving, dementia can impact negatively on the ability to operate a motor vehicle and consequently the ability to manage certain driving situations.

Mild cognitive impairment (MCI) is a condition that presents with a slight impairment in cognitive functioning, typically memory, that is greater than expected for the persons age and education level, and does not meet the criteria for dementia (Petersen et al., 2001). Although the definition of mild cognitive impairment remains controversial, there is now evidence from neuropsychological and neuroimaging
studies to suggest that MCI is a distinct entity from dementia (Lonie, Tierney, & Ebmeier, 2009). Furthermore, survey studies of physicians confirm that the condition of MCI is internationally recognised in clinical practice (Mitchell, Woodward, & Hirose, 2008; Rodda, Gandhi, Mukadam, & Walker, 2012). Earlier definitions of MCI included intact or only slight difficulties in tasks of daily living (Petersen, 2003). Recently, however there is evidence to suggest that as many as one third of adults with MCI do in fact demonstrate difficulties with complex tasks of daily living (Albert et al., 1999; Aretouli & Brandt, 2010; Barberger-Gateau, Fabrigoule, Helmer, Rouch, & Dartigues, 1999; Okonkwo et al., 2009). It is likely that deficits in functional abilities of daily living exist on a continuum between deficits associated with normal ageing and those associated with dementia. Currently, there is no consensus on the extent to which complex activities of daily living (of which one is driving) are compromised by MCI.

MCI can be further differentiated into clinical subtypes that differ according to pathological origins and clinical outcomes. Amnestic MCI single-domain refers to a condition where only one cognitive domain (i.e. memory) is impaired. Non-amnestic MCI multi-domain, on the other hand, refers to a condition where more than one cognitive domain (excluding memory) is impaired. The cognitive domains can include deficits in brain areas associated with orientation, praxis or language (Ritchie, Artero, & Touchon, 2001). Typically individuals with amnestic MCI are at higher risk for developing dementia, and as a consequence, MCI is sometimes referred to as a transition state between normal ageing and dementia (Peterson, 2004). This continuum between normal ageing, MCI and dementia is not necessarily linear. While some patients go on to develop dementia, in others cognitive ability can remain stable or even improve (Ganguli, Dodge, Shen, & DeKosky, 2004). In a study
of 82 older adults diagnosed with MCI, 41.5% went on to develop dementia, and 58.5% did not have progressive symptoms after a 3-5 year follow up period (Alexopoulos, Grimmer, Perneczky, Domes, & Kurz, 2006).

**Prevalence of mild cognitive impairment.**

Prevalence rates for mild cognitive impairment are difficult to ascertain because of the wide variations in characteristics of patient samples, the inconsistent use of diagnostic criteria and the lack of consensus in definition. It is known that the prevalence of MCI increases with age and is more prominent for those aged above 75 years (Lopez et al., 2003). In a population based study, Busse, Hensel, Guhne, Angermeyer, & Riedel-Heller (2006) estimated that prevalence rates for MCI were 9% when using a cutoff criteria of 1 SD from age and education specific norms and 42% when using cutoff criteria of 1.5 SD from age and education specific norms. This study consisted of 1692 community dwelling individuals aged over 75 years. Participants were followed for six years and underwent neuropsychology testing every 1.5 years. MCI was identified using a semi-structured interview for diagnosing dementia of the Alzheimer’s type. However, these prevalence rates should be taken with caution, as the interview is likely to differ according to the administering physician. Furthermore, the criteria for identifying MCI were poorly defined.

In another study by Graham et al. (1997), the prevalence rate of cognitive impairment without dementia was estimated to be 16.8%. This Canadian study consisted of 1800 people aged greater than 65 years who lived in the community or in residential institutions such as nursing homes or care facilities. Initially participants were screened using the Mini Mental Status Examination (Folstein, Folstein, & McHugh, 1975) and a subset of people who scored above or below the designated cut off score underwent further clinical examination. The findings of this
study are limited by the failure to cite the nature of the clinical examination and the fact that the researchers did not use a standardised method to define cognitive impairment without dementia. As a consequence the researchers were not able to distinguish between MCI subtypes or age-related cognitive impairment arising from other medical conditions. Therefore, the prediction of 16.8% is likely to be an overestimate.

In one of the most comprehensive prevalence studies undertaken by Lopez and colleagues (2003) identified the prevalence of MCI in a sample of 2470 participants. Data was obtained from a number of sources including: neuropsychology tests, psychiatric histories, and results from neurology scans. Information was reviewed by a neurologist who determined a diagnosis of dementia, MCI or no cognitive deficits. The first 200 patient files were then reviewed by two other neurologists, with inter-rater reliability established at 87%. A committee of dementia experts reviewed the files and classified the identified MCI according to different subtypes. The overall prevalence of MCI was found to be 19%. The prevalence for the non-amnestic MCI subtype was found to be higher (16%) than for the amnestic MCI subtype (6%) (Lopez et al., 2003). This finding is not surprising due to the many pathological causes for non-amnestic MCI, such as depression or delirium, which were not excluded in this study. A major strength of this study is the clinically detailed patient information that enabled the researchers to classify the MCI patients according to their clinical subtypes.

Assessment of cognitive impairment.

Assessment of cognitive impairment is complex, as it requires the physician to distinguish between symptoms of a medical condition and symptoms associated with the normal ageing process. Furthermore, several conditions such as depression,
alcohol use, delirium and anxiety have memory loss as part of their presentation. It is therefore important to exclude these conditions when identifying MCI. Assessment tools that are typically used to identify MCI comprise those that were originally developed to diagnose and screen for dementia. The most widely used general measure of cognition is the Mini Mental State Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). The MMSE assesses five areas of cognitive functioning including; orientation, registration, attention and calculation, recall, and language. Results from a meta-analysis of 34 dementia studies indicated that the MMSE was more effective at ruling out a diagnosis of dementia in a primary care setting than it was in identifying individuals with mild cognitive impairment. The author therefore recommended against using the MMSE as a diagnostic tool (Mitchell, 2009). Although the administration time is brief the assessment tool is not without its limitations. For example, it encompasses broad levels of function and can therefore be insensitive to the detection of early stage dementia (Morris et al., 2001). Additional limitations relate to the fact that the MMSE does not assess executive functioning and it produces variable responses according to age, education, ethnicity and education level (McDowell, 2006). Despite these limitations, the MMSE continues to be used as a brief screening tool for dementia by General Practitioners and, in Australia, it is required to be administered for the prescription of acetylcholinesterase inhibitors.

A more comprehensive measure of cognitive function is the Clinical Dementia Rating Scale (CDR) (Morris et al., 2001). Unlike the MMSE, the CDR can not only identify the presence of dementia, but it can also provide an indication of severity. The CDR consists of a structured interview that assesses the patient’s individual functioning in the following domains: memory, orientation, judgement
and problem solving, community affairs, home and hobbies, and personal care. Patients are classified on a five point severity scale as: CDR-0 (healthy) CDR-0.5 (very mild), CDR-1 (mild), CDR-2 (moderate) and CDR-3 (severe). It has been suggested that individuals with a CDR of 0.5 clinically meet the criteria for MCI (Petersen & Negash, 2008). While the CDR is particularly useful for classifying memory impairment it is not a useful measure of daily living activities. Often an informant (i.e., spouse or carer) can provide a reliable description of a person’s cognitive abilities in everyday function (Carr, Duchek, & Morris, 2000).

**Telephone interviews for assessing cognitive impairment.**

In some circumstances, it can be challenging or it is not feasible to conduct a cognitive assessment face to face. In these scenarios, a telephone interview can be a useful alternative option due to ease of administration, and flexibility in accessing patients who live in remote areas or who are limited due to disability or lack of transport options. Telephone interviews are limited in their ability to assess all components of cognitive function, (particularly visuo-motor skills); however, there is evidence to support their use for assessing memory, language and some components of executive function (Martin-Kahn, Wooton, & Gray, 2010). Adequate reliability and validity has been obtained for the use of the Telephone Interview for Cognitive Status (TICS) (Brandt, Spencer, & Folstein, 1988), and it has been shown to reliably distinguish between older adults with and without dementia (Klopman et al., 2010; Lines, McCarroll, Lipton, & Block, 2003).

There are other methods of screening for and diagnosing MCI and a review of these measures and their validity has been provided by Lonie, Tierney and Ebmeier (2009). Ultimately, the only accurate way to determine whether a person has
dementia of the Alzheimer’s type is through an autopsy. Due to the difficulty in diagnosing mild cognitive impairment, it is common for the physician to miss the diagnosis in the initial consultation (Valcour, Masaki, & Blanchette, 2002). Early detection of MCI through the development of effective screening tools is an important step towards developing effective treatments and interventions. In summary, the identification of cognitive impairment is a challenge due to the variation in assessment tools, lack of consensus on clinical presentations, and co-morbid conditions. However, the identification of cognitive impairment is a necessary step towards making clinical decisions about fitness to drive. The next section describes the relationship between cognitive components and driving behavior.

**Models of Driver Performance and Cognitive Components**

It is useful to envisage the relationship between cognitive function and driving performance via theoretical models of driving behavior. As driving is a dynamic process with simultaneous interplay between multiple functions, it can be difficult to derive a model that captures all the components required for driving. Two well established models of driving behavior are presented below with the aim of emphasising cognitive components.

**Information processing model of driver behaviour.**

The information processing model of driver error provides an understanding of the processes involved in driver perception through to driver action (Refer to Figure 1).
Upon presentation of a stimulus (i.e., car braking ahead) the driver perceives and attends to the preceding car using visual and auditory cues to form an interpretation of the situation. Following this, the driver formulates a plan of action, which is based on existing knowledge from previous experiences as well as situational cues from the environment. Finally, the driver chooses to execute the plan by acting. This action could involve placing their foot on the brake, or steering away from the car ahead. This sequence of processing taps in to both higher level executive skills (i.e., action planning and mental flexibility) as well as lower level cognitions (i.e., visual scanning for monitoring traffic). Drivers with cognitive impairment may experience deficits in one area of cognition or multiple areas of cognition. Their ability to drive a motor vehicle safely will depend on the nature and extent of their cognitive impairment, and they may experience deficits at any stage of the model. A limitation of the information processing model is that it fails to account for the influence of driver motivation or emotional factors on driver behaviour (Ranney, 1994).

**Michon model of driver behaviour.**

A more comprehensive model of driver behaviour was provided by Michon (1985) According to Michon, driving comprises three hierarchical levels of
behaviour which underlie the cognitive control of driving. These behaviour levels are referred to as the: **strategic or planning** level, the **manouvering or tactical** level, and the **operational** level.

At the **strategic** level behaviours involve mapping out the route of the trip, determining the goal of the trip, and evaluating the costs and benefits. They rely on higher-level executive processes, which occur in the frontal, parietal and temporal lobes in order to form knowledge based decisions about the forthcoming trip. The **tactical** level behaviours include the manner in which the driver adapts and responds to changes in the traffic environment. Selecting appropriate gaps in traffic, overtaking a slow moving vehicle and adjusting speed to give way to a pedestrian are all examples of driving situations which involve tactical behaviours. These behaviours tap in to both higher level executive skills and lower level cognitions. The higher executive skills include action planning and mental flexibility, while the lower level skills are required for monitoring traffic by visual and attentive tracking of moving objects.

The **operational** level consists of the direct mechanical operations such as steering, braking and accelerating which are automatic procedural operations learnt through years of driving experience. These skills are necessary to respond quickly and efficiently to changes in the immediate driving environment. Operational behaviours utilise the cognitive domains of information processing, visual search, visuo-spatial attention and motion perception. More recently a greater emphasis has been drawn towards the role that sensorimotor transformations play in driving (Gamache, Hudon, Teasdale, & Simoneau, 2010). Sensorimotor transformations involve the transfer of information from the senses and can result in motor execution (Strauss, Sherman, & Spreen, 2006). This is an automatic process that occurs at the
A deficit of sensorimotor transformation can result in an inappropriate motor response such as confusing the brake pedal with the accelerator. This error has often been referred to as unintended acceleration (Freund, Colgrove, Petrakos, & McLeod, 2008).

Cognitive deficits can influence the ability to drive at the tactical level, strategic level and the operational level. For example, poor planning, judgement and impulsivity can influence the strategic level, distraction and reduced awareness in traffic can influence the tactical level. The operational level can be directly influenced by reduced information processing, slow reaction time, slow motor responses and/or confusion.

Michon’s (1985) model of driving behaviour is widely utilised as a model for researching driving performance. It incorporates a greater number of factors involved in driving compared to the information processing model.

**On-Road Driving Performance and Cognitive Impairment**

Currently, there is inconclusive evidence to determine whether drivers with mild cognitive impairment remain safe to drive (Carr et al., 2000; Dubinsky et al., 2000; Hunt et al., 1993; Wadley et al., 2009), or whether these individuals engage in risky driving behaviour (Snellgrove, 2005; Whelihan, DiCarlo, & Paul, 2005). On-road driving studies have consistently found driving impairments in drivers with Alzheimer’s disease (Ott et al., 2008; Rizzo et al., 2005; Rizzo et al., 2001; Uc, Rizzo, Anderson, Shi, & Dawson, 2004) however very few studies have investigated driving performance of drivers with MCI (Hunt et al., 1993; Hunt et al., 1997; O’Brien, 2011; Okonkwo et al., 2009; Snellgrove, 2005; Wadley et al., 2009; Whelihan et al., 2005).
In a pioneering pilot study, Hunt et al. (1993) assessed 12 drivers with very mild dementia (indicative of MCI), 13 drivers with mild dementia, and 13 controls with no cognitive impairment on an on-road driving route. An assessor classified the drivers with an overall score of pass/fail and was blind to the cognitive status of the participants. All drivers with very mild dementia (i.e. MCI) passed the test, however, five of the drivers with mild dementia failed. In contrast, Snellgrove (2005) found that approximately half of an Australian sample of 115 drivers with MCI failed the on-road test compared to 75% of drivers with early stage dementia. However, the results of this study may be an overestimate of poor fitness to drive due to the method used to assess MCI. Cognitive impairment was examined using DSM-IV (American Psychiatric Association, 2000) criteria and the MMSE, which is arguably a less robust measure of the extent of cognitive impairment than the clinical interviews and neurological examinations administered by Hunt et al. (1993).

A study by Wadley and colleagues (2009) examined 46 drivers with well-defined categories of MCI using Peterson/Mayo criteria (Peterson, 2004), which enabled the identification of MCI subtypes. Forty-three drivers with amnestic-MCI, and three with non-amnestic MCI were compared to 59 healthy older drivers on an on-road driving course. The drivers with MCI demonstrated poorer driving performance overall compared to controls and made significantly more errors than controls, particularly when making left hand turns (right hand turns in Australia) and maintaining lane position - skills which have also been shown to be problematic for drivers with dementia (Uc et al. 2005). In another on-road study, Whelihan et al. (2009) used a standardised route to examine the relationship between on-road performance and measures of executive function and visual attention. Twenty-three drivers with a CDR = .5 (representing MCI) and 23 matched controls participated in
the study. According to the Rhode Island Driving Evaluation scale, drivers with MCI made significantly more errors than controls. The exact error types were not mentioned in this study.

There are many difficulties inherent in the recruitment of participants with early stage memory impairments and therefore sample sizes, including in the studies reviewed above, are typically small. This in turn, results in decreased power and limited generalisability. An additional challenge in this research relates to inferring conclusions from cross-sectional studies, particularly with respect to drivers who may have a degenerative condition. One method that enables collection of longitudinal data is the use of in-vehicle instruments. Recently, Eby et al. (2012) compared the on-road driving behavior of 17 drivers with early stage dementia, with 17 drivers without cognitive impairment over a 1-2 month period using an in-vehicle instrument. Drivers with cognitive impairment were recruited from memory clinics and were included in the study if they self-reported a diagnosis of early stage dementia provided by a health professional. Overall, both groups were found to be relatively safe, making few overall errors. However, drivers with early-stage dementia were more likely to fail to wear a seatbelt and drive at a slower speed than other traffic on the road. They were also more likely to get lost and demonstrated a reduced driving space (i.e., drive fewer kilometres, avoid freeways and drive less at night). A limitation of the study is that drivers in this sample had recently been deemed as safe to drive by a driving assessor and there was no cognitive screen of the controls. Although in its infancy, in-vehicle monitoring of drivers may prove to be a useful measure of driver performance in the future.
Based on the research described in this section, there are indications that drivers with MCI have suboptimal performance in regard to their overall driving performance; however this performance does not necessarily translate into unsafe driving. Rather, it is possible that drivers with MCI have difficulties with specific driving manoeuvres. In particular they may make errors in decision making; have difficulties shifting attention, recognising signs and remaining aware, all of which can become problematic in challenging driving situations (Hunt et al., 1993; Snellgrove, 2005).

**Driver Error and Neuropsychology Test Performance**

There are several reasons why drivers with cognitive impairment may be more vulnerable to motor vehicle crashes. These include, but are not limited to: their inability to recognise or accurately assess risk, slower information processing skills, poor sequencing skills, perception, attention or poor deficits in higher order processing skills required for executive functioning (Uc, Rizzo, Anderson & Dawson, 2005; Snellgrove, 2005). It has been suggested that driver error can result from deficits in any one of these functions. According to Reason, Manstead, Stradling, Baxter and Campbell (1990), human error can be further differentiated into slips (errors of execution), lapses (errors of storage) and mistakes (errors of action planning). Drivers may display lapses in memory concerning vehicle operation errors including how to signal (Duchek et al., 2003), or may display lapses in motor function which result in pedal error (Wallace & Chen, 2005). For example, although it is difficult to assess, there are reports of drivers accidently mistaking the accelerator for the brake by confusing the pedals (Snellgrove, 2005). This
phenomenon has been defined as unintended acceleration (United States Department of Transportation, 1989) and is often reported in the media.

The majority of driving studies into the relationship between neuropsychology test performance and driving capability have focused on deficits in visual selection attention, executive function (Duchek, Hunt, Ball, Buckles, & Morris, 1998; Schieber & Gilland, 2005) and visual processing speed (Owsley, McGwin, Sloane, Stalvey, & Wells, 2001). Few studies have investigated the relationship between memory deficits and driving ability (Anderson et al., 2007). Recently, a study by Anstey and Wood (2011) focused on the association between driver errors recorded via an on-road driving assessment, and poor performance on cognitive tests that tapped into cognitive abilities specific to driving. A total of 266 current drivers were recruited from the community and those with probable dementia were excluded. A driving instructor rated participant driving performance according to the following seven behavior types: braking/accelerating, observations of blind spots, indicating, lane position, gap selection, general observation of environmental cues and other road users, and planning and judgment upon approach. A greater number of errors were found with increase in driver age, and failing to observe blind spots was the most common error overall. In regard to neuropsychological test performance, reaction time alone did not correlate with driver errors, however selective attention and task shifting difficulties were associated with driver error. More specifically, selective attention and task shifting performance predicted brake and accelerator errors. Drivers with dementia were excluded by using the MMSE cut off score of < 24, and therefore it is possible that some drivers in this study had MCI. Hence, it appears that selective attention and task shifting are important cognitive
processes related to driving performance that are worth investigating further in a sample of drivers with MCI.

**Executive function.**

Executive function refers to a wide range of central control processes in the brain that are involved in organising goal directed behaviour, through recognising the need for a response, planning the response and then executing the response (Strauss et al., 2006). Typically, dysfunction in the dorsolateral prefrontal cortex is associated with deficits in executive function (Kandel, Schwartz, & Jessell, 2000). Executive function has a significant role to play in driver performance and competence. A negative association between tests of executive function and driving simulator performance has been demonstrated (Anderson, Rizzo, Shi, Uc, & Dawson, 2005; Rizzo et al., 2005). Similar findings have been replicated using on-road tests (De Raedt & Ponjaert-Kristoffersen, 2000b). Older adults with MCI can have dysfunction of the prefrontal cortex, and studies using neuropsychological test performance have demonstrated that individuals with MCI perform poorly on tests of executive function (Michon, Deweer, Pillon, Agid, & Dubois, 1994). For example, the Trail Making Tests A and B (Reitan & Wolfson, 1985) are frequently used to assess mental flexibility, divided attention and processing speed, all aspects of executive function. Adults with MCI have demonstrated poorer performance on the TMT-B test compared to age-matched controls (Okonkwo et al., 2009). However, the relationship between driving performance and TMT-B performance for drivers with MCI is yet to be explored.

O’Brien (2011) recently investigated the cognitive correlates of driving performance in a sample of 68 drivers with MCI as assessed via the Mayo/Peterson criteria (Petersen, 2004) and a neurological examination. Participants completed an
on-road driving task and a series of neuropsychology tests assessing a range of cognitive functions related to driving. It was interesting to note that severity of cognitive impairment was not related to driving performance in this study. An overall composite score for executive function was found to correlate with driving performance. The specific processes related to optimal driving performance included visual speed of processing and attention. These findings support the argument that executive function deficits may contribute to poor driving performance in individuals with MCI.

This section of the thesis focuses on the impact of cognitive impairment on driving performance. As intersections are known to be a challenging driving situation for older drivers (Clarke et al. 2010; Gстalter & Fastenmeier, 2010), it is important to understand older driver behavior on approach to intersections. Firstly, in Chapter 3 the research literature relating to older driver braking behavior is evaluated. Following this, studies concerning braking behaviour of older drivers with mild cognitive impairment are reviewed.
Chapter 3: Older Driver Intersection Approach

Braking Behaviour of Older Drivers

Older drivers are over-represented in crashes at complex traffic scenarios such as intersections, which require integrating information from multiple sources to execute an appropriate motor response (Clarke et al. 2010; Gstalter & Fastenmeier, 2010). When decelerating upon approach to an intersection, the driver is required to perform a repeated motor task by switching the right foot from the accelerator to the brake pedal when driving an automatic transmission vehicle. An appropriate braking response becomes critical in congested traffic, and responding to an unexpected hazard such as a critical light change at an intersection. Braking involves taking the time taken to identify the stimulus and remove the foot from the accelerator (perception reaction time), as well as the time taken to move the foot from the accelerator onto the brake (brake movement time) (Warshawsky-Livne & Shinar, 2002). The perception reaction time relies on skills of visual search, visual perception and attention, while brake movement time depends upon sensorimotor skills.

