Running Head: MEASURING AWARENESS AND SELF-REGULATORY DRIVING

BEHAVIOUR AMONG OLDER ADULTS

Adapting to an Ageing Self: Measuring Awareness and Self-Regulation in a

Community-Based Sample of Australian Older Drivers

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Acknowledgements

"I wonder if I've been changed in the night. Let me think.
Was I the same when I got up this morning? I almost think I can remember feeling a little different.
But if I'm not the same, the next question is, 'Who in the world am I?'
Ah, that's the great puzzle!"
~ Alice's Adventures in Wonderland, Lewis Carroll

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Finally, to my Pop – I am sorry you never got to see this through to the end. I know you'll be watching over me the day I wear my "funny hat", cheering so loud I just might hear you from heaven.

For my grandfather,

Donald George Davis

(9th July 1930 - 25th October 2016).

Abstract

For many Australians, driving is more than a means of transportation. Access to a personal automobile and the ability to 'hop in the car', over time, becomes intertwined in our daily lives, synonymous with our independence and essential to our quality of life and sense of self. In the absence of disease or disability, few individuals consider a future that does not include driving. However, for older adults, driving cessation often becomes a reality they are required to negotiate. Recognition of the importance of driving, alongside acknowledgement of the considerable inter-individual variability in the effects of age- and disease-related decline on driving ability, has prompted the shift from restrictive to supportive approaches to older driver safety. Driving self-regulation refers to the changes older drivers voluntarily introduce into their driving behaviour to compensate for self-perceived changes in skill level or driving confidence. This gradual reduction in driving exposure and avoidance of risky internal and external states has been viewed as a means through which older drivers can maintain a safe level of mobility. For this practice to be effective, the self-regulatory practices of older adults should match their functional driving skills, and as such, are dependent upon their capacity (and willingness) to accurately self-monitor their driving ability and appropriately adjust their driving behaviour. This research had four aims: 1) to develop and validate a measure of driving self-regulation that distinguishes compensatory from non-compensatory driving behaviour; 2) to distinguish between older drivers who possess the capacity to effectively evaluate their driving skills and those who do not; 3) to determine the influence of neuropsychological and psychosocial factors in explaining instances of unawareness in older drivers; and 4) to examine whether the degree of compensatory driving behaviour reported differs between older drivers with intact awareness and those with neuropsychologically and/or psychosocially based unawareness.

The Situational Avoidance Questionnaire is a 16-item self-report measure designed to assess avoidance of potentially challenging driving situations, a form of driving self-regulation at the strategic level of driving behaviour. Three hundred and ninety-nine Australian drivers ($M = 66.75$, $SD = 10.14$ range: 48 to 91 years; 204 males, 51.5%) completed the SAQ and their responses were subjected to Rasch analysis (Study 1, Chapter 4). The scale is psychometrically sound and the construct of situational avoidance was identified as unidimensional and hierarchical or cumulative in terms of frequency of avoidance. The SAQ was validated in Study 2 (Chapter 5). Seventy-nine Australian drivers ($M_{age} = 71.48$, $SD = 7.16$, range: 55 to 86 years; 36 males, 45.6%) were classified as *compensatory-restricted* or *non-restricted* based on a semi-structured interview designed to assess the motivations underlying avoidance behaviour reported on the SAQ. Using receiver-operator characteristic (ROC) analysis, the SAQ was found to have high diagnostic accuracy (sensitivity: 85%, specificity: 82%) in correctly classifying the driver groups. Group comparisons found that compensatory-restricted drivers were self-regulating their driving behaviour to reduce the perceived demands of the driving task.

In Study 3 (Chapter 6), awareness of memory and driving-related skills including contrast sensitivity, divided attention, reaction time and hazard perception, were assessed within the theoretical framework proposed by Toglia and Kirk (2000). Seventy-nine Australian drivers ($M_{age} = 71.48$, $SD = 7.16$, range: 55 to 86 years; 36 males, 45.6%) completed questionnaires measuring metacognitive knowledge and online awareness in relation to each of the objective tests. A discrepancy method of awareness assessment was used, comparing subjective estimations to objective test performance. Correlational analysis supported the distinction between the two forms of awareness. Online awareness indices were found to be more strongly associated with objective test scores than metacognitive knowledge, confirming these indices as task- and time-specific (Toglia & Kirk, 2000). Domain-specific awareness was

observed with awareness levels varying between and within objects of awareness (i.e., driving versus memory domains). These results highlight the importance of multi-domain assessment of awareness given the complexity of the driving task.