Brake response patterns appear to differ according to age (Bao & Boyle, 2007; Cantin, Blouin, Simoneau, & Teasdale, 2004). Bao and Boyle (2007) assessed age differences in braking responses on approach to an intersection using an instrumented vehicle. There were ten adults in each age group; 18 to 25 years, 35 to 55 years and 65 to 80 years. Younger drivers depressed the brake later than older drivers and reached maximum brake pressure in less time, suggesting they braked later and harder. Conversely, older drivers applied the brake earlier and took longer to fully depress the brake pedal to the maximum brake pressure. In a driving
simulator study, Cantin et al. (2004) also found that older adults displayed longer deceleration patterns on approach to an intersection. In addition, video recordings of right foot movements revealed that younger drivers typically made a smooth movement from brake to accelerator without any hesitation, while older adults produced a number of sub-movements before applying the brake. It was suggested by the authors that the sub-movements resulted from older adults misperceiving their environment. However, this behaviour could also be sign of hesitancy arising from difficulty making a decision about whether to stop or to continue driving.

In another driving simulator study, Bélanger, Gagnon and Yamin (2010) compared braking responses of young (n = 20, age = 20-45 years), and older (n = 20, age = 65+ years) drivers in response to a pedestrian crossing the road. When response times and brake pressure were assessed, older drivers took longer to apply the brake compared to younger drivers, and also applied greater pressure on the brake at the end of the event. The authors speculated that older drivers were less likely to engage in driving behaviours simultaneously (i.e., in parallel) due to extra demands on cognitive workload. Rather, the authors suggested that older drivers engaged in behaviours in a serial fashion, whereby some tasks were prioritised over others.

Cognitive predictors of braking response time and brake/accelerator errors have included psychomotor speed, attention, and visual search (Anstey & Wood, 2011; Zhang et al., 2007). Zhang and colleagues (2007) examined the cognitive, visual and physical factors associated with brake reaction time using a driving simulator task. Participants consisted of 1425 older drivers aged 67-87 years. The sample included a small number of drivers (8%) who showed evidence of cognitive impairment as assessed by the Mini Mental State Examination (MMSE). Poor scores
on the MMSE were related to slower initial reaction times, as was increasing age and being female. Small effects on brake response time can have consequences for reacting appropriately to avoid a hazard. Braking hesitations and right foot movements were not investigated in this study, nor was the relationship between braking response time and driving performance.

While it appears that braking response profiles differ according to age (Bao & Boyle, 2007; Cantin et al., 2004), it remains to be determined whether brake profiles of drivers with mild cognitive impairment differ when compared to healthy older drivers. The limited research concerning drivers with cognitive impairment and their braking behaviour is reviewed in this next section.

**Braking Behaviour of Older Drivers with Mild Cognitive Impairment**

There is a paucity of studies of the brake responses in older drivers with cognitive impairment. However, results from driving simulator studies of individuals with Alzheimer’s disease suggest that drivers with cognitive impairment decelerate more abruptly (Rizzo et al., 2005), and apply less pressure on the brake when compared to healthy controls (Cox, Quillian, & Thorndike, 1998). Frittelli et al. (2009) examined the driving performance of 20 patients with a clinical dementia rating score (CDR) score of 0.5, 20 patients with a CDR score of one, and 20 age-matched controls. The researchers did not specifically assess braking responses although the numbers of stops at the traffic lights were recorded and no differences were found for this measure amongst the three participant groups (Fritelli et al., 2009). In another simulator study, Stein and Dubinsky (2011) investigated driving performance of 17 drivers with Alzheimer’s disease, eight drivers with MCI (CDR = .5), nine drivers with probable AD (CDR = 1), and 63 controls without cognitive impairment. The driving tasks consisted of traffic-light controlled intersections and
uncontrolled intersections. Drivers with MCI demonstrated more problematic driving behaviour at controlled intersections compared to drivers without cognitive impairment. The problematic driving behaviours were classified by the researchers as errors of judgment whereby the drivers with MCI were driving more conservatively than controls, for example, by slowing down at a green light. No differences were found between the groups for approaches to uncontrolled intersections. These results may suggest that drivers with MCI may be demonstrating conservative driving behaviour to compensate for impaired processing speed to allow more time to respond. In an Australian study, Snellgrove (2005), conducted an on-road driving investigation of 49 drivers classified as having symptomology of MCI as indicated by a CDR score of 0.5. The investigators found almost half of the MCI participants failed the driving task and noted that a common mistake was confusing the pedals. This study did not provide any data on the number of participants who engaged in this behavior or the circumstances in which pedal confusion occurred.

All of the studies listed above included heterogeneous groups of drivers with MCI. This makes it difficult to determine which cognitive functions are contributing to driving behaviour. With this in mind, Kawano et al. (2012) recruited 12 older drivers with MCI of the amnestic type and compared their driving performance on a driving simulator to 19 younger drivers, and 26 older drivers without cognitive impairment. Participants completed the following three tasks: a car-following task, a road tracking task and a harsh braking task. The drivers with MCI performed more poorly on the car-following task then the other groups, however no differences were found between the groups for the harsh braking task. To the author’s knowledge, no studies have investigated brake response patterns (including brake hesitancy) of older drivers with mild cognitive impairment.
Summary

It is well established that older drivers are over-represented in intersection crashes in comparison to other age groups (Clarke et al., 2010; Sifrit, Stutts, Maretell & Staplin, 2010). The available evidence suggests that older drivers demonstrate different braking patterns on approach to intersections compared to both middle aged drivers and younger drivers (Bao & Boyle, 2007; Cantin et al., 2004). In particular, studies indicate that driver lack of cognitive flexibility and driver indecision are characteristic of adults with cognitive impairment (Chang, Burke, & Glass, 2010; Snellgrove, 2005). These deficits can be problematic for older drivers at signal-controlled intersections where a driver is required to make a stop/go decision when presented with a critical light change. Although there are reports of pedal confusion occurring after a crash has occurred in drivers with cognitive impairment, there are few studies that have investigated this occurrence. It is important to identify whether there are differences in driving behaviour at intersections between drivers with cognitive impairment compared to those without.
Rationale of Study 1

This study was designed on the basis of the literature reviewed in Chapters 1 and 2, which identified the relative scarcity of experimental studies that have been undertaken with drivers with MCI. In particular, the driving characteristics of drivers with cognitive impairment on approach to intersections are not well understood.

Aims and Objectives of Study 1

The aim of this study was to explore the brake patterns of older drivers with mild cognitive impairment on approach to intersections. Key outcomes envisaged from the simulator study include:

- Establish brake profiles of older adults with and without cognitive impairment
- Investigate right foot movements among older adults with and without cognitive impairment
- Investigate the association between right foot movements (braking hesitancy) and driving performance.

It was hypothesised that, compared to healthy older adult drivers, cognitively impaired older drivers would display a greater number of right foot hesitations (between the accelerator and the brake) and would engage in higher risk brake response patterns.
Paper 1: Investigating Driving Behaviour of Older Drivers with Mild Cognitive Impairment Using a Portable Driving Simulator


**Preamble to Paper**

This chapter comprises a study that was published as an article in *Accident Analysis and Prevention*. The copyright permission was obtained from the journal editors in order to insert the paper in to this document. A driving simulator was used to examine any differences in driving behavior on approach to intersections for drivers with MCI compared to those without. Overall, there was a trend for drivers with MCI to demonstrate less than optimal driving performance across a range of measures compared to controls; however none of the individual simulator measures reached significance. These findings are consistent with findings from other studies investigating driving performance of drivers with MCI (Eby et al., 2012; Hunt et al. 1993) and should be interpreted with caution due to the limitations of the study.

**Paper 1**

A facsimile of the full paper is presented in the remainder of this chapter.
Investigating driving behaviour of older drivers with mild cognitive impairment using a portable driving simulator

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Intersection

ABSTRACT

While there is a large body of research indicating that individuals with moderate to severe dementia are unfit to drive, relatively little is known about the driving performance of older drivers with mild cognitive impairment (MCI). The aim of the current study was to examine the driving performance of older drivers with MCI on approach to intersections, and to investigate how their healthy counterparts perform on the same driving tasks using a portable driving simulator. Fourteen drivers with MCI and 14 age-matched healthy older drivers (aged 65–87 years) completed a 16-min simulator drive in an urban environment. The simulator drive consisted of stop-sign controlled and signal-controlled intersections. Drivers were required to stop at the stop-sign controlled intersections and to decide whether or not to proceed through a critical light change at the signal-controlled intersections. The specific performance measures included: approach speed, number of brake applications on approach to the intersection (either excessive or minimal), failure to comply with stop signs, and slower braking response times on approach to a critical light change. MCI patients in our sample performed more poorly than controls across a number of variables. However, because the trends failed to reach statistical significance it will be important to replicate the study using a larger sample to quantify whether the results can be generalised to the broader population.

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1. Introduction

The point at which an individual should cease driving is of particular concern to driving authorities, physicians and family members of older drivers who are potentially unsafe. While there is a large body of research indicating that individuals with moderate to severe dementia are unfit to drive, relatively little is known about the driving performance of older drivers with mild cognitive impairment (MCI). MCI is a condition that presents with a slight impairment in cognitive functioning, typically memory, that is greater than expected for the persons age and education level and does not meet the criteria for dementia ( Petersen et al., 2001 ). The prevalence of MCI increases with age and is more prominent for those aged above 75 years, and in thus a growing concern in conjunction with the increase in the number of older individuals in the population (Lopez et al., 2003).

Neuropsychological and neuroimaging studies suggest that mild cognitive impairment does not equate to early stage dementia (Leslie et al., 2009). However, people with MCI are at higher risk for developing dementia than those without any subjective memory complaints (Petersen, 2004). There is accumulating evidence to suggest that individuals with MCI can experience some impairment in instrumental activities of daily functioning such as managing finances and organising medications (Burton et al., 2005; Pereira et al., 2010; Tsookko et al., 2005). Currently, there is no consensus on the extent to which driving is compromised in people with MCI, or whether they have a higher crash risk than age-matched peers (Iverson et al., 2010). To our knowledge no studies have assessed the crash rates of drivers with MCI compared to a control group or to the general population, and few studies have investigated the relationship between MCI and driving performance (Berns et al., 2008; Duchek et al., 2003; Iby et al., 2012; Fritelli et al., 2009; Herrmann et al., 2006; Hunt et al., 1993; Kawano et al., 2011; Snellgrove, 2005).

1.1. Mild cognitive impairment and driving ability

The Information Processing Model of Driver Error proposed by Anderson et al. (2005; see Fig. 1) provides a framework for understanding the cognitive processes involved in driving, from driver perception through to driver action.
According to the model presented in Fig. 1, upon presentation of a stimulus (i.e., a car braking ahead) the driver 'perceives and attends' to visual and auditory cues to form an interpretation of the situation. Following this, the driver formulates a 'plan of action' which is based on existing knowledge from previous experiences, as well as situational cues from the current environment. Finally, the driver 'executes the plan' as a response action. This action could involve placing their foot on the brake, or steering away from the car ahead. This sequence of processes taps in to both higher level executive skills (i.e., action planning, mental flexibility) as well as memory, and lower level cognitive processes (i.e., visual scanning, attention and perception). Drivers with cognitive impairment may experience deficits in one area of cognition or multiple areas of cognition. There are multiple pathologies of MCI represented by the different clinical presentations and pathological origins (MCI multiple domains, MCI amnestic, MCI single non-memory) which can either result in specific deficits in higher level executive skills, memory, or in lower levels of cognition (Winblad et al., 2004).

The ability to perceive, attend and interpret visual stimuli while driving (the first step in the Information Processing Model; Fig. 1) depends upon visual attention, perception and rapid spatial information processing. The Useful Field of View (UFoV) is one assessment tool used to assess visuospatial information processing as well as simple, selected and divided attention (Ball and Owsley, 1993). Poor performance on tasks of divided attention is characteristic of adults with Alzheimer's Disease and findings suggest that divided attention may also be impaired in many individuals with MCI (Belleville et al., 2007; Okonkwo et al., 2008). Information and psychomotor processing speed, attentional control and mental flexibility are also key skills required in Steps 1 and 2 of the Information Processing Model, that are frequently assessed using the Trail Making Test (TMT; Reitan and Wolfson, 1985; De Raedt and Jonkert-Kristoffersen, 2000; Mathias and Lucas, 2005). Poor performance on the TMT-Part B has been shown to occur in individuals with MCI (Okonkwo et al., 2008), however a correlation between TMT performance and driving performance in MCI patients has yet to be reliably demonstrated by empirical research and is worthy of exploration.

1.2. Evidence from on-road and driving simulator studies

Evidence from driving simulator and on-road driving studies provide a basis for understanding which driving behaviours may be compromised in MCI patients. Driving simulators allow for assessment of response to road hazards in a safe and controlled environment. Driving simulator recordings are also sensitive to age-related changes in driving performance and cognition (Lee et al., 2003), and have been shown to predict older drivers who experience future crashes (Hoffman and McDowd, 2010). Fritelli et al. (2009) used a STISIM driving simulator to examine the performance of 20 individuals with a Clinical Dementia Rating Scale (CDR) (Morris et al., 2001) score of 0.5 (indicative of MCI). 20 individuals with a CDR score of 1 (indicative of early AD) and 20 age-matched controls. Individuals with MCI demonstrated shorter mean time to collision compared to controls; however they did not differ on simple visual reaction times, number of off road events or total time to complete the drive. The researchers did not specifically assess braking responses in this study, although the numbers of stops at traffic lights were recorded, with no differences found for this measure amongst the three participant groups (Fritelli et al., 2009). This finding contrasts with the results of Anderson et al. (2005) who in a larger cross-sectional simulator study (70 drivers with mild dementia, 152 controls; Anderson et al., 2005) demonstrated that drivers who crashed at intersection scenarios were more likely to have a lower composite neuropsychology test score compared to drivers who did not crash.

On-road driving assessments are generally acknowledged as the 'gold standard' for providing an assessment of driving ability (Reger et al., 2004). In many cases the participant is required to drive around either an open or closed road circuit in an instructor vehicle, usually with dual control operation. The few on-road studies assessing drivers with MCI have reported poorer performance on specific driving measures for drivers with MCI compared to healthy controls (Duchek et al., 2003; Wadley et al., 2009). In a longitudinal study, Duchek et al. (2003) assessed changes in on-road driving ability for those drivers who received a CDR of 0.5 which is indicative of MCI (Morris, 2005; Petersen and Negash, 2008), those who recorded a CDR of 1 (indicative of early dementia) and drivers with a CDR of 0. Duchek et al. found evidence of a decline in driving ability for all groups in the three year period, however the greatest decline was found for the MCI group. The behaviours that showed greatest decline for all three participant groups were: qualitative judgments, reactions to others and the ability to control speed. The ability to observe stop signs and traffic signs and to signal, however, remained stable over time.

1.3. Pedal confusion and right foot hesitations

Inappropriate motor responses while driving, such as pressing the accelerator instead of the brake pedal, has been defined as 'pedal confusion' and may occur due to factors such as failure to adequately integrate sensory and motor signals within the posterior parietal cortex (Freund et al., 2008; Garnache et al., 2010; Greifes et al., 2004). Pedal confusion has been found in one Australian on-road driving study of patients with MCI (Smellgrove, 2005). Right foot hesitations are another related phenomenon that has received little
attention (Caird et al., 2007; Cantin et al., 2004). Drivers anticipate a change in the driving environment by releasing their foot from the accelerator without placing it on the brake. The few studies that have investigated this driving behaviour have found that older drivers display hesitations in foot movements and take longer to move their foot from the accelerator to the brake compared to young adults (Cantin et al., 2004). Furthermore, older drivers increase their number of foot hesitations when they are provided with more time to stop on approach to a light change from green to amber (Caird et al., 2007).

In summary, the limited research available from driving simulator and on-road studies suggests that drivers with MCI could have a range of potential difficulties including lane positioning, maintaining appropriate speed, reacting appropriately to other road users, and pedal confusion. Intersections are complex traffic scenarios requiring the integration of information related to the perception of distance, speed, other road users (e.g., pedestrians) and environmental cues (e.g., traffic lights). Consequently navigating intersections requires a high cognitive load (Caird et al., 2005; Daigleault et al., 2002; Wadley et al., 2000). Therefore, intersection negotiation affords a useful driving scenario to assess differences in driving abilities amongst drivers with MCI compared to healthy age-matched peers. Given that drivers with MCI are at increased risk for developing dementia, they are an important group to monitor in terms of driving safety, since driving is a relatively complex behaviour and therefore sensitive to interference in the early stages of dementia (Tiraboschi et al., 2006).

1.4. Current Study

The aim of the current study was to examine the brake patterns of older drivers with mild cognitive impairment when approaching intersections. On the basis of previous literature we predicted that drivers with MCI would engage in braking behaviour patterns that might result in an elevated crash risk on approach to intersections compared to healthy controls. More specifically, their behaviour would be characterised by a higher frequency of on-off applications on approach to the intersection (either excessive or minimal), slower braking response times on approach to a critical light, and failure to comply with stop signs. In addition, drivers with MCI may be more likely to engage in foot hesitations between pedals. If a distinction between cognitively impaired and healthy older adults is found in terms of brake profiles, this measure could be used as a key indicator in the detection of older drivers who may become unsafe.

2. Method

2.1. Participants

The participant group included twenty-eight drivers (18 males: 10 females) aged 65–87 years (M = 76.89, SD = 6.76) who resided in Metropolitan Melbourne, the capital city of the State of Victoria, Australia. The group comprised 14 drivers with mild cognitive decline (13 diagnosed with MCI, 1 diagnosed with early onset dementia) and 14 age-matched older drivers without cognitive impairment (controls). Due to the inconveniences between clinicians regarding the diagnosis of MCI, the inclusion criteria in this study consisted of the symptomsology for MCI or early cognitive decline identified by a geriatrician working in a memory clinic. All participants were required to hold a current drivers license, have a MMSE score of 24 or higher, and have conversational English communication skills. Participants with any physical, ophthalmological, or neurological disorder that may impair their driving ability were excluded, as were participants who suffered from a visual condition that impaired their driving, alcohol abuse, depression or any neurological condition other than Alzheimer’s disease. Participants with cognitive impairments were recruited through the Cognitive Assessment and Dementia Management Services (CODAMS) and the Delmar Memory Clinic. Comparison healthy older adults were recruited via an advertisement in a seniors’ magazine and flyers. Seven participants (one case, six controls) withdrew due to simulator discomfort. Five were female; two of these drivers were male and four were aged between 81 and 83 years.

2.2. Materials

2.2.1. Survey

A survey was administered to obtain demographic information, information about driving exposure, general health and crash history over the past two years.

2.2.2. Cognitive, sensory and physical assessments

In the testing session (which was of approximately 50 min duration) the Mini Mental State examination (MMSE) (Folstein et al., 1975) was administered as a brief quantitative screening measure of cognitive status. The scores were categorised according to possible dementia (>24 out of a maximum of 30), possible cognitive impairment or mild cognitive impairment (24–26), and no or minimal cognitive impairment (<20). This criteria is often used in driving studies (Ross et al., 2000). As the MMSE is insensitive to mild cognitive changes, particular in high functioning individuals MCI participants with MMSE scores above 26 were not excluded from the study. All drivers recruited from Memory Clinics were invited to participate in the study if they had a diagnosis of MCI. Drivers completed additional cognitive, vision and physical tests to further distinguish between drivers with MCI and drivers without. The tests included the Rapid Foveal Wave test which assesses lower limb mobility, which is important for sustaining accelerator and brake control, and has been linked in prior research with increased crash and citation rates (Marottoli et al., 1994). The Trail Making Test – Part B (TMT-B; Reitan and Wolfson, 1985) is a measure of information processing, mental flexibility and complex visual scanning (Lafont et al., 2008). Visual acuity was assessed using a 4-en LogMAR distance visual acuity chart and the participant was assessed with corrective lenses if typically worn. All participants had a binocular acuity of 20/40 or higher. Participants also completed a computer based reaction time task as a measure of psychomotor speed.

2.2.2.1. Simulator component

The Monash University Accident Research Centre (MUARC) portable driving simulator was used in this component to investigate and evaluate differences in braking patterns of drivers with MCI and healthy older drivers. It is difficult to obtain absolute validity of driving in a simulator and driving on the road due to the difficulty in replicating experimental conditions. However, relative validity has been established for some driving operations such as lane position, speed, brake onset, and risky driving behaviours (refer to Mullens et al., 2011 for a review). The simulator comprised a small cab with genuine vehicle parts including an adjustable seat, pedals, steering wheel, gear box, seat belt and automatic transmission. The visual images for the driving scenarios were presented on three flat monitors that generate synthetic 3-D images in real time and provided a field of view of 120°. Adjustable rear view mirrors were depicted on the bottom left and right screen (for the left and right mirrors) and an overhead rear vision mirror was also projected on the central screen. Audio feedback of the engine noise could be heard through the simulator speakers.

2.2.2.2. Simulator drive

Participants were administered a practice drive (5 min) and a test drive (approximately 10 min). They were
Table 1
Demographic details.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Drivers with MCI (n=14)</th>
<th>Controls (n=14)</th>
<th>p Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (Male, Female)</td>
<td>9.5</td>
<td>9.5</td>
<td>p = .840</td>
</tr>
<tr>
<td>Age (Years)</td>
<td>77.14 (6.93)</td>
<td>76.64 (6.8)</td>
<td>p = .734</td>
</tr>
<tr>
<td>Education (Years) (Medium)</td>
<td>12.5</td>
<td>13.0</td>
<td>p = .856</td>
</tr>
<tr>
<td>Driving experience (Years)</td>
<td>54.93 (9.28)</td>
<td>54.29 (10.0)</td>
<td>p = .034</td>
</tr>
<tr>
<td>MMSE score</td>
<td>28.5 (1.55)</td>
<td>28.5 (1.57)</td>
<td>p = .009</td>
</tr>
<tr>
<td>&gt;10 or more crashes in past 2 yrs (%)</td>
<td>6 (42.86)</td>
<td>3 (18.75)</td>
<td>p = .886</td>
</tr>
<tr>
<td>&gt;1 infringement in past 2 yrs (%)</td>
<td>1 (7.14)</td>
<td>4 (28.57)</td>
<td></td>
</tr>
<tr>
<td>Visual acuity (Log MAR)</td>
<td>4.88 (0.50)</td>
<td>4.75 (0.19)</td>
<td></td>
</tr>
<tr>
<td>Driving frequency per week (%/week)</td>
<td>6 (21.43)</td>
<td>4 (14.29)</td>
<td></td>
</tr>
<tr>
<td>&lt;50km</td>
<td>3 (10.71)</td>
<td>4 (14.29)</td>
<td></td>
</tr>
<tr>
<td>501–200km</td>
<td>3 (10.71)</td>
<td>4 (14.29)</td>
<td></td>
</tr>
<tr>
<td>&gt;200km</td>
<td>2 (7.14)</td>
<td>2 (7.14)</td>
<td></td>
</tr>
<tr>
<td>Distance of most stops (km)</td>
<td>4 (14.29)</td>
<td>2 (7.14)</td>
<td></td>
</tr>
<tr>
<td>&lt;5km</td>
<td>2 (7.14)</td>
<td>4 (14.29)</td>
<td></td>
</tr>
<tr>
<td>5–10km</td>
<td>8 (28.57)</td>
<td>8 (28.57)</td>
<td></td>
</tr>
</tbody>
</table>

* Values are mean (SD) unless otherwise stated.

asked to drive exactly as they would in real conditions following Victoria road rules. The driving scenario incorporated a number of intersection manoeuvres known to be challenging for older drivers including two stop signs, two traffic light-controlled intersections with critical light changes, and two uncontrolled intersections (i.e. an intersection where no traffic lights or signs are used to indicate the right-of-way). The critical light change (green to amber) was programmed to occur when the driver was 4.5 s away from the intersection exit. Hidden cameras in the driving simulator monitored driver foot movements on the pedals and provided an estimate of driver gaze direction.

2.3. Procedure

After prospective participants were provided with a detailed explanation of the study purpose and requirements, they were invited to provide written informed consent to participate. Participants were also notified about their option to withdraw from the study at any time and the researcher explicitly stated that the results of the study were for research purposes only and would not impact upon their license status. The Alfred Hospital Human Research Ethics Committee, Monash University Human Research Ethics Committee, and the Deakin University Human Research Ethics Committee granted ethics approval for this study.

2.4. Data analysis

The aim of the simulator component of the study was to investigate driver braking behaviour on approach to stop-sign controlled intersections and critical light change intersections. The simulator variables that were analysed were: the number of brake applications on approach to the intersection, mean approach speed 200 m before the intersection, speed when drivers first applied the brake on approach to the intersection, whether drivers stopped at stop-sign controlled intersections, brake response time to the critical light change intersections, and the number of right foot hesitations. A hesitation was defined as occurring when a driver removed their foot from the accelerator and positioned their foot over the brake without applying any pressure before returning to the accelerator. Statistical analyses were conducted using PASW Statistics (version 18). All variables were tested for normal distribution and differences between participant groups were analysed using either Mann-Whitney U tests, or independent t-tests where appropriate. A Generalised Estimating Equation (GEE) using a binary regression model was used to examine the relationship between participant group and braking behaviour. The GEE was used to account for inter-correlations between each intersection type. Using the current research design, a power analysis of a two-tailed test with an alpha level of .05 suggests an 80% chance of finding a .05 or less difference between 14 cases and 14 controls for brake response times (BRT) at the critical light change. A power analysis was also calculated for the sample size required to detect group differences in BRT at the stop sign intersection. A sample of 30 cases and 30 controls gave a statistical power equal to 93% with an alpha level of .05.

3. Results

3.1. Cognitive and vision tests

The participant groups were matched according to age, education, driving experience and self-reported collisions experienced in the past two years (refer to Table 1). There were a greater proportion of males (n=18) compared to females (n=10). There was a significant difference between the MMSE scores of drivers with MCI (M = 26.5, SD = 1.65) compared to controls (M = 28, SD = 1.57, p = .054) whereby on average drivers with MCI scored lower than controls (Table 1). Drivers with MCI experienced a greater number of crashes in the past two years compared to healthy drivers. Only one of the crashes resulted in minor injuries. Five occurred when the driver was driving straight ahead, two when turning left, one when turning right, and one while reversing. Three drivers in each group reported confusing the accelerator with the brake at least once. When asked about general health, 85% of drivers in the healthy group reported themselves as having excellent or very good health compared with 57% of drivers with MCI.

Drivers with MCI took more time to complete the TMT-B test compared to controls, and were slower to complete both the reaction time task and the rapid pace walk, however none of these differences reached significance (Table 2).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Drivers with MCI</th>
<th>Controls</th>
<th>p Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reaction time (seconds)</td>
<td>432.61 (111.31)</td>
<td>371.95 (52.04)</td>
<td>p = .110</td>
</tr>
<tr>
<td>Rapid pace walk (seconds)</td>
<td>8.05 (1.51)</td>
<td>7.81 (0.94)</td>
<td>p = .783</td>
</tr>
<tr>
<td>TMT-B (seconds)</td>
<td>120.73 (32.03)</td>
<td>97.42 (40.34)</td>
<td>p = .08</td>
</tr>
</tbody>
</table>

* Values are mean (SD) unless otherwise stated.
3.2. Stopping behaviour

Four drivers with MCI and one control did not stop at the first stop sign. However, all participants stopped at the final stop-sign controlled intersection. A GEE model was used to adjust for potential intercorrelations among stopping behaviour for each individual at both stop-sign controlled intersections. A binomial logistic GEE showed that the drivers with MCI were not significantly more likely to stop compared to the controls (OR = 5.27, 95% CI = 0.52, 3.846, p = .136). Drivers who stopped at the stop-sign intersections were less likely to have been involved in a crash in the past two years (r = .478, p = .01). There were no significant differences between drivers with MCI (Median = 2.5) and controls (Median = 4, W = 176, z = -1.26, p = .208, r = -.19) at the first stop-sign in regards to the number of brake applications. However, on approach to the second stop sign controlled intersection, drivers with MCI braked more frequently than controls (Median = 4, versus M = 2.51, z = 2.20, p = .027, r = .36).

3.3. Critical light change intersections

At the first critical light change four drivers stopped and the remaining 24 drivers drove through the amber light. These four drivers consisted of three controls and one driver with MCI. At the second critical light change, 11 controls and 8 drivers with MCI stopped, while 3 controls and 6 drivers with MCI proceeded through the intersection. A GEE model was used to adjust for potential intercorrelations among stopping behaviour for each individual at both critical light change intersections. A binomial logistic GEE revealed that there were no significant differences between the groups for stopping behaviour (OR = 2.25, SD = 52, CI 95% = 0.212, 1.83, p = .12). The proportion of drivers with MCI and controls who stopped at each of the four intersections is displayed in Fig. 2.

3.4. Brake response time at critical light changes

The time from the orange light change to the time until the brake was depressed was the braking response time (BRT). There were no significant differences between BRT for drivers with MCI (M = 1.26, SD = 0.97) or controls (M = 1.75, SD = 1.16) at the first critical light change (p = .458). Nor were there any significant differences for BRT for drivers with MCI (M = 0.52, SD = 0.34) and controls (M = 0.73, SD = 0.16) at the second critical light change intersection (p = .13). The speed of the driver when the light changed from amber-to-red was calculated for all drivers who stopped when the light changed from green to amber when the driver was 4.5 s away from the intersection exit. There were no differences in speed for drivers who stopped (M = 15.8 m/s, SD = 1.47 m/s) compared to those who proceeded (M = 15.36 m/s, SD = 3.12 m/s) at the first critical light change. F(1, 26) = 0.028, p = .87. However, the difference in speed for drivers who stopped (M = 15.178 m/s, SD = 1.70 m/s) compared to those who proceeded through the intersection (M = 13.94 m/s, SD = 3.16 m/s) was significant for the second critical light change intersection. F(1, 26) = 32.88, p < .001. Drivers who stopped were more likely to be approaching the intersection at a higher speed.

3.5. Hesitations

Overall, 11 drivers hesitated within 200 metres on approach to the stop-sign controlled intersections and critical light change intersections (n = 11). However, when analysed according to groups, a greater proportion of control participants than those with MCI engaged in hesitations on approach to both stop-sign controlled and critical light change intersections (Fig. 3).

4. Discussion

The aim of the current study was to compare driving performance between drivers with MCI and those without on approach to urban intersections using a driving simulator. For the purpose of this study, the specific aspects of driving performance of interest were the number of brake applications, brake response time at critical light change intersections, number of right foot hesitations and whether drivers stopped at both stop-sign controlled and critical light change intersections. Small and consistent trends were found across the data for a number of measures whereby drivers with MCI performed worse than their healthy peers. This finding was reassuring significance for stopping behaviour, whereby drivers with MCI were less likely to stop at stop sign controlled intersections. MCI drivers in the sample were also less likely to stop at critical light change intersections, although this finding did not reach statistical significance. The relatively few studies which have investigated stopping behaviour at intersections for drivers with MCI found no differences in stopping violations compared to healthy controls (Duchek et al., 2003; Fritelli et al., 2009). In agreement with previous research (Okonkwo et al., 2008), drivers with MCI were slower to complete Trails B; however, this finding failed to reach significance, possibly due to the large variability in scores for the drivers with MCI. Thus, there appears to be great variation in cognitive ability amongst the drivers with MCI in this study. It was interesting to note that healthy drivers demonstrated a greater number of right foot hesitations compared to drivers with MCI. Older drivers may adopt this behaviour as a strategic mechanism rather than a consequence of cognitive impairment.
Given that several trends in our dataset failed to reach statistical significance, this raises questions about their generalizability to the broader population. However, given the trends were consistent with our hypothesis based on the results of previous research in the literature, limitations in the current study effecting statistical power may have obscured us from revealing genuine population differences. For example, our sample size was relatively small and the effect size between our independent groups on critical outcome variables may be small in the population due to the heterogeneous nature of MCI. However, the sample size is large enough to provide the amount of performance variability found in the MCI group in the current study. Therefore, while our results have demonstrated potentially interesting trends we acknowledge that caution should be taken when interpreting our study outcomes.

Failing to obey a stop-sign, is clearly an indication of poor driving performance that can often result in a fine. In Australia, a greater proportion of older driver crashes have been recorded at sign-controlled intersections (e.g., Stop, Give Way) compared to traffic signal control intersections (Filides et al., 2000). Hence, the conversion of sign-controlled intersections into traffic signal controlled intersections has been suggested as a potential countermeasure where appropriate (Stokes et al., 2000). As presented in Fig. 2 of Section 3, one healthy driver and four drivers with MCI failed to demonstrate any brake response while approaching the first stop-sign controlled intersection. The first stop-sign controlled intersection was the very first event that drivers participated in, while the second stop-sign was the last event. It was promising to see that all drivers in the study stopped at the second stop-sign controlled intersection, unlike the first stop-sign intersection. This suggests that drivers become more familiar with the simulator road environment when nearing the end of the drive, and older drivers may have been subject to a learning effect. However, there are other possible explanations for stop sign violations, described below, that are less likely and were not assessed in this study. Future research could aim to explore the role of these factors on braking in MCI as limited empirical research exists in the literature on this area.

This stop-sign intersection task is heavily reliant upon the ability to divide attention between the most relevant objects in the environment, a function that has been shown to be problematic for some older drivers (Belleville et al., 2007; Oktokko et al., 2008). Drivers with MCI may have been less likely to anticipate the presence of an intersection. This corresponds with the first step in the information processing model whereby a driver can fail to either attend to and/or perceive important information in their environment. Alternatively, drivers with MCI could have been more likely than controls to misperceive their immediate environment due to being unfamiliar with the simulator, or take more time to adjust to and manage the demands of the task. The inability to accurately judge approach speed (Clarke et al., 2010) has also been suggested in previous literature as determinant of braking response, however, no significant differences in braking speed was found in the current study between drivers who ultimately stopped and those who did not, suggesting that the inability to judge speed was not a contributory factor in this event. It is also possible that visual search difficulties contributed to this occurrence as evidence suggests that older drivers have a narrow visual search field compared to younger drivers and spend less time scanning to the left and right (Charlton et al., 2005); however this was not assessed during the current study and therefore warrants further investigation. Road infrastructure countermeasures could assist in preventing or minimizing older driver crashes at intersections and should be developed with the older driver in mind.

Another interesting finding from the current study concerned right foot hesitations on approach to the intersections. Older drivers have been shown to engage in a greater number of right foot hesitations compared to younger drivers (Cantin et al., 2004), and have been found to occur more frequently in the oldest-old (>84 years) (Freund et al., 2008). These findings suggest that foot hesitations are associated with increasing age. It remains to be determined whether foot hesitations result from driver indecision related to cognitive deficits or underlying pathology, or whether hesitations are utilised by drivers as strategic mechanisms to integrate all information needed to make a decision about how to proceed (Caïd et al., 2007). This study has the advantage of using observational data using a foot camera to assess braking hesitations. In this study, it was interesting to find that a greater proportion of healthy drivers engaged in hesitations than drivers with MCI, and there were similar numbers of hesitations on approach to stop-sign controlled intersections as there were at critical light change intersections. This finding is in conflict with the hypothesis that drivers with cognitive impairments would be more likely to engage in hesitations and supports the notion that hesitations may be advantageous. The increasing use of naturalistic driving studies as a research tool is expanding our understanding and provide a greater understanding of the implications of right foot hesitations.

It is important to acknowledge the heterogeneous nature of mild cognitive impairment, which is often referred to as a transient state between normal ageing and dementia. As MCI is comprised of different sub-types according to the location and extent of cognitive impairment, it is possible that certain cognitive domains affect driving performance more than others (Duache et al., 2003; Frithelli et al., 2009). According to the MMSE scores, drivers with MCI in this study differed according to their degree of cognitive impairment. This variation could be one explanation for the non-significant results found against the healthy drivers. For example, the lack of significant group differences for performance on Trails-B is possibly an indicator of the large performance variability, particularly for the older participants. However, there are other possible explanations for stop sign violations, described below, that are less likely and were not assessed in this study. Future research could aim to explore the role of these factors on braking in MCI as limited empirical research exists in the literature on this area.

4.1. Limitations

This study contains some limitations which may impact the generalizability of the results. The drivers with MCI were volunteers recruited from memory clinics. The cohort may therefore not be representative of a population-based sample. In addition, the study may not be generalizable to all older drivers who typically volunteer for research are likely to be confident or skilled drivers and therefore may not be representative of older drivers with MCI. Recruitment to this study was difficult due to strict inclusion criteria. There were also indications that reluctance may have been linked to a misunderstanding of the nature of the research task and its implications for loss of their license. As previously acknowledged, the small sample size may have limited findings. As a result of these limitations the investigators acknowledge that older drivers with early cognitive decline who have recently obtained a diagnosis are a very difficult group to recruit, possibly due to their reluctance to participate in driving studies and their ability to come to terms with a diagnosis of dementia. It could be advantageous to include clinicians who have direct access to participants in the research. In addition, community-based initiatives that educate the public about the benefits of participating in research investigating driving and MCI may also assist the recruitment process.

The MMSE is a common screening tool for cognitive impairment that is frequently used in driving studies due to efficient administration times (Frithelli et al., 2009; Wood et al., 2008), however the brief assessment tool is not without its limitations. The assessment tool encompasses broad levels of function, does not assess executive functioning and produces variable responses according to age, ethnicity and education level (McDowell, 2000). The majority of
participants in our study were highly educated reflecting the type of people who typically volunteer for driving studies and therefore the MMSE may have produced inflated scores for some participants. Therefore, the investigators recommend a full neuropsychological assessment of the drivers with MCI as well as the control group. This would assist with identification of different subtypes of MCI and any participants in the control group who may have included individuals with age-related cognitive impairment.

5. Conclusion
The study results provide preliminary evidence to suggest that drivers with MCI demonstrate poorer performance on approach to stop-sign controlled intersections and critical light change inter-sections. It is important to be cautious when interpreting these findings as although the findings on individual measures were nonsignificant, when taken together there was a trend for drivers with MCI to perform worse on the measures compared to their healthy counterparts. Currently there are a lack of specific evidence-based tests and criteria to judge older drivers who are potentially at risk (Mohr et al., 2005). It is important to establish an evidence base to enable the objective determination of risk, so that individuals who are safe can continue to drive for the maximum possible time, thus enhancing independence and quality of life while minimising the risk to the driver or other road users. A number of interventions have been proposed which aim to either improve or maintain level of cognitive functioning for older individuals, including education programs, cognitive training programs or medication, however, there is limited evidence specifically relating to drivers with MCI and whether they, could benefit from participation in such interventions.

Acknowledgements
This work was supported by a grant from Alzheimer’s Australia. Anna Devlin was funded by Rotary Health Australia. The authors would like to acknowledge the support of Elizabeth Rand who assisted with recruiting and all the participants who gave up their valuable time. The authors would also like to acknowledge Angelo D’Elia and Ashley Verdrom for assistance with the simulator data extraction and data analysis.

References


Chapter 5: Self-Regulation of Older Drivers

Introduction

The preceding chapters focused on driver performance of older drivers with MCI. The findings from the first experimental study were presented and discussed. In order to better understand the current driving practices of older drivers with cognitive impairment, it is important to investigate whether drivers with cognitive impairment are firstly aware of any driving difficulties, and secondly whether they engage in any self-regulatory driving practices. This has implications for policy makers, driving authorities and health professionals and may inform recommendations about restricted driving practices.

This chapter provides important definitions, classifications and models of driving behaviour that underpin the thesis. In addition to driver performance, as investigated in the preceding chapter, a greater understanding of older drivers with cognitive impairment can be obtained by investigating the factors that underpin driver behaviour such as driver self-monitoring and driver behaviour change.

Self-Regulation Defined

According to Forgas, Baumeister, & Tice (2009), self-regulation from a psychological perspective refers to the “regulation of the self by the self or changing one’s self or one aspect of one’s self to conform to an idea or standard” (pg 4). In regards to the driving literature self-regulation has been defined in many different ways including; the extent to which drivers alter the amount and type of driving they do and the conditions in which they elect to drive (Baldock, Mathias, McLean, & Berndt, 2006). Self-regulation has also been defined more broadly by researchers
who have incorporated reasons for self-regulation in their definition. For example, Kingston, Reuben and Rogowski (1993) define self-regulation as an alteration of driving patterns based on socio-demographic factors and specific health conditions. Other researchers propose that self-regulation is specific to older drivers, who self-regulate as a result of changes in cognitive, sensory or motor capabilities (Charlton, Oxley, Fildes, & Les, 2001) or to compensate for age-related declines in abilities (Dobbs & Dobbs, 2001). Theories of behaviour change seek to explain the processes that influence and lead to behaviour change. In this context, these processes may include: driver’s intentions to change their behaviour, the process of decision making, the contribution of external pressures, and driver self-awareness. It can be argued that these underlying psychological factors are equally important to investigate, if perhaps not more so, than the actual driving behavior as they may heavily influence or determine this behaviour.

**Theoretical Models of Self-Regulation**

Theoretical models of driving behaviour and driving competence aim to explain the processes that influence driver self-regulation practices. These models can be useful for evaluating these processes, generating hypotheses about the processes and informing research questions. Three models that incorporate driver performance, driver self-regulation and driver cognition have informed the development of this thesis and are described below.

**Michon hierarchical model of driver compensatory behaviours**

According to the model proposed by Michon (1981), self-regulation can be classified at three different levels of driving: the strategic, tactical or operational level (refer Table 1).
Compensation at the *strategic* level relates to how drivers plan their trips, and it incorporates any decisions to avoid certain situations. Compensation at the *tactical* level relates to choices to modify driving behaviour in the moment and includes choosing to maintain a safe distance between themselves and a lead vehicle, speed choice and adapting to changes in the environment. Finally, compensation at the *operational* level is automatic and instantaneous and is likely to involve a high level of cognitive function (De Raedt & Ponjaert-Kristoffersen, 2000a). Examples of compensatory behaviour at the operational level include steering and applying the brakes. Researchers have typically focused on compensatory strategies at the strategic and tactical level driving levels, possibly because these behaviours are less ingrained, easier to assess, and easier to modify than behaviours at the operational level (Christ, 1996; De Raedt & Ponjaert-Kristoffersen, 2000b). The literature on self-regulation typically focuses on healthy older adults and to a lesser extent on older drivers with cognitive impairment. *The primary focus of this section of the*
thesis will be on self-regulation of drivers with cognitive impairment at the strategic level in terms of avoidance behaviour.

Driving as an Everyday Competence Model.

There is an abundance of research in the older driver literature focusing on self-regulation of older drivers (Braitman & Williams, 2011; Kostyniuk & Molnar, 2008; Ruechel, & Mann, 2005). However, few studies have focused on the relationship between driver cognition, driver awareness and self-regulation (Meng & Siren, 2013; Wong, Smith, Sullivan, 2012). It has been argued that Michon’s model of driving should be viewed within a broader context that accounts for the underlying factors that contribute to self-regulation and “not just the actual behaviours of the individual” (Lindstrom-Forneri, Tuokko, Garrett, & Molnar, 2010). In order to account for these underlying factors, Lindstrom-Forneri et al. (2010) developed the Driving as an Everyday Competence Model (DEC) (Figure 2), which incorporates Michon’s hierarchical model of driver performance. This model is particularly useful in older driver research as it accounts for the social, environmental and individual factors such as health and cognition that interact and relate to driving competence. According to this model, the level of driver competence can fluctuate and is not directly measurable. For example, a driver in an unfamiliar area who has depressed mood may demonstrate lower competence than when they were healthy and driving in familiar territory.
Figure 2. Driving as an Everyday Competence Model (Lindstrom-Forneri et al. 2010)

According to this model, personal factors such as driver cognition, driver beliefs, driver awareness and driver capacity for self-monitoring, can each moderate and influence driving performance. The strength of the model is that, unlike previous models of driver behaviour, it takes into account that external factors and psychological factors can influence driver competence. The model has not yet been validated and therefore further research is required. However, once validated, the model may serve as a useful tool for understanding factors related to older drivers and could serve as a communication tool amongst researchers. The focus of this part of the thesis is on the following aspects of the model: driver cognition, awareness and self-regulation at the strategic level.