Lastly, to achieve research aims two to four, cluster analysis was used to identify four distinct typologies of individuals according to their awareness of hazard perception and simple reaction time skills, and their responses on measures of executive function, denial/defensiveness (Marlowe-Crowne Social Desirability Scale) and driving discomfort (Study 4, Chapter 7). The smaller subsample of 79 Australian drivers was used, minus one participant due to missing data (M_{age} = 71.31, SD = 7.04, range: 55 to 86 years; 36 males, 46.2%). Groups included: 1) a good self-awareness, unimpaired group (n = 29) characterised by good executive function skills, normal defensiveness, average driving discomfort and a tendency to underestimate their hazard perception and reaction time skills; 2) a good self-awareness, impaired group (n = 14) characterised by domain-specific awareness (simple reaction time), high driving discomfort, good executive function and low defensiveness; 3) a high defensiveness group (n = 17) characterised by overestimation of their driving-related skills, low levels of driving discomfort and a tendency to present themselves in an overly favourable light; and 4) an impaired but not restricted group (n = 18) characterised by domain-specific awareness (hazard perception), high driving discomfort, low defensiveness and below average executive function. These groups demonstrated meaningful differences on the SAQ with both good self-awareness groups reporting behaviour in line with their objective skill level (i.e., the unimpaired group reporting little to no situational avoidance, and the impaired group reporting a mean SAQ above 33, indicating the practice of compensatory situational avoidance). The remaining two groups reported low levels of situational avoidance despite demonstrating difficulty on the objective driving tasks.

From a theoretical perspective, this research advances our understanding of awareness in older drivers, the factors that influence its expression, and its relationship to situational avoidance. At a practical level, this research is expected to inform educational interventions targeted at increasing the appropriate use of compensatory driving self-regulation among older drivers. These interventions may obtain better outcomes should they employ individually tailored, awareness-based interventions given the different needs of the awareness typologies identified in this thesis.

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Statement of Originality

I hereby certify that this thesis is the result of my original research. All sources and references quoted have been acknowledged in the text. The material contained in this thesis has not been submitted, in whole or in part, for a degree at this or any other University.

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Jessica Davis
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May 2017

Statement of Ethical Protocol

The Griffith University Human Research Ethics Committee granted ethical clearance for the studies reported in this thesis (GU Ref No: PSY/2012/211/HREC). I confirm that the research was conducted in accordance with the approved protocols.

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Jessica Davis
Griffith University
May 2017

Publications

Davis, J., Conlon, E., Ownsworth, T., & Morrissey, S. (2016). Measuring situational avoidance in older drivers: An application of Rasch analysis. *Accident Analysis and Prevention, 87,* 68-77. doi: 10.1016/j.aap.2015.11.018

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Acknowledgement of Publications included in this Thesis

The aforementioned journal articles comprise Chapters 4 and 5, respectively. These publications are in accordance with Section 9.1 of the Griffith University Code for the Responsible Conduct of Research ("Criteria for Authorship"), Section 5 of the Australian Code for the Responsible Conduct of Research, and Section 9.3 of the Griffith University Code ("Responsibilities of Researchers"). An acknowledgement of my contribution to each co-authored paper is outlined at the front of each relevant chapter, alongside the publication status and bibliographic details. Appropriate acknowledgements of those who contributed to the research but did not qualify as authors are included in each paper.

Each article is presented in the form it was submitted and/or accepted for publication. Presenting the articles in this form has not breached Copyright Policies of the relevant publishing company, Elsevier, on the use of own articles in a thesis. For the published paper (Chapter 4), a license to re-produce this article has been obtained (see Appendix A).