Self-Regulation and Driver Insight

Insight or awareness are terms that have been explored in many different contexts. According to the DEC model, with respect to driving, awareness acts as a moderator between driver cognition, driver self-regulation (at the strategic level) and
driver competence. Insight has been defined as the discrepancy between the persons perception of reality compared to that of others (Howorth & Saper, 2003). Insight has often been used interchangeably with awareness. It is important for drivers to have a realistic awareness of their driving competence, as overestimation or underestimation of competence can be dangerous and may result in an increased risk to safety (Cotrell & Wild, 1999; Lundberg, Hakamies-Blomqvist, Almkvist, & Johansson, 1998). It is proposed that a realistic perception of driver competence is obtained when a person is able to adequately self-monitor and evaluate their capacity to drive safely (Anstey et al., 2005). Adequate self-monitoring involves awareness of one’s capacity to drive, as well as awareness of any limitations that may have a negative impact on driving. Evidence from surveys of older drivers indicates that drivers who are aware of their own age-related sensory or perceptual changes may choose to adapt or compensate for these changes by self-regulating driving behaviour (Cabeza, Nyberg, & Park, 2005). Similarly, older drivers may modify their driving behaviour to compensate for age-related changes in cognition (O'Connor, Edwards, Wadley, & Crowe, 2010). Intuitively it could be argued that drivers with cognitive impairment have less insight and thus may be less likely to self-regulate their driving behaviour. However, there is an emerging body of research to suggest that drivers with cognitive impairment do in fact, regulate their driving, even without insight into cognitive deficits or insight into their driving ability (Ackerman, Vance, Wadley, & Ball, 2010; Freund, Colgrove, Burke, & McLeod, 2005). Clearly, there is a need for a greater understanding of the relationship between insight, self-regulation and cognitive impairment. In particular, the extent to which insight is a predictor of self-regulation for older drivers with cognitive impairment remains to be determined.
Self-Regulation, Driver Insight and Cognitive Impairment

The extent to which drivers with cognitive impairment engage in self-regulation practices and the extent to which driver insight plays a role remain unclear. The relationship between driver insight, driver avoidance and driver cognition has been investigated in a sample from the general population (Gabaude, Marquié, & Obriot-Claudel, 2010), a sample consisting of MCI drivers (O'Connor et al., 2010) and a small sample of drivers with Alzheimer’s disease (Cotrell & Wild, 1999). In a survey study of 568 drivers (aged 55-91 years) recruited from the general population in France, Gabaude et al. (2010) established that self-reported cognitive difficulties were the best predictor of driver avoidance, even more so than poor driver behaviour such as speeding, failing to give way and braking too quickly. O’Connor and colleagues (2010) conducted a pioneering longitudinal study, with an impressive sample of 304 drivers with MCI and 2051 drivers with no cognitive impairment. The researchers found that self-reported driving difficulty increased at a greater rate for the group with MCI compared to drivers without cognitive impairment. Furthermore, drivers with cognitive impairment reported driving less often in challenging situations. These findings are similar to those reported by Cortell and Wild (1999) whereby 12 of 14 drivers with Alzheimer’s disease restricted their driving voluntarily. In addition, the drivers who reported greater awareness of memory difficulties and ability to perform everyday activities tended to restrict their driving more than drivers with poor awareness. Unfortunately the authors did not include a control group in this study and the sample size is limited.

Not all research has demonstrated a relationship between cognition and self-reported driving restrictions. In a cross-sectional study Kowalski et al. (2011) asked drivers of varying cognitive status about whether they had made any changes by
reducing or restricting their driving in the past year. No differences were found in driving restrictions made in the past year regardless of cognitive status. However, when asked about intentions to restrict driving in the future, the group with greatest cognitive impairment reported having greater intentions to stop or restrict driving when the situation arose compared to groups with mild or no cognitive impairment. The authors concluded that the greater intention to change driving in the future expressed by the group with cognitive impairment indicates that they may have some insight into their cognitive impairment. However this insight was clearly not of enough concern for drivers to change their behaviour at the time of the study.

Recently, a number of studies have proposed that the extent of driving comfort and driving stress may be a contributory factor in self-regulation of driving behaviour, in addition to the awareness of cognitive impairment (Meng & Siren, 2012). In a Danish study, self-report data on driving avoidance, cognitive awareness (self-rated cognitive functioning), and driver discomfort was obtained via telephone interviews with 888 drivers aged over 75 years (Meng & Siren, 2012). A greater proportion of drivers with low cognitive awareness reported avoiding more driving situations than drivers with high cognitive awareness. The lower functioning cognitive awareness group also reported greater driving discomfort than the high cognitive awareness group, indicating that driving discomfort may be a motivator for restricting driving behaviour.

**Summary**

Self-regulation of driver behaviour occurs when an individual self-monitors their driving, identifies a need to alter their driving behaviour and alters their behaviour accordingly. Awareness of functional deficits has been identified as a key
motivator for engaging in self-regulation (Stalvey & Owsley, 2000). Drivers with cognitive impairment have been thought to have less insight than their healthy counterparts and therefore may fail to regulate their driving. However, few researchers have investigated the extent to which drivers with cognitive impairment have insight and engage in self-regulation (Cotrell & Wild, 1999; Kowalski et al., 2011). In addition, the extent to which drivers with cognitive impairment engage in compensatory behaviours remains unclear (Anstey & Smith, 2000; O'Connor et al., 2010). It is important to identify whether drivers with cognitive impairment self-regulate and the factors that influence the decision to do so, in order to enhance road safety amongst this distinct cohort of drivers.
Chapter 6: Self-Regulation of Older Drivers with Cognitive Impairment: A Systematic Review


Preamble to Paper

A systematic literature review was conducted to identify existing literature on the topic of self-regulation in older drivers with cognitive impairment, to determine and evaluate the evidence, to illustrate the current understanding in the field. This review is provided as a paper in Chapter 6. This paper expands on the research presented in Chapter 5, and systematically evaluates the literature according to the level and quality of evidence. The primary aim of the review was to identify whether drivers with cognitive impairment self-regulate their driving behavior. The secondary aim was to determine the factors that influence their decision to do so in order to enhance road safety amongst this distinct cohort of drivers. This review has been submitted as a paper to a journal and is currently under peer review.

Paper 2

A facsimile of the full paper is presented in the remainder of this chapter.
Review Article
Self-regulation of older drivers with cognitive impairment: A systematic review

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Background: Cognitive decline contributes significantly to the safety risk of older drivers. Some drivers may be able to compensate for the increased crash risk by avoiding complex driving situations or restricting their driving.

Objective and Method: A comprehensive English-language systematic review was conducted to determine the level of evidence for older adult drivers with cognitive impairment engaging in self-regulation.

Results: Twelve studies were included in the review. The majority of studies investigated driver avoidance, followed by driver restriction. Few studies ascertained the reasons for changing driving behaviour.

Conclusions: The evidence supports the view that drivers with cognitive impairment do restrict their driving and avoid complex driving situations. However, it remains to be determined whether the drivers who do engage in self-regulation require insight into their own driving abilities or whether external factors result in self-regulation of driving behaviour.

Key words: cognition, driver, self-regulation.

In common with other western societies, a substantial increase in the proportion of older individuals in Australia is predicted in the foreseeable future as the current population ages [1]. Consequently, the number of older adults with dementia is also expected to increase by approximately 254% from 2011 to 2050 [2]. A corresponding increase in the number of these individuals who continue to drive is anticipated, together with an escalation in the concern for their safety. In particular, older drivers who experience age-related changes in physical and sensory functioning and who also suffer from a medical condition can be at a heightened risk for motor vehicle crash involvement [3]. While evidence suggests that most drivers with poor cognition cease driving, a significant proportion of drivers with cognitive impairment continue to drive [4]. It is thus paramount that strategies are developed to minimise risk for these drivers to enable them to continue to drive safely in a society where transportation by car is the primary mode of transport, and loss of a licence may result in decreased independence and lowered self-esteem [5].

It has been suggested that older drivers can modify their driving behaviour to compensate for age-related changes that place them at an increased driving risk. Evidence from survey studies of older drivers indicates that they may choose to adapt to, or compensate for, perceptual and sensory changes that occur with age [6]. For example, drivers may reduce exposure to challenging driving situations by driving fewer kilometres or driving less frequently [7,8]. When an individual self-monitors their driving, identifies a need to change their driving and then alters their behaviour accordingly they are said to engage in self-regulation [9].

The process of self-regulation and the factors that influence self-regulation, such as perceived driver difficulty and level of driver cognition are not well understood. In addition, the extent to which drivers with cognitive impairment engage in self-regulatory driving behaviours remains unclear [10–12]. The literature on self-regulation typically focuses on healthy older adults and to a lesser extent on older drivers with cognitive impairment. Therefore, the objective of this systematic review was to firstly determine whether older drivers with cognitive impairment engage in self-regulatory driving practices via restricting their driving or avoiding specific driving situations, and secondly to determine the relationship between self-regulation and severity of cognitive impairment.

Significance and purpose
It is important to identify whether drivers with cognitive impairment self-regulate their driving behaviour and the factors that influence their decision to do so in order to enhance road safety amongst this distinct cohort of drivers. If drivers with reduced fitness to drive due to a decline in physical or cognitive functioning are aware of this state and are able to modify their driving behaviour accordingly, they may increase their safety on the road [13,14]. However, it is important to note that further research is required into the association between self-regulation and crash risk, as well as the factors that predict self-regulation.

Methods
The search strategy was developed to answer the question: "What is the level of evidence for older adult drivers with cognitive impairment engaging in self-regulation? A comprehensive English language literature search was conducted using the following databases; MEDLINE, CINAHL, PsycINFO, Cochrane Central Register of Controlled Trials and the combined Transportation Research Information Services and International Transport Research Documentation for the..."
following years 1985–2012. The following search terms were used: driving, driving, motor vehicle, automobile, avoidance, restriction, self-regulation, compensatory, mild cognitive impairment (MCI), Alzheimer’s and dementia. A manual search was also conducted of the reference lists of each selected article to identify other relevant articles. The studies were selected for the review if they met the following criteria: (i) the study involved self-regulation as an outcome measure as defined by restriction or avoidance; (ii) the study included an assessment of driver cognition; (iii) the article was written in English; (iv) participants were older drivers. The ‘grey literature’ (i.e., reports, non-peer-reviewed journals or opinion pieces) were not reviewed as there is no systematic way of doing so. Only studies that identified groups of participants according to cognitive status or cognitive severity were included. Studies that administered cognitive tests and failed to provide an overall measure of cognitive ability for participants groups were excluded.

Quality assessment

The identified studies were rated according to the quality of evidence using a level of evidence system defined by MacDermid and Law [15]. According to the system, there are five levels of evidence represented by roman numerals. The highest level of evidence is represented by ‘I’ and the lowest level of evidence is ‘V’. Following this, two authors (AD and JM) independently assessed the quality of each study and any disagreements were discussed and resolved. The quality of the studies was rated according to the NHMRC guidelines [16], which are outlined in Table 1. The seven selection criteria were answered as yes/no/unsure and scores of yes were included in the overall quality score. Studies that scored 5 or more out of 7 were rated as high quality, scores between 3 and 5 were rated as moderate quality and scores less than 3 were rated as low quality. The overall quality scores are presented in Table 2.

### Table 1: Quality assessment criteria used in the review (Based on NHMRC guidelines [16])

<table>
<thead>
<tr>
<th>Category</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort studies</td>
<td>Are study participants well defined in terms of time, place and person?</td>
</tr>
<tr>
<td></td>
<td>Was the inclusion time point clearly stated?</td>
</tr>
<tr>
<td></td>
<td>Did the study have clear exclusion and inclusion criteria?</td>
</tr>
<tr>
<td></td>
<td>Did the study use a representative sampling technique?</td>
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<tr>
<td></td>
<td>Were outcomes measured in a standard, valid and reliable way?</td>
</tr>
<tr>
<td></td>
<td>Was follow-up long enough for outcome to occur?</td>
</tr>
<tr>
<td></td>
<td>Are confounding factors comparable between the groups and if not, were they adjusted for in the analysis?</td>
</tr>
<tr>
<td>Case/control studies</td>
<td>Was the definition of cases adequate?</td>
</tr>
<tr>
<td></td>
<td>Were the controls randomly selected from the source of population of the cases?</td>
</tr>
<tr>
<td></td>
<td>Were the non-response rates and reasons for non-response the same in both groups?</td>
</tr>
<tr>
<td></td>
<td>Is the outcome variable measured in the same way for cases and controls in a standard, valid and reliable way?</td>
</tr>
<tr>
<td></td>
<td>Are the two groups comparable on demographic characteristics and important confounding factors?</td>
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</tbody>
</table>

### Results

**Search strategy**

The initial search identified 91 articles. The abstracts of these articles were reviewed and 12 studies met the criteria for inclusion (Table 2). The studies identified were published between 1991 and 2012. The results of the literature review, including the study characteristics and quality ratings are presented in Table 2. The studies were conducted in the United States (n = 9), Australia (n = 1), Denmark (n = 1) and Canada (n = 1).

**Level of evidence/quality assessment**

In general, the majority of studies in the review (n = 9) provided level III evidence (i.e., cross-sectional study), while the remaining three studies provided level II evidence (i.e., prospective cohort study). Table 2 provides a list of the information collected for each study. The information presented includes study type, study population (size, location and age), study design, study outcomes (measures of self-regulation, restriction or avoidance), type of cognitive screen or assessment, and follow-up time period where relevant. Consensus was achieved when rating the quality of evidence as the two reviewers were in concordance 100% of the time. One study was rated as high quality [12], six studies were rated as moderate quality [8,19–22,24], and five studies were rated as low quality [17,18,23–25].

**Cognitive assessments**

Within the included studies, 11 different cognitive screening and assessment measures were used. These included the Mattis Organic Mental Status Examination (MOMSSE) [27], the Short Form Memory Questionnaire, Short Blessed Cognitive screen [28], a telephone interview for cognitive status [29], Mini Mental Status Examination [30], Short Portable Mental Status Questionnaire (SPMSQ) [31], the Clock Drawing Test [32], self-rated perception of memory and attention [23], as well as physician-administered assessments using the Clinical Dementia Rating Scale (CDR) [33], the NINDSADRA criteria [34] and an algorithm for MCI [35]. Assessment of cognitive impairment can be problematic as there is no gold standard of assessment and an accurate assessment must distinguish between symptoms of a medical condition and symptoms associated with the normal ageing process. Typically, research studies rely upon general screening measures of cognition such as the Mini Mental Status Examination (MMSE) as they are brief and easy to administer. Furthermore, studies rarely specify cut-off criteria according to the degree or severity of cognitive impairment. Consequently, sample populations with cognitive impairment can vary widely, which presents challenges for distinguishing between drivers with MCI from those drivers with mild or moderate dementia.

**Self-regulation of driving**

Avoidance of driving situations was the primary outcome measure of self-regulation in 10 studies, while six studies
<table>
<thead>
<tr>
<th>Study/author</th>
<th>Study design</th>
<th>Study population</th>
<th>Quality of evidence score and rating</th>
<th>Measure of cognition</th>
<th>Outcome measures (i.e., dose assessment)</th>
<th>Main findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball et al. (2016) [1]</td>
<td>Cross-sectional study</td>
<td>521 drivers, aged 50 years - 79 years, from general populations</td>
<td>3 (moderate)</td>
<td>Cognitive function was assessed with the Mattis Dementia Rating Scale (MDRS), Mini-Mental State Examination (MMSE), and Frontal Assessment Battery (FAB).</td>
<td>Self-reported driving assistance. Self-reported driving exposure.</td>
<td>Diverse with poor cognitive reserve is likely to avoid driving.</td>
</tr>
<tr>
<td>Bratton et al. (2019) [2]</td>
<td>Cross-sectional study</td>
<td>201 drivers, aged 65 years - 89 years, from general populations</td>
<td>4 (good)</td>
<td>Cognitive function was assessed with the Mattis Dementia Rating Scale (MDRS), Mini-Mental State Examination (MMSE), and Frontal Assessment Battery (FAB).</td>
<td>Self-reported driving assistance. Self-reported driving exposure.</td>
<td>Participants with greater awareness of memory difficulties and reservations about driving were more likely to avoid driving.</td>
</tr>
<tr>
<td>Cidino et al. (2019) [3]</td>
<td>Cross-sectional study</td>
<td>126 drivers, aged 70 years - 90 years, from general populations</td>
<td>2 (low)</td>
<td>Cognitive function was assessed with the Mattis Dementia Rating Scale (MDRS), Mini-Mental State Examination (MMSE), and Frontal Assessment Battery (FAB).</td>
<td>Self-reported driving assistance. Self-reported driving exposure.</td>
<td>Participants with greater awareness of memory difficulties and reservations about driving were more likely to avoid driving.</td>
</tr>
<tr>
<td>De la Vallee et al. (2019) [4]</td>
<td>Cross-sectional study</td>
<td>60 drivers, aged 65 years - 80 years, from general populations</td>
<td>4 (good)</td>
<td>Cognitive function was assessed with the Mattis Dementia Rating Scale (MDRS), Mini-Mental State Examination (MMSE), and Frontal Assessment Battery (FAB).</td>
<td>Self-reported driving assistance. Self-reported driving exposure.</td>
<td>Participants with greater awareness of memory difficulties and reservations about driving were more likely to avoid driving.</td>
</tr>
<tr>
<td>Elovic et al. (2019) [5]</td>
<td>Cross-sectional study</td>
<td>150 drivers, aged 65 years - 89 years, from general populations</td>
<td>3 (moderate)</td>
<td>Cognitive function was assessed with the Mattis Dementia Rating Scale (MDRS), Mini-Mental State Examination (MMSE), and Frontal Assessment Battery (FAB).</td>
<td>Self-reported driving assistance. Self-reported driving exposure.</td>
<td>Participants with greater awareness of memory difficulties and reservations about driving were more likely to avoid driving.</td>
</tr>
<tr>
<td>Fish et al. (2019) [6]</td>
<td>Cross-sectional study</td>
<td>60 drivers, aged 65 years - 85 years, from general populations</td>
<td>4 (good)</td>
<td>Cognitive function was assessed with the Mattis Dementia Rating Scale (MDRS), Mini-Mental State Examination (MMSE), and Frontal Assessment Battery (FAB).</td>
<td>Self-reported driving assistance. Self-reported driving exposure.</td>
<td>Participants with greater awareness of memory difficulties and reservations about driving were more likely to avoid driving.</td>
</tr>
</tbody>
</table>
measured driver restriction (i.e. driver exposure). In addition, in two studies, drivers were asked about their intention to change driving behaviour in the future (i.e. restricting or ceasing driving) [21]. All reviewed studies obtained driver avoidance information via self-report; however, one study also obtained collateral information from informants [18]. All of the studies used various listing difficult driving situations requiring either a response on a scale ‘never, sometimes, always’, or a yes/no response. Furthermore, the number of driving situations ranged from a minimum of four in one study [24] to a maximum of 17 in another [25].

Information about driver restrictions (i.e. driver exposure and frequency) was investigated by self-report in all cases. Two of the studies cited used a Driving Habits Questionnaire to ascertain driver avoidance and driver exposure; however, only one of these studies used an existing survey [21]. The remaining studies varied in the duration of driving exposure collected, which ranged from ‘how many miles did you drive in the past year’ [22,26], and ‘how many miles did you drive in the past week’ [12]. One study collected information on current driving practices asking two questions about driving exposure including ‘are you able to drive’, as well as ‘do you limit your driving to nearby places or do you also drive on long trips’ [20]. These wide variations in driver exposure times frames present difficulties for comparing across studies, particularly when the information is obtained via self-report.

Very few studies investigated intentions to change driving behaviour in the future [21,25]. The two studies that assessed intentions to change differed in their assessment methods. The Driving Habits and Intentions Questionnaire was utilised in the study by Kowalski and colleagues [21], while in the study by Wong et al. [25], intentions were examined by asking the following question ‘to what extent do you plan to continue driving in the future’. Although intention to change is not a self-regulatory driving practice, intentions can serve as strong motivators, which increase the likelihood of the individual engaging in a certain type of behaviour [36].

Relationship between cognition and self-regulation

1 RESULT: Avoidance – The existing evidence suggests that drivers with cognitive impairment do self-regulate by avoiding certain driving situations. Two level II studies [8,18], and six level III studies [17,19,20,23–25] found a significant relationship between poor cognition and an increase in the number of situations avoided. It was interesting to note that Gallo et al. [26] did not find a relationship between cognitive impairment (as measured by the total MMSE score) and number of driving situations avoided; however, the researchers found that poor performance on the visuospatial task of the MMSE correlated with increased avoidance.

2 RESULT: Restriction – Drivers with cognitive impairment demonstrate greater driving restrictions than drivers without cognitive impairment [12,20,22,24]. However, Kowalski et al. [21] did not find any differences in driving restrictions for participants in their study regardless of cognitive status. The studies that analysed sex differences found greater restrictions for women compared to men [20], conversely Sturts [24] found men with cognitive impairment were more likely to report reduced driving exposure than women. Unfortunately, the reasons behind why people restricting their driving is rarely examined and only investigated in two of all the studies in this review [18,21]. Vision problems, as well as no longer needing to drive were reported as the main reasons for driver restriction in one study [21]. In another study, the majority of drivers with cognitive impairment reported that they voluntarily restricted their driving by avoiding unfamiliar routes, with a small number claiming that they restricted their driving upon the request of a caregiver [18].

3 RESULT: Cognitive Severity and Driver Restriction – In a study by Cornell and Wild [18], carers reported that drivers with mild levels of cognitive impairment (CDR = 1) self-monitored by avoiding certain driving situations. However, these drivers were identified as those who possessed insight into their memory difficulties. Awareness was measured by assessing the discrepancy between carer and driver responses on a questionnaire asking about the following abilities of the driver: attention, remote memory, recent memory and everyday activities. As this study lacked a control group, the results require cautious interpretation.

There is evidence to suggest that drivers who potentially lack insight and who have cognitive impairment continue to drive despite not restricting their driving in any way [20]. The results of the study by Freund and Szmoczak [20] provide level III evidence and indicated that approximately half of drivers with MCI and one-third of drivers with severe cognitive impairment continue to drive. In their level III study, O’Connor et al. [12] found that drivers with amnestic and non-amnestic MCI reported greater restrictions in their driving over a 5-year period compared to both drivers without any cognitive impairment and drivers with multi-domain cognitive impairment. These findings suggest that drivers with multi-domain MCI possibly lack insight and therefore do not self-regulate. This is one of the first studies to assess longitudinal changes in driving behaviour across the different subtypes of MCI. The evidence as presented suggests that degree of insight into deficits is possibly a greater predictor of driver restrictions than the severity of cognitive impairment.

4 RESULT: Driver Intentions to Change Driving Behaviour – Kowalski et al. [21] reported that drivers with cognitive impairment had greater intentions to change their driving than the drivers without cognitive impairment. Conversely, Wong et al. [25] found neither drivers with cognitive impairment or healthy controls had any intentions to change their driving in the future. Compared to Wong et al. [25], Kowalski et al. [21] asked a greater number of questions in relation to future intentions and it may be...
that this provided a more accurate representation of drivers’ intentions to change their future behaviour.

Discussion
The results of this systematic review clearly demonstrate that older drivers with cognitive impairment do in fact engage in self-regulation by either reducing their driving or avoiding certain driving situations. For example, in eight of the 12 studies, poor cognition was significantly associated with a greater number of driving situations avoided. Furthermore, this relationship was replicated when driving restriction was used as an outcome measure. Four studies found drivers with cognitive impairment were more likely to restrict their driving than drivers without any cognitive impairment. The reasons behind restricting driving was investigated in two studies [38,41], which reported changes in visual abilities, a reduced need to drive and an awareness of attention deficits as the primary reasons. This finding is consistent with previous research investigating reasons for self-regulation, whereby drivers often report changes in physical abilities such as vision [37,38] and a decrease in confidence levels [7] as more pertinent reasons than declines in cognitive abilities.

It is important to note that there continues to be a subset of drivers with cognitive impairment who either fail to restrict, or cease driving. One possibility is that these drivers lack insight and awareness into either a decline in their cognitive abilities or a decline in their driving performance. Only one study included in this review investigated the relationship between driver insight and self-regulation in a sample of older drivers with cognitive impairment [25]. The results of this study combined with others [39,40] indicate that drivers lacking insight are potentially less likely to engage in self-regulation and may even overestimate their driving ability [41]. This group of drivers poses a select group that may be at higher risk. However, insight is a difficult construct to measure and therefore there is wide variation in study methodology. More comprehensive studies of older driver insight are required, together with agreed upon measures of driver awareness before the characteristics of this group potentially high-risk group are well understood.

With regards to the assessment of self-regulation, all studies relied upon self-report measures. Therefore, it is difficult to ascertain the exact extent to which drivers are engaging in self-regulation as self-report depends upon the driver’s memory of the event, which may be diminished due to cognitive decline, and can change over time. It has been estimated that older drivers with cognitive impairment often overestimate their driving abilities and functional abilities [42,43] and recent evidence suggests that this relationship may be correlated with degree of cognitive impairment [43].

For example, adults with MCI may have more accurate self-report of functional abilities than adults with more severe cognitive impairment. Although it can be challenging to do so, it is beneficial to obtain collateral information from significant others or utilise more objective measures than self-report when obtaining information about functional ability and changes in driving behaviour. Advances in technology can allow for the collection of driving patterns via electronic data logging systems that are inserted into vehicles [44]. Although in its infancy, this method could provide more accurate representations of changes in driving behaviour and verify self-report of driver self-regulation practices.

There are many different types of self-regulation and influencing factors as outlined in the model by Backman and Dixon [45]. Driver avoidance and restriction are just two types of many which may increase driver safety. The following self-regulatory behaviours are also recognised as being specific to older drivers with cognitive impairment: use of a co-pilot [46], choosing a safe vehicle or one that is equipped with advanced technology such as Global Positioning Systems [47], driver retraining programs or programs focussed on enhancing cognitive processing [48] or the use of medication for cognitive impairment [49]. Future research could investigate a range of self-regulation strategies to determine whether drivers with cognitive impairment are more reliant upon one strategy compared to another. Currently, these additional self-regulatory strategies are not routinely included in studies investigating self-regulation of older drivers with cognitive impairment. In addition, it is important to acknowledge that restriction of driving may occur for reasons other than compensating for a cognitive decline, for example older drivers may choose to restrict their driving due to an increase in alternative transport options [50], or the presence of older drivers in the household [20] or due to licence restrictions imposed by the driving authorities. It is surprising that very few studies have assessed the safety benefits of licence restrictions. Recently, an analysis compared crash rates of drivers in Victoria, Australia with restricted licences to those without and a significant decrease in crash risk was found for the restricted drivers [51]. It is important to understand whether driving restrictions for drivers with cognitive impairment translate into a reduced crash risk. The results of this review indicate that drivers with cognitive impairment are self-restricting their driving, and therefore, it could be important to account for these factors when reviewing licensing practices.

At present, there is an abundance of research investigating self-regulatory driving practices of older drivers; however, the vast majority of studies do not focus on older drivers with cognitive impairment. There is a need for research to examine the extent to which older drivers with cognitive impairment self-regulate as dementia becomes the leading cause of disability for adults aged over 65 years and remains a major public health issue [2]. The majority of studies identified in this review are cross-sectional, with very few prospective cohort studies and (to the authors’ knowledge) no randomised control studies. Future studies could include randomised control evaluations of interventions such as older driver training programs promoting driver restriction.
while assessing the impact on driver crash rates and driver self-regulatory patterns. The relationship between self-regulation and crash risk is still contentious, and robust evidence about whether self-regulation protects against crash risk is lacking [12]. However, self-regulation has been identified as one way in which drivers can limit their driving to prevent them from driving as high-risk situations. It is important for drivers to have a realistic awareness of their driving competence and limitations as overestimation or underestimation of competence can be dangerous and may result in an increased risk to safety [18].

In conclusion, it appears from the available literature that many drivers with cognitive impairment do self-regulate by restricting their driving and avoiding certain driving situations. The extent to which the degree of insight is directly related to the number of self-regulatory strategies, however, is not clear. In addition, the majority of studies group drivers according to broad levels of cognitive impairment. Individuals differ according to the severity and type of cognitive impairment and it is thus important to account for these differences. This is particularly relevant to policy-makers and licence holders due to the emerging evidence indicating that drivers with MCI may be safe to continue to drive for longer periods than drivers at moderate or severe stages of dementia [53]. Until assessments can reliably detect those individuals with cognitive impairments who are at risk of driving unsafely, the promotion of self-regulatory strategies may assist drivers to modify their driving according to their limitations.

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Key Points
• Drivers with cognitive impairment do in fact self-regulate their driving behaviors, and reasons for doing so are not directly related to a decline in cognitive abilities but rather to changes in vision and decreased confidence levels. At present, the majority of studies assessing self-regulation have relied upon self-report data, which is subject to bias and often underestimates level of risk. Therefore, more objective measures of self-regulation such as vehicle tracking systems are required to enhance reliability of self-report.
• The extent to which severity of cognitive impairment relates to lack of insight of older drivers is not well understood. Well-defined measures of cognitive impairment combined with data from longitudinal studies are required to clearly identify those drivers who lack insight and are potentially at risk.

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Chapter 7: Rationale and Aims of Study Two

Rationale of Study Two

Survey studies of older driver self-regulatory behaviour provided in the review in Chapter 6 indicate that older drivers may choose to adapt to, or compensate for, the perceptual and sensory changes that accompany ageing (Cabeza, Nyberg, & Park, 2005) by modifying their driving behaviour (Adler, Rottunda, & Kuskowski, 1999; Braitman & Williams, 2011; Donorfio et al. 2009). The process of self-regulation and the factors that influence it, such as perceived driver difficulty and level of driver cognition are not well understood. Furthermore, it remains inconclusive as to whether drivers who self-regulate their driving behaviour require insight into a decline in their driving skills.

Aims and Hypotheses of Study Two

The aims of the study were;

• to investigate the relationship between cognitive status and the ability to engage in self-regulatory driving practices (i.e., driver avoidance);

• to determine whether drivers who self-regulate their driving behaviour demonstrate insight into a decline in their driving skills, and

• to investigate the discrepancy between driver and passenger responses regarding self-regulation and driving difficulty.
Paper 3: Self-Regulation of Older Drivers by Cognitive Status: Discrepancy between Driver and Passenger Reports


Preamble to Paper

This chapter comprises the second study in this thesis and has been submitted to a journal. Telephone interviews were conducted with older drivers and their passengers in order to understand the relationship between self-regulatory practices, driver cognition and driver insight. The findings suggest that older drivers who self-regulate are more likely to have dementia. In addition, drivers with MCI and their passengers are more likely to report difficulty with driving situations compared to drivers with no cognitive impairment and drivers with dementia. Additional findings are discussed in more detail in the discussion section of the paper, including any discrepancies between driver and passenger ratings of driver difficulty.

Paper 3

A version of the paper that has been submitted for publication, and is currently under peer review and is presented in the remainder of this chapter.
Title: Self-Regulation of Older Drivers by Cognitive Status: Discrepancy between Driver and Passenger Reports

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Abstract

It has been suggested that older drivers can modify their driving behaviour to compensate for age-related changes that place them at an increased driving risk by engaging in self-regulatory driving practices. However, the extent to which drivers with cognitive impairment engage in self-regulatory driving behaviours remains unclear. In the current study, the relationship between self-regulatory behaviours and driver cognitive status was explored in relation to three groups; no cognitive impairment, mild cognitive impairment and dementia. In addition, any discrepancy between driver and passenger reports of self-regulation and driver difficulty was examined to ascertain the role of insight into driver self-regulatory behaviour. Telephone interviews were conducted with 49 drivers aged 65 years and above and with 39 passengers. Overall, the results suggest that drivers with dementia are more likely to engage in self-regulatory avoidant driving behaviours than drivers with mild cognitive impairment or drivers with no cognitive impairment. In addition, drivers with mild cognitive impairment and their passengers were more likely to report occasional problematic driving behaviours than either drivers with or with no cognitive impairment. It is important to consider and understand factors in addition to cognitive status that may influence self-regulation in this potentially at-risk group of drivers.

Key Words: Self-regulation, insight, older driver, passenger, cognitive impairment
In common with other western societies, a substantial increase in the proportion of older individuals in Australia is predicted in the foreseeable future as the current population ages (ABS, 2009). Consequently, there will be an increase in the number of older drivers, and a corresponding escalation in the concern for their safety. In particular, older drivers who experience age-related changes in physical and sensory functioning and who also have a medical condition can be at a heightened risk for motor vehicle crash involvement (Charlton et al., 2010). Evidence from survey studies of older drivers indicate that older adults may choose to adapt to, or compensate for, perceptual and sensory changes that occur with age (Cabeza, Nyberg, & Park, 2005). Similarly, it has been suggested that older drivers can modify their driving behaviour to compensate for age-related changes that place them at an increased driving risk. For example, drivers may reduce driving exposure to challenging driving situations, drive fewer kilometers or drive less often (Adler, Rottunda, & Kuskowski, 1999; Braitman & Williams, 2011; Donorfio, D’Ambrosio, Coughlin, & Mohyde, 2009). When an individual self-monitors their driving, identifies a need to change their driving and then alters their behaviour accordingly they are said to engage in self-regulation (Dobbs & Dobbs, 2001). It remains to be determined whether drivers require insight into their own driving abilities to self-regulate driving behaviour or whether other factors, such as perceived driver difficulty or level of cognition moderate self-regulation (Lindstrom-Forneri, Tuokko, Garrett, & Molnar, 2010). In addition, the extent to which drivers with cognitive impairment engage in compensatory behaviours remains unclear (Anstey & Smith, 2000; O’Connor, Edwards, Wadley, & Crowe, 2010).

Insight or awareness of functional deficits has been identified as a key motivator for engaging in self-regulation of driving behaviour (Stalvey & Owsley, 2000). A lack of insight often accompanies cognitive decline, particularly in moderate and severe stages of cognitive impairment (Ball et al., 1998; Man-Son-Hing, Marshall, Molnar, & Wilson, 2007). There is mixed and sometimes inconsistent evidence for a relationship between driver
insight and self-regulation of drivers with cognitive problems. There is some evidence to suggest that drivers with cognitive impairment may have less insight than their healthy counterparts and are therefore less likely to regulate their driving, which may thus place themselves and others at risk of having a crash (Holland & Rabbitt, 1992; Wong, Smith, & Sullivan, 2012). However, other research has indicated that older drivers with MCI or severe cognitive impairment do in fact self-regulate, primarily by restricting their driving or avoiding certain driving situations (Freund & Szinovacz, 2002; O’Connor et al., 2010). It is important to identify whether older drivers with various levels of cognitive impairment self-regulate their driving behaviours in order to enhance road safety amongst this distinct cohort of drivers.

In this study a sample of older drivers from the Victorian community with varying levels of cognitive ability were interviewed to identify self-regulatory driving practices (i.e., driver avoidance). In addition, a possible relationship between awareness and self-imposed driver avoidant strategies was examined by investigating any discrepancy between passenger and driver ratings.

Method

Participants

This cross-sectional study consisted of 90 community dwelling older adults. There were 49 drivers with a mean age of 75.50 years ($SD = 6.73$, range = 65-88 years), and 39 passengers with a mean age of 73.40 years ($SD = 9.13$, range = 51-99 years) who acted as informants. Participants were recruited from bowling clubs, independent living units, and older adult organisations from the metropolitan and rural areas of Victoria. Note that Victoria, unlike other states in Australia, does not have any age-based requirements for licence testing. The inclusion criteria included; a current driver’s licence, driving more than once a week, having English as a first language, and being able to provide informed
consent. Drivers with depression or any physical, ophthalmological, or a neurological disorder that may impair their driving ability were excluded via a screening questionnaire. Passengers were eligible to participate if they were familiar with the drivers driving and drove with them at least once a week.

**Materials**

The data for this study were collected via telephone interviews. The interviews took approximately 20 minutes for the driver and seven minutes for the passenger to complete. Both interviews were administered by the primary researcher and scheduled at a time convenient to the participants.

**Driver Survey**

The telephone interviews included a series of questions relating to; demographics, driving exposure, general health, and medical conditions likely to affect driving, and crash history in the past two years.

**Cognitive and Mood Status**

During the driver telephone interview, the Geriatric Depression Scale (Sheikh & Yesavage, 1986) was administered as a brief screening tool for depression. Those drivers who scored greater than 5 points out of a possible 15 were classified as suffering from depressive symptoms and were excluded from the study as depression could potentially influence cognitive impairment. In order to screen for cognitive impairment the driver was administered the Telephone Interview of Cognition (TICS-m) (Brandt et al., 1993). The TICS-m is a 13 item telephone interview assessing orientation; registration, recent memory and delayed recall (memory); attention/calculation, semantic memory, comprehension and repetition (language) and with scores ranging from 0-39 (Brandt et al., 1993). The TICS was derived from the Mini Mental Status Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). It has subsequently demonstrated high correlation ($r = 0.94$) with the MMSE and has
high test-retest reliability (Brandt, Spencer & Folstein, 1988). A score below 23 indicates cognitive impairment or the presence of dementia, a score below 27 indicates mild cognitive impairment or probable cognitive impairment, while a score at or above 27 represents no cognitive impairment (Berri, Werner, Davidson, Schmidler, & Silverman, 2003; de Jager, Budge, & Clarke, 2003). In this study, the term dementia will be used to refer to participants with a score below 23 to distinguish them from participants with mild cognitive impairment. As reported in Breitner et al. (1990) raw scores were adjusted for educational achievement according to the following criteria; 5 points added for < 8 years of education, 2 points added for ≥ 8-10 years of education, no adjustment of score for 11-12 years of education, and 2 points subtracted for > 13 years of education.

Self-regulation of driving

An eight item questionnaire was developed to collect information about self-regulatory driving behaviours including avoidance of the following situations; driving in the rain, driving at night, driving on freeways, making right hand turns, driving in peak hour traffic, driving on slippery roads, driving interstate and driving through roundabouts. Drivers were asked to respond in terms of whether they always, sometimes or never avoided the eight driving situations. Passengers were also asked to respond in terms of whether the driver always, sometimes or never avoided the eight driving situations. Both the driver and passenger were asked to report on whether the driver had changed their driving in any way since ten years ago.

Assessment of insight

A possible measure of insight was obtained by assessing any discrepancy between the driver and their passenger’s rating of the driver’s difficulty performing seven driving situations, as well driver/passenger reports on whether the driver avoided eight driving situations. Both the driver and passenger completed the same questions concerning the
driver’s behaviour. A list of the seven driving situations is provided in Appendix 1 and was adapted from the Driver Behavior Questionnaire (Reason, Manstead, Stradling, Baxter, & Campbell, 1990).

**Passenger Survey**

In addition to commenting on the driver self-regulatory driving practices, and driver difficulty ratings, the passengers were asked about their relationship to the driver and whether they had any concerns about the driver’s current driving.

**Procedures**

Participants were provided with detailed written information about the study purpose and the requirements for participation, prior to an invitation to provide written informed consent to participate. Once the researcher received the consent forms, a suitable time for the telephone interview was made. The researcher explicitly stated that the results of the study were for research purposes only and would not impact on their licence status. The Deakin University Human Ethics Committee granted ethics approval for this study.

**Data Analysis**

To explore differences between cognitive status and self-regulation drivers were divided into three groups: drivers with no cognitive impairment, drivers with mild cognitive impairment and drivers with dementia. The division was based upon the total cognitive score on the TICS-m. Fischer’s Exact test was used to test for differences between the cognitive groups. Data cleaning was conducted and one driver was removed as an outlier. The statistical analysis was conducted using IBM SPSS Statistics 21©.
Results

Demographics

The initial sample of drivers consisted of 20 females and 30 males with an average age of 73.4 years ($SD = 9.13$ years) and an average of 55.33 years ($SD = 6.91$ years) driving experience. There were a greater number of males than females in the study. Forty of the 50 drivers nominated passengers to participate in a telephone interview. Thirty-three of the passengers were spouses, six were friends and one was an acquaintance. The majority of drivers ($n = 22$) demonstrated no cognitive impairment as indicated by the TICS-m score at or above 27 (Brand et al. 1993). Eighteen participants had mild cognitive impairment as indicated by a score of 23 to 27, and ten participants had dementia (indicated by a score below 23). The cognitive scores ranged from 17 to 34 ($M = 26.27$, $SD = 4.04$).

Table 1 provides a summary of demographic and health variables according to cognitive status. None of the drivers with mild cognitive impairment reported having a crash in the past year. There were two drivers with dementia and two drivers with no cognitive impairment who had reported having a crash in the past year.

Driver Self-Regulation

The cognitive groups did not differ according to whether they had changed their driving in any way in the past year ($\chi^2 (2, 49) = .176$, $p = 1$). Similarly, there was no significant difference between the groups for changes in driving behaviour compared to ten years ago ($\chi^2 (6, 49) = 5.78$, $p = .436$). However, when asked whether drivers have changed their driving behaviour compared to ten years ago, 67% of drivers with dementia reported driving much less compared to 44% of drivers with MCI and 41% of those with no cognitive impairment.
Driver Avoidance.

The analysis of responses from all drivers in the study indicated that drivers sometimes or always avoided driving in peak hour traffic (n = 27, 69.23%), and also avoided driving at night (n = 19, 38.7%) and driving in the rain (n = 14, 35.90%). Very few drivers reported that they avoided making right hand turns across oncoming traffic (n = 6, 20.69%), driving on slippery roads (n = 6, 20.69%), driving interstate (n = 11, 37.93%) and driving on freeways (n = 8, 27.59%).

When analysis across cognitive groups was conducted, the drivers with dementia were found to report avoiding the most driving situations with an average avoidance score of 3.33 (SD = 3.04). The group with no cognitive impairment recorded an average avoidance score of 2.68 (SD = 3.08), and the mild cognitive impaired group average avoidance score was 2.22 (SD = 2.65). Although the group with dementia demonstrated the greatest avoidance, none of the group differences proved to be significant (F (2, 36) = .283, p = .794, $\eta^2 = .012$). Drivers with dementia always or sometimes avoided the following driving situations; peak hour traffic (n = 8, 88%), driving at night (n = 5, 56%) and driving in the rain (n = 5, 31%). Two drivers with dementia sometimes avoided driving at night and one driver always avoided driving at night.

Further analysis of the most frequently avoided driving situations revealed that 88% of drivers with dementia reported always or sometimes avoiding driving in peak hour traffic. This compared to 48% of drivers with MCI, and 45% of drivers with no cognitive impairment. All of the drivers, except for one, who always avoided driving in peak hour traffic, drove less than 100 km in an average week. The majority of drivers, irrespective of cognitive status, did not avoid driving in the rain. However, 31% of the drivers with dementia sometimes avoided driving in the rain compared with 22% of drivers with MCI and 18% of drivers with no cognitive impairment.

Driver Difficulty.
Driver self-reported driving difficulty was obtained for seven driving situations. Drivers across all groups reported often or occasionally having difficulty maintaining the appropriate speed limit (n = 11, 22.45%) followed by becoming confused in familiar surroundings (n = 8, 16.33%). When difficulty ratings were analysed according to cognitive status, no significant differences were found ($F(2, 36) = 1.189, p = .316, \eta^2 = .062$) between the groups (Table 2).

**Passenger Ratings**

The majority of the thirty-nine passengers were female spouses of the driver, and rated their health as good. According to the passenger, the main reason that they were the passenger was that the driver had a preference to drive (n = 9, 23.0%). Other reasons included that the driver drives out of habit (n = 6, 15.4%), while some passengers (n = 5, 17.24%) were not able to drive as they did not have a licence. Approximately 37% (11 passengers) reported that they had concerns about their driver’s driving. The demographic information relating to the passengers is displayed in Table 3.

**The summary of passenger and driver ratings of driver avoidance and driver difficulty is presented in Table 4.** Passenger reports on driver avoidance indicated that drivers with dementia avoided the most driving situations ($M = 3.6, SD = 4.09$), followed by drivers with MCI ($M = 2.08, SD = 2.15$) and drivers with no cognitive impairment ($M = 1.95, SD = 2.69$). However, none of these group differences reached significance ($F(2, 36) = .750, p = .480, \eta^2 = .039$). Driver self-report and passenger reports concerning driver difficulty were found to be higher for drivers with MCI ($M = 1.42, SD = 1.44$), compared to drivers with dementia ($M = .80, SD = 1.30$) and drivers with no cognitive impairment ($M = .36, SD = .66$). Approximately 75% of drivers with MCI reported difficulty with at least one driving
situation, compared to 40% of drivers with dementia and 58.3% of drivers with no cognitive impairment. Analysis of specific problematic driving situations demonstrated that 39% (n = 7) of drivers with MCI reported occasional difficulty with maintaining the speed limit, 22% (n = 4) reported occasionally becoming confused in familiar surroundings, 22% (n = 4) of drivers with MCI reported occasionally failing to see or respond to stop signs and 17% (n = 3) of drivers with MCI reported occasional difficulties with giving way appropriately at intersections.

The passenger ratings of driver difficulty were found to be significant \( F(2, 36) = 4.002, p = .027, \eta^2 = .182 \) across the groups. Seventy-five percent of passengers concurred that drivers with MCI had difficulty with at least one driving situation, compared to 40% of passengers of drivers with dementia and 27% of passengers of drivers with no cognitive impairment. The situations that passengers of drivers with MCI reported as being the most difficult were: maintaining the proper speed limit (n = 6, 33%), and failing to see or respond to a stop sign (n = 4, 22%).

**Passenger and Driver Discrepancy Scores**

Discrepancy scores between driver and passenger ratings were obtained by subtracting passenger ratings from driver ratings. The average discrepancy scores for driver and passengers according to cognitive status are presented in Table 5. A negative value represents drivers rating themselves as having less difficulty with driving situations and better performance compared to passenger ratings. Furthermore, a positive rating indicates drivers rated themselves as avoiding situations more often than stated by passengers and having greater difficulty with driving situations than rated by passengers. On average, drivers rated themselves as having less difficulty with driving situations compared to their passenger ratings. The drivers reporting the greatest discrepancy
between passenger ratings for driving difficulties were the drivers with dementia ($M = 1.75$, $SD = 0.5$). Drivers with dementia also indicated that they avoided fewer situations than their passengers reported (i.e., passengers indicated that drivers with dementia self-regulated their driving more often that the drivers reported). A one-way ANOVA was conducted for between group comparisons and no differences were found for discrepancy scores for driver avoidance ($F(2, 36) = .328$, $p = .722$, $Ƞ^2 = .018$), or for driver difficulty ($F(2, 36) = .036$, $p = .964$, $Ƞ^2 = .002$).

INSERT TABLE 5 HERE

**Self-Reported Estimates of Driving Ability**

The results revealed that passengers typically rated the participant driver as better drivers than others their own age, regardless of driver cognitive status. However, drivers with no cognitive impairment and MCI typically rated themselves as better than drivers their own age (55% and 72% respectively), while the majority of drivers with dementia reported being the same as drivers their own age (56%).

**Discussion**

The principal aim of this study was to examine self-regulatory driving behaviour amongst Victorian drivers according to cognitive status. In addition, the awareness of self-imposed driver avoidant strategies was assessed by investigating the possible discrepancy between driver and passenger responses regarding self-regulation and the extent of difficulty experienced by the driver.

Four main findings were established. Firstly, there was no significant linear association between extent of self-regulation and cognitive status. However, drivers with dementia typically reported avoiding more situations than drivers in the other two participant groups. Second, passenger ratings endorsed the finding that drivers with dementia self-regulate more often than drivers with MCI or no cognitive impairment.
Furthermore, the passengers reported that this occurred to a much greater extent than was reported by the drivers. Third, in relation to driver difficulty, drivers with MCI were more likely to report difficulty with driving situations in comparison to drivers in the other participant groups. Accordingly, passenger rated difficulty of drivers with MCI was higher than passenger rated difficulty for other participant groups. This finding reached significance. Finally, when asked to compare their driving performance with other drivers their age, drivers with dementia typically rated themselves the same as drivers their age, while drivers with MCI and drivers with no cognitive impairment rated themselves as better than other drivers their age. Passengers typically rated the participant drivers as better drivers than other drivers their own age, irrespective of cognitive status. In addition, a significant relationship between age and self-regulation was found whereby older drivers were more likely to self-regulate more often than younger drivers.

**Driver Self-Regulation**

In this sample of forty-nine older drivers, self-regulation appeared to be common with most (71.4%) drivers reporting sometimes or always avoiding one of eight driving situations. The leading cause for restricting their driving was avoiding driving in peak hour traffic \((n = 27, 55.1\%)\), followed by driving at night \((n = 19, 38.8\%)\) and driving in the rain \((n = 14, 35.9\%)\). These findings correspond with findings from previous studies (i.e., Baldock, Mathias, McLean, & Berndt, 2006; Betz & Lowenstein, 2010). Furthermore, the trend for drivers with dementia to report the greatest avoidance in the current study is similar to findings of Ross and colleagues (2009) who demonstrated that drivers who scored poorly on tests of cognition reported greater levels of self-regulation.

One possible contributor to the increase in self-regulatory behaviours for the drivers with dementia could be a reduction in driving exposure. Approximately 90% of drivers with dementia in this study reported driving less than 100 kilometres per week, while 67% reported that their average trip was less than five kilometres. Drivers with
dementia were also less likely to report having ‘excellent’ health than drivers with MCI or no cognitive impairment. There are many reasons why drivers may restrict their driving, of which a decline in cognition is only one. According to the results of a survey study by Donorfio and colleagues (2008), older drivers in better health were less likely to change their driving behaviour compared to drivers in poor health. Therefore, the recognition of a decline in health may influence the degree of driver avoidance in this sample.

All drivers in the study reported they drove much less often compared to ten years ago irrespective of cognitive status. Consistent with other studies (Braitman & Williams, 2011; Donorfio, D'Ambrosio, Coughlin, & Mohyde, 2008), there was a significant association between age and degree of self-regulation. However, it may not be age per se that governs changes in driving behaviour but rather the factors that are associated with the ageing process such as; a decline in health (Donorfio, D'Ambrosio, et al., 2008), a reduced need to drive as much due to lifestyle changes (Braitman & Williams, 2011), or driving related discomfort relating to the seating position or operating the vehicle (Meng & Siren, 2012). Furthermore, there is likely to be great individual variability amongst each of the individuals within each of the three cognitive groups. For example, drivers within the MCI group may have deficits in either spatial orientation, memory or language, all of which could influence the degree of self-regulation.

**Driver Insight**

Drivers with dementia typically rated themselves as the same in terms of competency level as other drivers their own age, while the majority of drivers with no cognitive impairment and drivers with MCI rated themselves as better drivers than drivers their own age. Studies concerning older drivers from the general population have consistently shown that drivers typically overestimate their driving abilities (Freund, Colgrove, Burke, & McLeod, 2005; Marottoli & Richardson, 1998). In addition, it has been suggested that adults with MCI retain insight into their functional abilities (Farias, Mungas,
& Jagust, 2005; Kowalski et al., 2011; Wadley et al., 2007). However, adults with dementia may fail to recognise a decline in their functional abilities or driving performance (Cotrell & Wild, 1999) due to lack of insight, which can accompany cognitive impairment. In this study, drivers with dementia showed a lower discrepancy score than drivers with MCI or no cognitive impairment. That is, drivers with dementia reported less self-regulatory driving behaviours than their passengers reported. These results possibly reflect a decreased awareness of the extent of self-regulation by the drivers with dementia.

Drivers with MCI and no cognitive impairment reported difficulty with more situations than reported by their passengers. Farias et al. (2005) reported similar findings in their investigation of the discrepancy between adult and informant reports of functional abilities of adults with varying levels of cognitive impairment. In their study, adults with no cognitive impairment and adults with MCI were more likely to report greater changes in functional abilities than their informants. It is important to note that this study assessed changes in everyday tasks and did not including driving. Very few driving studies have investigated passenger ratings of problematic driving behaviour or self-regulatory practices in older drivers (Croston, Meuser, Berg-Weger, Grant, & Carr, 2009) and very few have investigated differences in driver/passenger ratings for drivers with MCI (Croston et al., 2009; Ott et al., 2003).

Passenger Ratings

Although it was not the main aim of the study, it is important to acknowledge the trends regarding difficulty ratings for drivers with MCI found in this study. Passenger reports indicated that drivers with MCI demonstrated more driving difficulties than drivers with no cognitive impairment or drivers with dementia. This significant finding suggests that passengers of drivers with MCI are observing more problematic driving behaviours compared to passengers of drivers with no cognitive impairment and passengers of drivers with dementia.
According to passenger reports, 33% of drivers in the group with MCI occasionally had difficulty maintaining the speed limit, and 22% of drivers occasionally failed to see or respond to a stop sign. Other studies have found that failure to monitor traffic and failure to maintain appropriate speed are common behaviours reported by informants of drivers with cognitive impairment (Croston et al., 2009). Moreover, drivers with MCI have been reported to have difficulty with making right hand turns, maintaining the speed limit, and maintaining appropriate lane position as assessed via an on-road driving task (Wadley et al., 2009). Therefore, the results of this study suggest that drivers with MCI demonstrate an awareness of occasional difficulties performing problematic driving behaviours and that these difficulties are being noticed by their passengers.

Limitations

There are limitations when relying on self-report for information relating to self-regulation practices such as difficulties with recall, social desirability bias, and overestimating or underestimating driving behaviour. Despite a number of studies demonstrating inconsistencies between driver ratings of driving performance (Freund et al., 2005; Horswill, Sullivan, Lurie-Beck, & Smith, 2013) few studies have investigated the accuracy of self-report of driver self-regulation practices (Huebner, Porter, & Marshall, 2006; Marshall et al., 2007; Wood, Lacherez, & Anstey, 2012). Furthermore, although the relationship between the passenger and driver in this study was ascertained, it is possible that other unknown factors may influence the accuracy of the passenger reports. For example, frequency of contact with the driver, or social desirability bias may occur if the driver was in close proximity to the passenger at the time of interview. A strength of the current study was the assessment of driver mood, however it is also possible that passenger ratings were influenced by passenger mood. Passenger mood was not assessed in this study and therefore if any of the passengers were depressed this may influence the discrepancy scores (Gilewski, Zelinski, & Schaie, 1990). Other limitations of the study
involved the methodology for sample selection and sample size. The study comprised a convenience sample of older drivers in Victoria, (who resided in both metropolitan and rural areas) and who were aged over 65 years.

**Implications**

This preliminary data on the characteristics of older drivers who self-regulate according to cognitive status by this study has clinical implications for clinicians and driving authorities. The results suggest that both drivers with MCI and their passengers are more likely to notice occasional problematic driving behaviours than drivers with dementia and drivers with no cognitive impairment. Often drivers will choose to engage in self-regulation to compensate for difficulties with driving performance or a noticeable decline in functional abilities. However, drivers and passengers were less likely to report engaging in self-regulation compared to drivers with dementia. Thus, it appears from the results of this study that drivers with MCI are not compensating for their self-reported driving difficulties by engaging in self-regulatory driving practices. In addition, drivers with MCI rated themselves as better than other drivers their age, while drivers with dementia rated themselves as the same as other drivers their age.

It is important to remember that MCI is heterogeneous in nature and therefore, drivers in this group have varying characteristics dependent upon their type of memory deficit. For example, a small proportion of drivers with MCI (22%) in this study reported occasionally becoming confused in familiar surroundings. This behaviour is common amongst drivers with dementia and may therefore be characteristic of drivers with a particular type of cognitive deficit. The identification of drivers with MCI according to their subtypes and associated deficits is clearly warranted to enable a greater understanding of the problematic driving behaviours in this group of drivers, and their subsequent road safety risk.
**Conclusion**

Drivers with dementia in this study reported avoiding more driving situations than drivers with MCI and drivers with no cognitive impairment. The lack of an association between driver and passenger ratings of driver difficulty indicated that drivers in this study had insight into their driving abilities, irrespective of cognitive status. While drivers with MCI reported occasional difficulties with driving situations, they were less likely to engage in self-regulatory practices and more likely to rate themselves as better than drivers their age. It is acknowledged, however, that these findings are preliminary and require further investigation within a larger cohort using established measures of self-regulation and cognition. However, there appears to be a difference between drivers with MCI, and drivers with dementia in regards to how they perceive their driving performance and the extent to which they engage in self-regulation.

**Acknowledgements**

The financial support from the Bartolina Peluso Dementia Rotary Health Scholarship is gratefully appreciated.
Appendix One: Driver Difficulty Questionnaire

Do you quite often, occasionally or never have difficulty.....

1) Maintaining lane position

2) Giving way appropriately at intersections

3) Become confused in familiar surroundings

4) Maintaining the proper speed limit

5) Failing to see or respond to stop signs

6) Making right hand turns

7) Choosing between the brake and the accelerator
Table 1

Summary Characteristics of Drivers According to Cognitive Status

<table>
<thead>
<tr>
<th>Cognitive Status</th>
<th>No Cognitive Impairment (n = 22)</th>
<th>Probable Cognitive Impairment or MCI (n = 18)</th>
<th>Dementia (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (Male, Female) (n, %)</td>
<td>10, 12 (45,55)</td>
<td>12, 6 (67, 33)</td>
<td>7, 2 (78, 22)</td>
</tr>
<tr>
<td>Age (Years) (M, SD)</td>
<td>75.05 (7.24)</td>
<td>76 (7.36)</td>
<td>75.56 (4.8)</td>
</tr>
<tr>
<td>65-74 years (n, %)</td>
<td>12 (52)</td>
<td>8 (35)</td>
<td>3 (13)</td>
</tr>
<tr>
<td>75-84 years (n, %)</td>
<td>7 (37)</td>
<td>6 (32)</td>
<td>6 (22)</td>
</tr>
<tr>
<td>85+ years (n, %)</td>
<td>3 (43)</td>
<td>4 (57)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Education (Years) (M, SD)</td>
<td>12.22 (2.55)</td>
<td>13.3 (2.45)</td>
<td>13.4 (2.5)</td>
</tr>
<tr>
<td>Driving experience (M, SD)</td>
<td>56.1 (7.8)</td>
<td>57.8 (10.1)</td>
<td>62 (1.4)</td>
</tr>
<tr>
<td>TICS-m score (M, SD)</td>
<td>29.90 (2.07)</td>
<td>24.77 (1.06)</td>
<td>20.33 (1.73)</td>
</tr>
<tr>
<td>How many km do you drive per week? (n, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 100</td>
<td>12 (55)</td>
<td>9 (50)</td>
<td>8 (89)</td>
</tr>
<tr>
<td>100-200</td>
<td>6 (27)</td>
<td>5 (28)</td>
<td>1 (11)</td>
</tr>
<tr>
<td>201-500</td>
<td>4 (18)</td>
<td>4 (22)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>&gt; 1 infringement in past 2 years (n, %)</td>
<td>4 (18)</td>
<td>4 (22)</td>
<td>3 (30)</td>
</tr>
<tr>
<td>Have you had a crash? (n, %)</td>
<td>2 (9)</td>
<td>0 (0)</td>
<td>2 (22)</td>
</tr>
<tr>
<td>Overall Health (n, %)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>9 (41)</td>
<td>7 (39)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Good</td>
<td>12 (55)</td>
<td>11 (61)</td>
<td>7 (78)</td>
</tr>
<tr>
<td>Fair</td>
<td>1 (5)</td>
<td>0 (0)</td>
<td>2 (22)</td>
</tr>
</tbody>
</table>
Table 2

Proportion of Drivers who reported Quite Often or Occasionally Having Difficulty with Driving Situations by Cognitive Status

<table>
<thead>
<tr>
<th>Cognitive Status</th>
<th>No Cognitive Impairment (n = 22)</th>
<th>Mild Cognitive Impairment (n = 18)</th>
<th>Dementia (n = 9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintaining the speed limit</td>
<td>3 (14%)</td>
<td>7 (39%)</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Maintaining lane position</td>
<td>4 (18%)</td>
<td>2 (11%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Failing to see or respond to a stop sign</td>
<td>2 (9%)</td>
<td>4 (22%)</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Becoming confused in familiar surroundings</td>
<td>3 (14%)</td>
<td>4 (22%)</td>
<td>1 (11%)</td>
</tr>
<tr>
<td>Choosing between the brake and the accelerator</td>
<td>0 (0%)</td>
<td>1 (6%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Completing a right hand turn</td>
<td>1 (5%)</td>
<td>2 (11%)</td>
<td>2 (22%)</td>
</tr>
<tr>
<td>Giving way appropriately at intersections</td>
<td>2 (9%)</td>
<td>3 (17%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
Table 3

**Characteristics of Passengers in the Study**

**Demographic Measures**

<table>
<thead>
<tr>
<th>Measure</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (Male, Female)</td>
<td>7</td>
<td>17.5</td>
</tr>
<tr>
<td>Age (Years) ($M, SD$)</td>
<td>73.4</td>
<td>9.13</td>
</tr>
<tr>
<td>Do you currently drive (Yes/No)</td>
<td>32</td>
<td>80</td>
</tr>
<tr>
<td>When travelling with your driver do they usually drive (yes/no)</td>
<td>38</td>
<td>95</td>
</tr>
<tr>
<td>Memory problems greater than someone your own age (n, %)</td>
<td>3</td>
<td>7.50</td>
</tr>
<tr>
<td>Do you have any concerns about their driving (Y, N) (n, %)</td>
<td>11</td>
<td>37.93</td>
</tr>
<tr>
<td>How would you rate your overall health (n, %)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Excellent</em></td>
<td>6</td>
<td>15%</td>
</tr>
<tr>
<td><em>Good</em></td>
<td>24</td>
<td>60%</td>
</tr>
<tr>
<td><em>Fair</em></td>
<td>9</td>
<td>23%</td>
</tr>
<tr>
<td><em>Poor</em></td>
<td>1</td>
<td>3%</td>
</tr>
</tbody>
</table>
Table 4

Summary of Driver and Passenger Reports of Driver Difficulty and Avoidance by Cognitive Status

<table>
<thead>
<tr>
<th>Measure</th>
<th>Cognitive Status</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No (n = 22)</td>
<td>MCI (n = 12)</td>
<td>Dementia (n = 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Impairment Impairment</td>
<td>No (n = 22)</td>
<td>MCI (n = 12)</td>
<td>Dementia (n = 5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver total avoidance score</td>
<td>2.18 .59</td>
<td>2.22 .81</td>
<td>3.33 .20</td>
<td>.23 .79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger ratings of driver avoidance</td>
<td>1.95 2.69</td>
<td>2.08 2.15</td>
<td>3.6 4.09</td>
<td>.75 .48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver total difficulty score</td>
<td>0.91 1.60</td>
<td>1.28 1.84</td>
<td>0.56 1.01</td>
<td>1.18 .31</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Passenger ratings of driver difficulty</td>
<td>0.36 0.65</td>
<td>1.42 1.44</td>
<td>0.8 1.30</td>
<td>4.00 .02</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 5

**Summary of Discrepancy Scores for Driver Avoidance and Driver Difficulty**

<table>
<thead>
<tr>
<th>Discrepancy</th>
<th>No Cog. Imp. (M1*, range)</th>
<th>MCI (M2, range)</th>
<th>Dementia (M3, Range)</th>
<th>(SD)</th>
<th>(SD)</th>
<th>(SD)</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Avoidance</td>
<td>-4 to 6</td>
<td>-4 to 4</td>
<td>-4 to 3</td>
<td>.23</td>
<td>.16</td>
<td>-0.6</td>
<td>32</td>
<td>.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(1.95)</td>
<td>(2.12)</td>
<td>(2.6)</td>
<td>8</td>
<td>22</td>
</tr>
<tr>
<td>Total Difficulty</td>
<td>1 to 2</td>
<td>1 to 2</td>
<td>1 to 2</td>
<td>1.47</td>
<td>1.7</td>
<td>1.75</td>
<td>.03</td>
<td>.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(.51)</td>
<td>(.48)</td>
<td>(.5)</td>
<td>6</td>
<td>64</td>
</tr>
</tbody>
</table>

*M1 = drivers with no cognitive impairment, M2 = drivers with MCI, M3 = drivers with dementia*


Horswill, M., Sullivan, K., Lurie-Beck, J., & Smith, S. (2013). How realistic are older drivers’ ratings of their driving ability? *Accident Analysis & Prevention, 50*(0), 130-137. doi: http://dx.doi.org/10.1016/j.aap.2012.04.001


Chapter 8: Prerequisites for Driving Cessation: Self-Reported and Passenger Reported Factors

Introduction

This chapter relates to a secondary component of the study reported in Chapter 7. While the focus of the previous chapter was on the self-regulatory driving behaviours of drivers with and without cognitive impairment, this chapter expands on these findings through a qualitative investigation of the factors that influence driving cessation. Data for this chapter was obtained from the study reported in Chapter 7. Firstly, by way of introduction, the implications of retiring from driving are discussed with respect to the driver and their family members and passengers. The methodology and data analysis methods are then provided, followed by the findings and a discussion of their implications.

Driving Cessation

Driving is an instrumental everyday activity that, for many individuals, is essential to remaining involved in social activities and is an integral component of self-esteem and well-being (Edwards et al., 2009). For many, the loss of a licence can be likened to a loss of identity, particularly for older males who may lack the ability to continue to independently participate in daily activities. The lack of alternative transport options can also place greater demands on the individual’s family and friends who may be required to chauffeur them around (Taylor & Tripodes, 2001). As retiring from driving has been associated with loss of independence, decline in physical health and an increased risk for depression (Edwards et al., 2009), it is important to keep older drivers driving safely for as long as possible. A greater understanding of the perceptions and attitudes of older drivers with and without cognitive impairment is needed to assist with fears or concerns
about retiring from driving, which in turn, may facilitate a smooth process towards driving cessation.

Family members are in a unique position to be able to provide information to health professionals about patients’ driving and are often key players in the decision making process surrounding driving cessation. In the majority of cases, drivers with cognitive impairment report that the physician’s advice was one of the main influences of their decision to stop driving (Croston, Meuser, Berg-Weger, Grant, & Carr, 2009) however many older drivers with cognitive impairment report that advice from family and friends was a contributing factor (O'Neill & Dobbs, 2004). The discussion of retirement from driving by family members is often a difficult task because members can lack knowledge about how to approach the topic, or may fear a negative response from the driver (Perkinson et al. 2005). Furthermore, this task can be particularly challenging when the driver lacks insight or denies any problems related to driving. It is for these reasons, among others, that very few families plan ahead for driving cessation (Adler et al. 2000). It is most pertinent for family and friends to assist in the transition towards successful driving cessation by being equipped with useful strategies to approach the topic and plan ahead. In addition, government and policy makers need to be aware of the broader implications of driving cessation and how it impacts on the individual, their families and the wider community. This study aimed to provide an overview of the potential factors that promote drivers to cease driving from both the driver and passenger perspectives.

**Method**

**Participants**

This cross-sectional study consisted of 80 community dwelling older adults. In total, there were 40 drivers (n = 24 male, n = 16 female) and 40 passengers (n = 7
male, n = 33 female). The passenger interviews provided an alternative voice with which to understand factors that influence behaviour change for older adults. Participants were recruited from bowling clubs, independent living units, and older adult organisations from the metropolitan and rural areas of Victoria. Note that Victoria, unlike other states in Australia, does not have any age-based requirements for testing. The inclusion criteria included; a current driver’s licence, driving more than once a week, having English as a first language, and being able to provide informed consent. Drivers with depression or any physical, ophthalmological, or a neurological disorder that may impair their driving ability were excluded via a screening questionnaire. Passengers were eligible to participate if they were familiar with the drivers driving and drove with them at least once a week. It is important to note that this study was derived from a larger study investigating self-regulation practices of older drivers which is described in Chapter Seven.

**Materials**

The data for this study were collected via telephone interviews. The interviews took approximately 20 minutes for the driver and seven minutes for the passenger to complete. Both interviews were administered by the researcher and scheduled at a time convenient for the participants.

**Driver and Passenger Interviews**

The driver and passenger interviews were a combination of structured and semi-structured questions designed to explore emergent themes relating to each participants’ perceptions of driving behaviour, and in particular the factors related to driving cessation.

**Cognitive and Mood Status**
During the telephone interview with the driver the Geriatric Depression Scale (Sheik & Yesagage, 1986) was administered as a brief screening tool for depression. Those drivers who scored greater than 5 points were classified as suffering from depressive symptoms and were excluded from the study. Drivers were screened for depression as there is evidence to suggest that people suffering from depression typically underestimate their abilities and therefore it can be difficult to obtain an accurate measure of driving ability, and insight (Gilewski, Zelinski, & Schaie, 1990).

In order to screen for cognitive impairment the driver was administered the Telephone Interview of Cognition – TICS-m (Brandt et al. 1993). The modified Telephone Interview for Cognitive Status is a 13 item telephone interview assessing orientation; registration, recent memory and delayed recall (memory); attention/calculation, semantic memory, comprehension and repetition (language) (Brandt et al. 1993). A score below 23 indicates cognitive impairment, a score below 27 indicates mild cognitive impairment or probable cognitive impairment, while a score at or above 27 represents no cognitive impairment (Beeri, Werner, Davidson, Schmidler, & Silverman, 2003; De Jager et al. 2003). As reported in Breitner et al. raw scores were adjusted for educational achievement according to the following criteria; 5 points added for < 8 years of education, 2 points added for ≥ 8-10 years of education, no adjustment of score for 11-12 years of education, and 2 points subtracted for > 13 years of education.

Passenger Survey

Passengers were asked about their role as a passenger including why and how often they are the passenger, and were asked to report any concerns they had about the driver’s driving. Passengers were also asked to comment on how they would know when it was time for the driver to cease driving.
**Procedures**

After participants were provided with detailed information about the study purpose and requirements participants were invited to provide written informed consent to participate. The researcher explicitly stated that the results of the study were for research purposes only and would not impact on their licence status. The Deakin University Human Ethics Committee granted ethics approval for this study.

**Approach and Analysis**

A phenomenological research procedure outlined by Colaizzi (1978) was employed for this study. Firstly, meanings were identified from sections of the text that related to indicators of future driving cessation. Transcripts from each driver and matched passengers were analysed together so as to gain an enriched understanding of each driver. Interviewer notes (from throughout the research process) also informed the process of meaning identification. These meanings were then organised into clusters of themes and subthemes for drivers, and for passengers, and to ensure the truthfulness of these findings, the transcripts were re-interrogated and another researcher was employed to check that the themes identified accurately reflected the data. A reliability of 87% was achieved for the two ratings of themes meaning the two researchers classified 87% of the responses in the same way. The themes, subthemes are definitions are provided in Table. 3. The responses were de-identified in order to protect the privacy of the participants in the study.

**Results**

The sample consisted of 40 drivers and 40 nominated passengers. The drivers were divided into two groups consisting of drivers with cognitive impairment (i.e., a TICS-m score of < 27) and drivers without cognitive impairment (i.e., a TICS-m
score of $\geq 27$). The characteristics of the drivers according to cognitive status as defined by the TICS-m are presented in Table 1.
Table 1

**Driver Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Cognitive Impairment (TICS-m score &lt; 27)</th>
<th>No Cognitive Impairment (TICS-m score ≥ 27)</th>
<th>Total Sample N = 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender (Male, Female)</td>
<td>15, 7</td>
<td>9, 9</td>
<td>24, 16</td>
</tr>
<tr>
<td>Mean Age (Years) (SD)</td>
<td>76.32 (6.23)</td>
<td>74.56 (6.52)</td>
<td>75.53 (6.35)</td>
</tr>
<tr>
<td>Mean Driving experience (Years) (SD)</td>
<td>57.23 (7.4)</td>
<td>54.94 (6.3)</td>
<td>56.20 (6.95)</td>
</tr>
<tr>
<td>Locality (Rural/Metropolitan)</td>
<td>(3, 19)</td>
<td>(3, 15)</td>
<td>(6, 3)</td>
</tr>
<tr>
<td>Mean TICS-m score (SD)</td>
<td>22.90 (3.6)</td>
<td>29.90 (2.08)</td>
<td>26.08 (4.58)</td>
</tr>
</tbody>
</table>

The characteristics of the passengers are presented in Table 2. The majority of passengers, 33 (82.5%), were spouses of the driver, and 6 (15%) were friends, one passenger was an acquaintance.

Table 2

**Passenger Characteristics**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (Male, Female) (n)</td>
<td>7, 33</td>
</tr>
<tr>
<td>Mean Age (Years) (SD)</td>
<td>73.40, 9.13</td>
</tr>
<tr>
<td>Do you drive? (Yes) (n)</td>
<td>(32, 8)</td>
</tr>
</tbody>
</table>

Four main themes emerged from thematic analysis of the data. A number of sub-themes contributed to the overall theme and are summarised in Table 3.
Table 3

*Key Themes and Subthemes, Definitions and Exemplars Derived from the Telephone Interview Data*

<table>
<thead>
<tr>
<th>Key Themes</th>
<th>Sub-themes</th>
<th>Definition</th>
<th>Exemplars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decline in Health or Functional Ability</td>
<td>Health Condition</td>
<td>Mention of a reduction in health or concerns about a decline in functional abilities such as reaction time, attention, perception.</td>
<td>“If I have a medical condition”</td>
</tr>
<tr>
<td></td>
<td>Cognitive and Visual Functioning</td>
<td></td>
<td>“When I do not react as quickly”</td>
</tr>
<tr>
<td>Assessment of Road Safety Risk</td>
<td>Problems performing driving situations</td>
<td>Mention of difficulties with problematic driving situations or statements about road safety risk.</td>
<td>“If I put others at risk”.</td>
</tr>
<tr>
<td></td>
<td>Crash Involvement</td>
<td></td>
<td>“I’ll know once I’ve had a crash”.</td>
</tr>
<tr>
<td></td>
<td>Awareness of putting other passengers and drivers at risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-Efficacy Beliefs</td>
<td>Decreased confidence</td>
<td>Mention of beliefs or feelings about driving competence.</td>
<td>“If I feel scared, stressed, overwhelmed”.</td>
</tr>
<tr>
<td></td>
<td>Decreased comfort/enjoyment</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Instinct about driving ability</td>
<td></td>
<td>“I will just know when to stop driving”.</td>
</tr>
<tr>
<td>External Attribution/Reliance on Others</td>
<td>Health professional advice</td>
<td>Mention of external factors. Limited responsibility indicated by the driver.</td>
<td>“Hopefully my family notice and tell me”</td>
</tr>
<tr>
<td></td>
<td>Advice from family</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Performance on driving tests or assessments</td>
<td></td>
<td>“I hope I will be told by a health professional”</td>
</tr>
</tbody>
</table>

**Decline in health or functional abilities.**

This theme reflects how drivers viewed a decline in their health as a key motivator for driving cessation. Typically, the prevalence of health conditions
increases with age and therefore drivers in this study appeared to be aware of the fact that a decline in health can have a negative impact on fitness to drive. Participants were not very specific about which health conditions may constitute a change in driving behaviour. Some quotes that illustrate this theme are as follows:

“If I have a health condition” or “Who knows, maybe my health.”

Another subtheme that was more specific related to particular cognitive and physical functions that are pertinent to the driving task. For example, the most frequently cited function was related to vision, followed by a decline in reaction times. For example:

“When I am not able to see or if my reactions don’t work fast enough”.

While a number of people listed problems with vision as a factor, very few people mentioned difficulties with cognitive functioning. One person mentioned that memory may be an issue stating:

“If I..........or forget where I’m going.”

Furthermore, lack of attention was only mentioned by one driver:

“If I’m not paying attention”

Participants failed to describe how they would know when delayed reaction time would become problematic and did not describe the extent to which visual problems would influence their driving behaviour.

Assessment of road safety risk.

Assessment of risk included; awareness of driver performance, crash involvement or having a near miss, awareness of placing others at risk and receiving
a traffic infringement. Awareness of driver performance was viewed as having difficulties with certain driving tasks overall:

“When I find different situations threatening or more challenging than usual”

“It is a long way off. It will be when I lose my ability to drive safely”

There is evidence-based research to show that older drivers are over-represented in intersection crashes (Travis et al. 2012) and have more difficulty with specific driving situations compared to younger drivers. Older drivers in the study reported the following driving scenarios:

“……………..or if I have difficulty reversing”

“Maybe when I have difficulty at intersections”

“If I confuse the pedals then I would consider giving up”

“If I make stupid mistakes, if I wander into other lanes, if I drive too slowly”

Approximately one quarter of drivers mentioned that having a crash or a near miss as a factor that would indicate that they would cease driving. The quotes that represent this subtheme are reported as follows:

“If I have a crash or a near miss. It's a difficult question to answer”

“Hopefully I stop before I have an accident”

“After I've had a crash”

“If I have a near miss…….”

”The first time I have a crash I will know”

“Maybe if I have a serious accident”
Older drivers acknowledged that others may be at risk on the road and indicated that this would be a factor relating to driving cessation for them.

“If I thought I was going to danger other people”

“It's in my mind all the time. I don't want to put anyone at risk or myself at risk”

“If I put others at risk”

There was strong view that if the driver had a crash they would cease driving as this would be a sign of their road safety risk. Drivers mentioned a range of driving situations they may find problematic in the future, however there was great variation among the situations listed.

**Self-efficacy beliefs.**

The third overarching theme represents driver self-efficacy beliefs about their ability to drive safely. As a driver noted; “*When the feeling of competence and when confidence decreases.*” For another it was feeling “*scared*”. The comfort and pleasure factors also received a mention with drivers stating: “*when I am unhappy on the road*, “*when I can’t cope*” or “*when I’ve had enough then I’ll hand my licence over to police*”. Some drivers stated that they “*had no idea,*” while others stated that “*I will just know when it is time to stop.*”

**External attribution and reliance on others.**

Drivers were aware that other people would notice changes in their driving behaviour and a proportion indicated that they would cease driving when: “*told by a health professional, policeman or friend*”. Others stated that they would rely on family members such as “*my kids [will] tell me to stop*”, or “*My GP will tell me or my wife*”. One person reported that they would “*rely on others to tell me.*”
Discrepancy between driver and passenger responses.

Drivers and passengers differed with respect to their responses about declining physical and cognitive functions. While drivers typically cited visual problems as a potential contributory factor, passengers were more inclined to report cognitive deficits as demonstrated by the following quotes:

“He becomes more confused”, “If he becomes more vague while driving”, “If he misses a turn”, “If he has concentration difficulties”, “If his judgment becomes impaired”.

With respect to road safety risk, very few passengers identified a crash as a potential indicator of time to cease driving for the driver. Passengers were more likely to comment on how difficult it will be to approach the topic and acknowledged that it is difficult to know what factors may be involved. This was represented by the following quotes:

“It will be hard we don't have much choice and he is a better driver than me”

“It would be devastating for him. It's a pride thing...you know men and their cars”

“If something happens to him I will drive. I can't think beyond that”

“I don't know. We don't really have any choice as we need to get around. I do worry about his driving and just have to hope it will be ok”

“I don't know as I haven't thought about it”

Perspectives of drivers with cognitive impairment compared to those without.
The responses of drivers with cognitive impairment (as indicated by a TICS-m score of < 27) were compared to the responses of those without cognitive impairment (represented by a TICS-m score of 27 and above). Both groups reported similar themes, with the exception of the theme of External Attribution. Drivers with cognitive impairment were more likely than drivers without cognitive impairment to report that they would rely on other people to know when they should cease driving.

Discussion

In this study the perspectives of 40 older drivers and their nominated passengers were explored to better understand their perspectives on the factors that would influence their driving cessation. The following four overarching themes emerged from the participant responses: Decline in health or functional ability, Assessment of road safety risk, Self-efficacy beliefs; and External attribution/reliance on others. Within the theme ‘Decline in health or functional ability’ drivers indicated a clear understanding that poor health or worsening functional capabilities can have a negative impact on driving competence. This relationship was illustrated through their acknowledgement that a decline in vision, reaction time or overall health could lead to their driving cessation. The impact of declining vision on driving cessation concurs with the findings from an interview study of 1840 older drivers from California by Satariano, MacLeod, Cohn, & Ragland (2004). Of the 861 drivers who reported avoiding specific driving situations, the majority identified visual problems as the main reason for limiting their driving. Specific difficulties included problems with focusing, problems with depth, glare, peripheral vision and night time vision. Although drivers reported visual problems as a potential reason for driving cessation in our study, there was no specific mention of the type of visual or health conditions that would lead to driving cessation. In
contrast to the drivers, the symptoms most commonly cited by passengers as reasons for the cessation of driving by the driver were related to driver confusion and drivers becoming vague or lost while driving. These problems are characteristic of drivers with cognitive impairment (Austroads, 2012).

Consistent with findings from previous studies (Croston et al. 2009; Perkinson et al. 2005), approximately one quarter of drivers in this study stated that having a crash would cause them to cease driving. This may suggest that they intend to continue driving until they crash and is a cause for concern for the safety of the driver and the community and highlights an area for intervention. Increasing knowledge of fitness to drive and educating drivers about being aware of their driving competence could also assist drivers to modify or cease their driving before they have a crash.

The driver responses for the ‘External attribution/reliance on others’ theme differed between drivers with and without cognitive impairment. Specifically, they were more likely to be adopted by drivers with cognitive impairment. This theme can be likened to the individual’s sense of control over the situation. For example, those drivers who believe they can personally control the situation demonstrate an internal locus of control, while those drivers who believe the outcome is determined by external factors demonstrate an external locus of control (Williams & Koocher, 1998). Often beliefs are determined by the individual’s self-efficacy (i.e., whether the individual believes they have the resources and ability to change the situation) (Azjen, 2006). It is difficult to ascertain why the drivers with cognitive impairment in this study were more likely to perceive the process of retiring from driving as out of their control. These drivers were potentially facing other losses or were facing other
situations that were out of their control, such as losing the ability to keep track of finances or losing their independence. It is of interest to note that some people stated that ‘they will just know’ which indicates that they predict that they will feel confident about deciding when to retire from driving. While it is possible that some drivers will know when it is time to cease driving, drivers with cognitive impairment may be less likely to adequately monitor their skills due to a lack of insight which can accompany cognitive decline (Man-Son-Hing, et al. 2007).

For many people retirement from driving is a significant loss and it can thus often be a difficult topic to discuss with the individual concerned. All passengers in this study acknowledged that it would be very difficult for the driver if they were to retire from driving. However, it was of interest that none of the drivers specifically mentioned any difficulties. The main reasons provided by the passengers were related to the driver’s loss of identity and pride as well as limited alternative transport options. These findings correspond with the findings of a study by Adler et al. (2000) whereby caregivers of drivers with dementia were concerned about them continuing to drive, although caregivers reported that they were unsure what signs to look for to accurately assess the risk. The majority of drivers in the current study resided in metropolitan areas. Therefore, it could be argued that they were more likely to be able to access alternate transport options compared to drivers in rural areas (Corcoran, James, & Ellis, 2005), and may therefore look upon the situation more favorably than drivers without alternative transport options. The finding that not all passengers and drivers were aware of any potential factors that would influence driving cessation is concerning. Passengers may not be aware of what signs to look out for when assessing fitness to drive or they may be reluctant to raise the issue. For example a number of participants stated “that’s a long way off”, or “we
don’t need to think about that now.” Other research (Adler & Rottunda, 2006) has also found a preference for passengers to avoid the topic and not to approach the driver who is resistant to driving cessation.

Self-efficacy and driver discomfort have been identified as key determinants of driver self-regulation (Ballock et al., 2006; Meng & Siren, 2012). In this current study, reports about the feelings of drivers were mixed. Some drivers stated that they anticipate becoming confused or scared, while others predicted that they would have the confidence to “just know” when to cease driving. In a previous comprehensive study of the factors contributing to older driver self-regulation Ackermann and colleagues (2010) found that driver self-efficacy reported at baseline predicted driver self-regulatory practices three years later. The researchers suggested that driver self-efficacy was a greater determinant of changes in driving behaviour than actual decline in functional abilities such as vision, cognition or physical functioning. Therefore, self-efficacy beliefs may be important factors to consider when designing interventions to assist drivers with the transition towards driving cessation.

Summary

Although the results of this study cannot be generalised to older drivers in the broader community due to the small sample size, a useful insight into the factors that may influence driver behaviour change is nonetheless provided. A change in health or functional ability was frequently identified by both drivers and their passengers; however, the extent to which these deficits would influence driver behavior was not mentioned. Currently, there are no reliable methods to assess fitness to drive, particularly for drivers with cognitive impairment. It is therefore likely that the statements provided in this study mimic this uncertainty. Furthermore, of greater concern is that drivers appeared to measure driving risk by whether or not they have
been involved in a crash. Although this is an objective measure of safety risk, the consequences can be irreversible, costly and life-changing. Therefore, there is a need to provide education and awareness about alternative indicators of road safety risk that may encourage drivers to change their behaviour at the appropriate time.
Chapter 9: General Discussion

Introduction

Physicians and licensing authorities have an ethical obligation to identify drivers with physical or mental impairments that may adversely affect their driving. However, identifying such individuals and evaluating how the impairment may impact on their driving presents a considerable challenge. Drivers with dementia such as Alzheimer’s disease are acknowledged as a significant safety concern on the basis that on-road driving studies have consistently found problematic driving behaviours in this population (Ott et al., 2008; Rizzo et al., 2005; Uc, Rizzo, Anderson, Shi, & Dawson, 2004). However, there is inconclusive evidence as to whether drivers with mild cognitive impairment remain safe to drive (Carr et al., 2000; Dubinsky et al., 2000; Hunt et al., 1993; Wadley et al., 2009), or alternatively, whether these individuals engage in driving behaviours that may place them at risk (Snellgrove, 2005; Whelihan et al., 2005). Concurrent with the increasing number of older drivers, is the increase in older drivers with cognitive impairment. A greater understanding of the driving behaviour of drivers across the spectrum of cognitive impairment is required in order to assist with identification, assessment, education and the development of interventions to keep older drivers driving safer for longer.

As the literature concerning driver performance and self-monitoring of older drivers with mild cognitive impairment is still in its infancy, there is a need for ongoing research. In particular there is a need to determine; the extent of the problem for drivers with MCI, the nature of any deficits in driving performance; whether drivers with MCI engage in self-regulatory behaviours; and finally, whether drivers with MCI have insight into their driving behaviour.
The goal of this thesis was to address these questions specific to this increasing subsection of older drivers. The aim of the first study was to explore the brake patterns of older drivers with mild cognitive impairment on approach to intersections via the use of a portable driving simulator. This performance of this group was then compared with older drivers without cognitive impairment. The objective of the second study was to investigate the relationship between cognitive status and the ability to engage in self-regulatory driving practices (i.e., driver avoidance), and to determine the extent to which drivers who self-regulate their driving behaviour demonstrate insight into a decline in their driving skills.

This chapter provides a summary of the main findings from the two studies and relates these findings back to the theoretical models of driving behaviour presented in the introduction. The strengths and methodological limitations of the studies are presented and the chapter extends the discussion of the overall findings provided in the papers presented in Chapters 5 and 7. The chapter concludes with a section on the theoretical implications and clinical implications for licensing authorities, health professionals and older drivers and directions for future research.

**Summary of Key Findings**

**Key findings from Study 1.**

This cross-sectional experimental study consisted of 14 drivers with mild cognitive impairment and 14 matched control drivers with no cognitive impairment. Participants completed a simulator drive and a battery of visual and cognitive tasks. The hypothesis that compared to healthy older adult drivers, drivers with mild cognitive impairment would display a greater number of right foot hesitations (between the accelerator and the brake) and would engage in higher risk brake response patterns was partially supported. Preliminary evidence was found to suggest
that drivers with MCI were significantly less likely to stop at stop-sign controlled intersections, and also less likely to stop at critical light change intersections, although this finding did not reach statistical significance. It is important to be cautious when interpreting these findings as although the findings on individual measures were non-significant, when taken together there was a trend for drivers with MCI to perform worse on the measures compared to their healthy counterparts. The findings are discussed with respect to the Driving as an Everyday Competence Model.

**Key findings from Study 2.**

The findings from the telephone interviews of drivers and their passengers provided some insight into older driver self-regulatory driving practices and cognitive status. There was a trend for drivers with dementia to report more self-regulatory avoidant behaviours than drivers with MCI or drivers with no cognitive impairment. Although this finding did not reach significance, reports from passengers also indicated that drivers with dementia were more likely to self-regulate their driving behaviours than drivers with MCI and drivers without cognitive impairment. The finding that older drivers with dementia engage in self-regulatory driving practices is consistent with the findings of the systematic literature review presented in Chapter 7. The extent to which self-regulatory practices are influenced by cognitive status and the extent to which other factors contribute is therefore yet to be fully explored.

The ratings of driver difficulty with situations known to be challenging for drivers with dementia also provided some interesting findings. Drivers with MCI and their passengers reported more difficulty with driving situations compared to drivers with dementia and no cognitive impairment. More specifically, drivers with MCI
reported occasional difficulty maintaining the speed limit, and becoming confused in familiar surroundings. Ratings from passengers concurred that drivers with MCI demonstrated difficulty maintaining the speed limit, and also reported that they noticed the drivers occasionally failed to see or respond to stop signs. These problematic driving behaviours can lead to driver error and could place the driver and their passengers at risk. The drivers in the study demonstrated insight into these problematic behaviours, however the next step is to investigate whether they perceive the behaviours as a road safety risk. From the results of Study 2 it does not appear that drivers with MCI are engaging in self-regulation to compensate for these driving difficulties.

**Discussion of Findings with Respect to Theoretical Models of Driver Behaviour**

**Differences between drivers with MCI and age-matched healthy adult drivers.**

The findings from the simulator study (Study 1) suggest that drivers with MCI may find stopping at stop-sign controlled intersections more challenging than drivers without cognitive impairment. The Information processing model of driver behaviour presented in Chapter 2 provides a useful basis for discussion of these results.

Research has indicated that older drivers who have problems at intersections may have difficulties with divided attention (Belleville, Chertkow, & Gauthier, 2007; Okonkwo et al., 2008). The first step in the information processing model of driver behaviour specifies that a driver perceives and attends to the presenting situation. Drivers with MCI may be less likely to attend to the traffic lights, or alternatively they may be less likely to anticipate any change in the environment. It is also
possible that drivers with MCI have difficulties with planning and selecting the appropriate maneuver resulting in a delay in their driving response. This corresponds with the second step in the information processing model whereby drivers plan and select appropriate actions before executing a response.

Visual capabilities are an essential part of driving and co-morbid visual problems cannot be discounted when assessing older drivers with cognitive impairment. A recent study provided evidence to suggest that older drivers are less likely to scan for potential hazards at intersections compared to younger drivers (Romoser et al., 2013). Although it is yet to be determined why this may be the case, the authors have proposed that it is due to habit, whereby drivers regularly succeed in driving through an intersection without crashing using their existing visual search strategy which becomes reduced over time. Other researchers investigating visual search patterns of adults with MCI compared to those without found that a proportion of adults with MCI demonstrated poorer visual search capabilities than matched healthy controls (Tales et al., 2010). These findings remained consistent when participants with MCI were followed up 2.5 years later. The participants in this study all had MCI of the amnestic type and the researchers warned that there was great variability in visual search patterns amongst the MCI group compared to the control group. The researchers did not assess the relationship between visual search performance and aspects of cognitive functioning in this study. Therefore, it is important not to discount the contribution of visual problems when investigating the extent to which cognitive impairment influences driving performance.

**Self-regulation and self-monitoring.**

It is difficult to change a behaviour that has developed over time and has become ingrained and automatic. For example, pre-attentive processes, visual
perception, and visual tracking are components of driving that are automatic and correspond with the operational level of driving behaviour in Michon’s model of driving. It can therefore be argued that behaviours at the strategic level such as driver planning, and driver avoidance are behaviours that the driver can monitor and change. The outcome measures from the simulator study relate to behaviours at the operational level, while the self-regulation study assesses behaviours at the strategic level. The Driving as an Everyday Competence Model (DEC) is a useful framework to use to illustrate the different levels of driving behaviour and their contextual factors. Furthermore, the findings of study one and study two can be integrated through referring this model.

**Driving as an Everyday Competence Model.**

When the findings of studies one and two are presented with respect to the model, it appears to be seen that driver cognition impacts on driver competence, driver performance and driver self-regulation. However, according to the model, if a driver engages in self-regulatory practices this can indirectly impact their driving performance. The results of study one suggest that drivers with MCI may have problematic driving behaviours at intersections and it can be argued that this finding is reinforced by the driver and passenger reports of difficulty obtained in study two. The lack of a significant relationship in study two between driver cognitive status and self-regulatory driving practices suggests that other factors are contributing to self-regulation. For example, as shown in Figure 3 below, personal factors may include sensory deficits, driver experience, as well as driver emotions and attitudes in addition to driver cognition.
Figure 3. Key components of the Driving as an Everyday Competence Model (adapted from the DEC model, Lindstrom-Forneri et al. 2010)

The factors identified by drivers in Chapter 8 concerning driving cessation may also contribute to self-regulation. The factors that were identified in Chapter 8 that are not specifically included in the DEC model relate to; driver knowledge and assessment of road safety risk, and external attribution/reliance on others. Therefore, these contributing factors are suggested areas for future research within the older driver population.

Summary: The Impact of MCI on Driver Performance and Driver Competence

Acknowledging the limitations of cross-sectional studies, the results suggest that drivers with MCI may demonstrate problematic driving behaviours, particularly at intersections. Furthermore, the findings from the second study suggest that drivers with MCI are aware of occasional difficulties with driving situations, and passengers of drivers with MCI are noticing these difficulties. It is therefore important to determine the extent of diving difficulties for this group, as well how these behaviours decline, remain stable or improve over time.

Limitations and General Comments on the Methodology

The overall intention of the thesis was to enhance knowledge in the area of older drivers with cognitive impairment, however, there were some shortcomings...
and limitations associated with study one and study two. This section provides comment on the study methodology and outlines limitations and the strengths of the studies.

**Study 1 limitations.**

**Study population and sample size.**

The original intention of this study was to recruit participants with MCI from a memory clinic at a hospital in Melbourne, Australia. Due to the specific inclusion and exclusion criteria only a small number of participants were recruited. Furthermore, it is common for people who are diagnosed with MCI to have co-morbid conditions such as depression (Gabryelewicz et al., 2004) and this was grounds for exclusion. In addition, older drivers with early cognitive impairment who recently obtained a diagnosis are a very difficult group to recruit, potentially due to their reluctance to participate in driving studies and their ability to come to terms with a recent diagnosis. Large variability in cognitive level was found within the drivers with MCI and this was also reflected in the outcome measures with the cognitive task. People with mild cognitive impairment are a heterogeneous group which varies in neuropathology. Some participants may therefore suffer from cognitive deficits that were not detected by the MMSE. Another limitation of the study is that the sample was not representative of the general population in that participants volunteered and tended to be highly educated. Therefore, caution should be taken when interpreting the results with respect to the general population.

A final important limitation is the criteria used to assess cognitive status in the drivers with MCI and the healthy controls. The MMSE is a common screening tool for assessing cognitive impairment in other driving studies (Eby et al., 2012; Fritelli et al., 2009). However, it has received some criticism for effectively
screening for MCI and has been subject to variability depending on age and education level (McDowell, 2006). It is therefore possible that some of the MMSE scores in the study were inflated due to the relatively high education level of the sample. A full neuropsychological assessment is recommended to assess for drivers with MCI and drivers without any cognitive impairment. Due to practical reasons the MMSE was used as the assessment measure in this study.

**Study design.**

Although a case-control study design has its advantages, it is difficult to determine the nature of causality as the data represent only one point in time. In addition, it remains unknown as to whether drivers with MCI who participated in the study would have cognitive deficits that would progress towards dementia, remain the same, or even improve with time. Seven participants withdrew from the study due to simulator sickness. This is expected to occur when using driving simulators to test participants. However, it does mean that selection bias cannot be discounted because a full set of data was not collected on these participants. Another limitation of using a driving simulator concerns the generalisability of the results with other driving simulator studies. There is great variation in driving simulators relating to the equipment, environment and proprioceptive information (Kaptein, Theeuwes, & Van Der Horst, 1996). It is important to keep in mind that simulator driving does not always equate to on-road driving.

**Study strengths.**

Despite these limitations, there are a number of strengths of the study that should be recognised. While previous studies have assessed driving performance of drivers with various levels of dementia, very few studies have focused on driving performance of a well-defined group of drivers with MCI (Duchek et al., 2003; Eby
et al., 2012; Fritelli et al., 2009). Secondly, this study used a state-of-the-art driving simulator which comprised a small cab with genuine vehicle parts including an adjustable seat, pedals, steering wheel, gear box and seat belt. The visual images for the driving scenarios were presented on three flat monitors which generated synthetic three dimensional images in real time and provided a field of view of 120°.

The advantage of using driving simulators is that they allow testing to take place in a safe and controlled environment. Research evidence exists to support the sensitivity of driving simulators to detect age-related changes in driving performance and cognition (Lee, Lee, & Cameron, 2003). It is important to establish validity for each specific cohort of drivers; however it is not yet common practice to determine simulator validity before each experiment. In addition, to ensure simulators adequately reflect driver behaviour, it is beneficial to examine the simulator for its ability to predict crashes. Another benefit of the simulator study was the ability to use observational foot cameras that provided valuable information about driver foot hesitations on approach to intersections. Very few studies have investigated the relationship between foot movements, older drivers and cognition. As such, this study makes a significant contribution to the literature by investigating the relationship between foot movements and cognitive status on approach to intersections.

Study 2 limitations.

Driver self-report.

Difficulties with recall and social desirability bias, including overestimating or underestimating driving behavior, are potential problems arising from self-report of information relating to self-regulation practices. Despite studies demonstrating inconsistencies between driver ratings of driving behaviour and actual driving
performance assessed via a simulator and a computerised hazard perception task (Freund et al., 2005; Horswill, Sullivan, Lurie-Beck, & Smith, 2013), few studies have investigated the accuracy of self-report of driver self-regulation practices (Huebner, Porter, & Marshall, 2006; Marshall et al., 2007; Wood, Lacherez, & Anstey, 2012). The intention of in-vehicle technology has enabled researchers to compare actual driving behavior with self-reported driving practices. A challenge with in-vehicle monitoring is ensuring that the devices are unobtrusive so that they don’t influence driver behaviour. Further research is needed in this area to understand the accuracy of drivers reporting self-regulation practices.

**Obtaining information from collateral sources.**

Health professionals often rely on reports from family members to obtain information regarding the patient’s ability to operate a vehicle. In a study by Croston and colleagues (2009), for example, family members of drivers with dementia were asked about the barriers and concerns about retiring from driving. Approximately 33% of informants reported that lack of insight and the personality of the driver were barriers to driving retirement. In this study, the primary reason for drivers ceasing to drive was worsening cognition (Croston et al., 2009). While some studies have found reports from family members provide adequate information (Carr, Gray, Baty, & Morris, 2000), other researchers have found these to be inaccurate measures of the patient’s driving ability (Bédard, Molloy, & Lever, 1998; Brown et al., 2005; Rees, Bayer, & Phillips, 1995).

**Sample size and study population.**

The study comprised a convenience sample of older drivers in Victoria, (who resided in both metropolitan and rural areas) and who were aged over 65 years. Participants were recruited in response to advertisements at bowling clubs, education
and activity centres for seniors. The sample was therefore not representative of the
general population and therefore caution is required when interpreting the results
with respect to the general population. A greater number of males than females
participated in the study, which is a common occurrence for driving studies. In
addition, the age of the participants varied across a wide range. The division of older
drivers into ‘young-old’ and ‘older-old’ can accommodate the wide variability,
however due to the sample size this division was not conducted.

Measure of insight.

Insight and awareness is a complex construct that is difficult to assess. A
number of approaches have been used and they typically involve assessing the
discrepancy between a patient’s rating of their own performance and an informant’s
rating of their performance. Other approaches include an evaluation by a physician,
or assessing the discrepancy between a physician’s rating and the patient rating
(Vogel et al., 2004). The few studies that have investigated the insight of drivers with
any type of cognitive impairment on their level of awareness have typically used
self-report surveys (Cotrell & Wild, 1999; Pachana & Petriwskyj, 2006). In addition,
these studies have typically assessed the level of insight into the driver’s memory
dysfunction rather than their level of awareness into the driving abilities. Assessment
of insight in study two was determined by examining the discrepancy between driver
and passenger ratings of driving difficulty. Insight may be influenced by factors such
as; the relationship between the driver and the passenger or the affective state of the
passenger (Wadley, Okonkwo, Crowe, & Ross-Meadows, 2008). For example, the
driver or the passenger may wish to deny any deficits and present the driver in a
favourable manner (Wadley, Harrell, & Marson, 2003).

Measure of cognition.
The TICS-m has been used frequently in epidemiological studies to screen for cognitive impairment. It has been validated in a number of studies and has been found to reliably distinguish between adults with Alzheimer’s disease compared to those without (Brandt et al., 1988). While there is an emerging body of evidence that TICS-m can reliably distinguish between adults with mild cognitive impairment and adults with normal cognition (Berri, Werner, Davidson, Schmidler, & Silverman, 2003; Duff, Beglinger, & Adams, 2009), this is still inconclusive as some studies have demonstrated poor validity for screening for MCI (Crooks, Clark, Petitti, Chui, & Chiu, 2005; Manly et al., 2011). The varying definitions of MCI and lack of agreed upon criteria for MCI may be one reason for these varying results. The administration of the TICS-m via the telephone offers ease of administration, and allows people from geographically diverse regions to participate. However, there are some limitations such as the applicability of the TICS-m for people with hearing problems. In addition, it is not known whether participants used aids to assist them with their answers such as pens or paper, diaries or calendars. It is also important to acknowledge that a number of illnesses and conditions as well as fatigue can affect cognition. Although participants were screened for common health conditions that could influence driving performance, it was not feasible to ask about all health conditions or substance use that could also impair cognition.

Implications for Research, Policy and Practice

Implications for licensing authorities.

The implications of the systematic review provided in Chapter 6 suggest that older drivers with cognitive impairment are voluntarily restricting their driving by engaging in self-regulation practices by avoiding certain driving situations. In Australia, a conditional licence administered by driving authorities may include
driver restrictions which aim to maintain mobility while increasing road safety. The restrictions may be specific to certain locations or driving situations. While licence restrictions are common in Australian jurisdictions and many overseas jurisdictions (Nasvadi & Wister, 2009), few studies have investigated whether licence restrictions translate into a reduced crash risk (Langford & Koppel, 2011; Marshall, Spasoff, Nair, & van Walraven, 2002; Nasvadi & Wister, 2009; Stutts, Stewart, & Van Heusen-Causey, 2000). The majority of studies in this area found no reduction in driver crash risk for those drivers who were restricting their driving compared to those with no restrictions. However, it’s important to note that driving authorities rarely administer conditional licences (Langford & Koppel, 2011) and therefore the safety impact of driver restrictions at the current time remains unclear.

A graduated licensing system has been proposed to assist those drivers who are at a heightened crash risk (Redelmeier & Stanbrook, 2012). This approach selects drivers based upon health status and administers them with a conditional licence which restricts them from driving in certain driving situations. Although this approach sounds promising for reducing driving exposure of potentially high-risk drivers, it may not be necessary for all older drivers with cognitive impairment as the results of the systematic review imply that drivers in this cohort are already restricting their driving. Furthermore, drivers with moderate or severe cognitive impairment may not consistently follow restrictions due to problems with memory. Alternative approaches for licensing may include involving a significant other who often acts as the passenger to collaboratively include them in the administration of the conditional licence so that they can also play a role in ensuring the restrictions are maintained.
Voluntary licence renewal and voluntary driver restrictions have been proposed as alternative options for promoting driver restrictions (Berry, 2011; Grabowski, Campbell, & Morrisey, 2004). This approach places the responsibility back on the driver who would present themselves to the driving authorities for licence renewal. This could enable the driver to be empowered throughout the process and provide them with the opportunity to have a say in how they wish to maintain safety and mobility. A discussion about potential interventions, which may include; driver education, cognitive retraining programs, driver restrictions, or cessation of driving could also occur at this time.

**Implications for health professionals.**

There is a need for health professionals to understand how to manage the outcome of an assessment of fitness to drive (Jones, Rouse-Watson, Beveridge, Sims, & Schattner, 2012). It can be useful for health professionals to frame the conversation about driving in a positive rather than negative light by focusing on alternative ways that the driver can enhance mobility rather than cease driving altogether (Kennedy, 2009). During these conversations it is important to respect the driver’s independence by collaboratively discussing interventions to increase their safety. Within the context of the therapeutic alliance a discussion about pre-empting driver risk can occur. For many older adults loss of licence is associated with independence and social functioning, and can be sensitive topic. Clinical judgment by health professionals is necessary when deciding when to discuss fitness to drive so that the physician-patient relationship does not become compromised. This is particularly salient for patients who suffer from depression who are unlikely to return to their physician after a threat of licence removal. A large survey study conducted by Nauman, Dellinger, Anderson, Bonomi and Frederick (2012) in the United States
found former drivers used mental health services more often than current drivers and also recorded more inpatient hospital stays. Health professionals have the challenge of balancing the safety risk of the patient and broader community, against prematurely reducing patient mobility which may in turn decrease patient quality of life.

As identified in Chapter 8, a small minority of drivers may be unaware of how illness, ageing and driving performance can increase crash risk. GP's, psychologists, driving assessors, nurses and optometrists can educate drivers about this association in order to convey the message about driving risk in an empathetic and compassionate manner. Physicians who explain this relationship clearly to the patient and provide warnings about crash risk may prevent future crashes from occurring (Redelmeier, Yarnell, Thiruchelvam, & Tibshirani, 2012). Passengers, family members and people who act as 'co-pilots' could play a role in reminding the driver about unsafe driving practices and safety risks (Kennedy, 2009; Man-Son-Hing et al., 2007).

The implications suggested from the telephone interview study (reported as Chapter 8) are that very few drivers think about the signs and conditions that would lead to cessation of driving behaviour. This may be due to denial, lack of knowledge about the risks associated with driving performance, ageing and changes in health, or adults may think it is too early to plan ahead for the transition towards driving cessation. The loss of licence is usually just one of many losses that drivers with cognitive impairment experience. Even adults at the mild stages of cognitive impairment face losses which may include; loss of communication, loss of social activities and loss of certain hopes for the future (Lu & Haase, 2009). The losses can be stressful for both the driver and their family members and may result in grief
responses such as sadness, guilt, anger, shock and uncertainty. Interventions that assist with adjustment to loss may be useful for drivers with cognitive impairment who are nearing driving cessation. Components of the interventions may include; acknowledging the situation, accepting the situation and finding ways to modify or adapt behaviour in order to compensate for limitations (Silverberg, 2006). A shift in the way society views transitions towards driving retirement could also assist this process. A system that encourages changes in driving behaviour across the lifespan could normalise the process and may reduce fears about driving cessation (Berry, 2011).

**Implications for Australian senior drivers with cognitive impairment.**

An increasing emerging area of study involves the application of self-screening workbooks and programs for older drivers (Classen et al. 2010; Eby, Molnar, Shope, Vivoda, & Fordyce, 2003). The workbooks are intended to encourage older drivers to take responsibility for their fitness to drive and to provide them with an opportunity to start a discussion with family members or the GP about driving. Self-screening workbooks and programs have typically asked drivers to assess a number of physical abilities and functional abilities (Eby et al., 2003; Marottoli et al., 2007) rather than psychological factors such as insight, confidence, and depression. However, it could be argued that psychological factors are just as important to assess as they can act as barriers towards driver behaviour change. For example, feeling connected to society, a sense of independence, self-confidence, and potential fears about ageing can all act as barriers to preventing driver behaviour change (Donorfio, D'Ambrosio, Coughlin, & Mohyde, 2009). It can be beneficial to address these psychological factors early and to empower drivers to decide when to self-regulate their driving behaviour and/or cease driving altogether. It could also be
beneficial to provide drivers with indicators of crash risk to monitor their capacity to drive safely before having a crash. It is important to identify these predictive factors among this specific group of drivers to tailor specific interventions to assist drivers with the decision to modify their driving behaviour. However, self-screening should only be used as one indicator of fitness to drive, it is important to also combine this with a medical assessment or an assessment by the driving authorities.

In addition to driver self-screening, there are programs that focus on improving older driver skills and awareness via education or physical training (Edwards, Delahunt, & Mahncke, 2009; Korner-Bitensky, Kua, von Zweck, & Van Benthem, 2009). However, it remains unknown as to what effect the cognitive components of these programs have on improving driver awareness and performance. Furthermore, these studies rarely include drivers from the general population but rather focus on a select group of drivers with cognitive impairment. Information processing has been cited as a common deficit in adults with cognitive impairment (Uc & Rizzo, 2008) and may be enhanced by practice using a computer program (Edwards et al. 2009). Although still in the early stages, programs consisting of cognitive training, cognitive rehabilitation or cognitive stimulation may hold promise for improving functioning of older drivers with cognitive impairment (Jean, Bergeron, Thivierge, & Simard, 2010).

**Implications for research.**

The simulator study undertaken as Study 1 provided preliminary data for understanding the driving performance of drivers with MCI at intersections. The evidence is preliminary, but suggests that drivers with MCI may have difficulty on approach to intersections compared to healthy controls. It is necessary to explore this
association further in a larger sample, preferably using a longitudinal research design.

The conceptual models of driver behaviour that were presented in the introduction provide a useful framework for examining the factors involved in driver performance and driver self-regulation for drivers with cognitive impairment. Although the models are yet to be evaluated, the Michon Model is widely cited throughout the transportation literature and provides a useful basis for informing future research questions concerning cognitive impairment and driving. The Driving as an Everyday Competence Model (Lindstrom-Forneri et al., 2010) attempts to incorporate driver self-regulation, driver competence and driver performance by acknowledging the contribution of driver insight and awareness. However, other factors such as driver knowledge and assessment of risk may have a significant role to play. Although theoretical models are useful for guiding research, these models are unable to provide a quantifiable measure of road safety risk. The next challenge is to evaluate the applicability of the model to the real world.

The findings of the systematic literature review demonstrated that drivers with cognitive impairment do in fact engage in self-regulatory driving practices by avoiding certain driving situations. Therefore, this finding should be kept in mind for future studies of self-regulation. A sophisticated understanding of the factors that influence self-regulation for this select cohort of drivers may assist with the development of interventions to promote safe driving practices.

**Directions for Future Research**

Given the limited research on driver performance and crash risk of drivers with mild cognitive impairment, further research is required to assess the generalisability of the preliminary findings from the simulator study. Firstly, studies
that employ a large sample size and include a longitudinal study design would be beneficial. In addition, a standardised procedure for assessing cognitive impairment across different time points would allow for monitoring cognitive decline. Ideally, on-road studies which enable a gold standard of testing would be preferable; however simulator studies with longitudinal time points using simulators that are validated for the cohort of interest could also greatly enhance knowledge in this area.

The implications of the findings from the systematic literature review on driver self-regulation strongly indicate the need for high quality studies employing large populations with longitudinal designs. The majority of studies identified in the review were cross-sectional, with very few prospective cohort studies and (to the authors’ knowledge) no randomised control studies. The majority of the studies in the review included self-report measures to assess driver self-regulatory practices. Self-report depends upon the driver’s memory of the event which may diminish due to cognitive impairment and therefore may change over time. Furthermore, it has been estimated that older drivers with cognitive impairment often over-estimate their driving abilities and functional abilities (De Simone, Kaplan, Patronas, Wassermann, & Grafman, 2007; Farias, Mungas, & Jagust, 2005) and recent evidence suggests that this relationship may be correlated with degree of cognitive impairment (Farias et al., 2005). Therefore, it is beneficial to obtain collateral information from significant others or to use more objective measures of driver behaviour such as electronic data logging systems.

The extent to which self-regulation translates into a reduction in driver crash risk is an important question. There have been limited studies in this area (Ball et al., 1998; De Raedt & Ponjaert-Kristoffersen, 2000a; Owsley, McGwin, Phillips, McNeal, & Stalvey, 2004; Raitanen, Törmäkangas, Mollenkopf, & Marcellini, 2003)
and this relationship is still not clear (Man-Son-Hing et al., 2007). Prospective longitudinal studies with large cohorts are required to determine this association. As driver insight and awareness can be an important predictor of self-regulation (Charlton et al., 2006), it is important to acknowledge insight of older drivers with and without cognitive impairment when designing studies on self-regulation. Additional research is required to determine the role of insight on self-regulation practices.

**Conclusions**

The ageing society presents health care providers, government and society at large with the challenge of ensuring that older adults are adequately cared for. The expected increase in the number of older drivers on Australian roads in the foreseeable future, combined with the expected increase in prevalence rates of dementia means that it is essential to understand the characteristics of older drivers with cognitive impairment. The results presented in this thesis add to the knowledge of older drivers with cognitive impairment in regard to driving performance, driver self-regulation and motivating factors for behaviour change. These results will be important for health professionals, driving authorities, policy makers and researchers.
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START

**Event 1** Intersection - (Stop Sign 1)

Start recording the Event 100m before the intersection to 100m after intersection.

**Event 3** Intersection (Green light 1)

Start recording the Event 100m before the intersection to 100m after intersection.

**Event 4** Intersection (Uncontrolled 1)

Start recording Event 100m before intersection to 100m after intersection.

**Event 5** Intersection (Critical light change 1)

Record data for Event 100m before light change pos to 100m after centre of intersection

**Event 6** Intersection (Critical light change 2)

Record data 100m before light change position to 100m after centre of intersection

**Event 7** Intersection (Uncontrolled 2)

Start recording Event 11 100m before intersection to 100m after intersection.

**Event 8** Intersection (Stop Sign 2)

Start recording Event 14 100m before intersection to 100m after intersection.

End the drive – 200m after last intersection