Jessica Davis

Elizabeth Conlon

Tamara Ownsworth

Shirley Morrissey   31/05/2017

Chapter 1 : General Introduction

Obtaining a license to drive on Australian roads represents an important developmental milestone in the transition from adolescence to young adulthood (Moller, 2004). A driver's license is a symbol of independence and autonomy, and a good indicator of wellbeing and quality of life (O'Neill, 2015; Oxley & Whelan, 2008; Ragland, Satariano, & MacLeod, 2004). Driving is particularly important in Australia, where dispersed land-use patterns, increases in urbanisation, and the present public transportation system have increased dependence on the personal automobile (Newman & Kenworthy, 1995). For older adults, driving is and will continue to be their most preferred and convenient transportation option (Kostyniuk & Shope, 2003; Oxley & Whelan, 2008; Oxley & Charlton, 2009; Rosenbloom, 2004). Loss of one's driver's license in late adulthood is an unenviable transition that has been associated with decreases in quality of life, self-esteem, and personal autonomy (Harrison & Ragland, 2003; Marottoli et al., 2000); as well as increases in depression (Fonda, Wallace, & Herzog, 2001; Marottoli, Mendes de Leon, et al., 1997).

Age- and disease-related changes in perceptual, physical and cognitive processes can compromise an older adult's capacity to drive safely (Anstey, Wood, Lord, & Walker, 2005), with many of these changes thought to underlie the unique profile of older driver crashes. Crashes involving older drivers are more likely to occur in good weather, during daylight hours, at intersections, or when turning across traffic (Langford & Koppel, 2006a; McGwin & Brown, 1999). There is also a greater frequency of crashes among older drivers involving failure to yield, unseen objects, changing lanes, and entering traffic (Cicchino & McCartt, 2015; McGwin & Brown, 1999). Certain subgroups of older drivers are particularly vulnerable to crash involvement (e.g., drivers aged 70 years and older (Staplin, Lococo, Martell, & Stutts, 2012) and those who have reduced their driving exposure significantly (Langford, Methorst, & Hakamies-Blomqvist, 2006)) and as a group, older adults are at

greater risk of serious injury or death if involved in a motor vehicle accident due to increased physical frailty (Koppel, Bohensky, Langford, & Taranto, 2011; Li, Braver & Chen, 2003). In light of the steady increases in population ageing (Australian Bureau of Statistics, 2016), these findings have prompted increased scrutiny of Australia's current licensing requirements.

All Australian states with the exception of Tasmania, Victoria and the Northern Territory, require their older residents to regularly prove their fitness to drive through medical assessment and/or on-road testing once they reach a specific age (between 70 and 80 years depending on the state) (Austroads, 2016). In Victoria, the Northern Territory, and Tasmania there is no mandated test of driving fitness or vision function after initial license application unless specific concerns are raised (Austroads, 2016). Despite this disparity in practice, no demonstrable differences in injury or accident rates have been found across Australian jurisdictions (Langford, Fitzharris, Koppel, & Newstead, 2004). Similarly, there is little evidence to suggest that age-based mandatory reassessment practices are associated with a reduction in crash rates internationally (Hakamies-Blomqvist, Johansson, & Lundberg, 1996; Langford & Koppel, 2006b; Organisation for Economic Co-operation and Development, OECD, 2001). It was these findings, alongside the economic and social (discriminatory) effects of age-based assessments, that prompted the end of compulsory annual driving assessments for Tasmanian drivers aged 85 years or older as of October 2011 (Department of Infrastructure, Energy & Resources, Tasmanian Government, 2010).

Considerable variability exists in the timing, amount and type of decline an older adult may experience as part of normal ageing or in the setting of pathology (Waller, 1991). Just because a driver has turned 70 years of age does not mean they are unable to drive safely, while the diagnosis of a medical condition alone is often not enough to sanction license removal. Rather, the question of driver safety is better expressed in terms of level of skill rather than the age or medical diagnosis associated with skill decline (OECD, 2001). This

fact, coupled with the negative outcomes associated with driving cessation, has led some to conclude that older adults must maintain ultimate responsibility for their driving (Berry, 2011; Tasmanian Government, 2010). Waller (1988, p. 86) wrote: "Just as there is growing recognition that young beginning drivers should not be introduced into the driving population all at once but rather eased in gradually, it should be recognised that many, if not most, older drivers do not have to be abruptly removed from the driving population". While Waller (1988) was advocating for an older driver graduated licensing program, this view has also been the primary motivation for research into voluntary driving self-regulation (Hakamies-Blomqvist, Siren, & Davidse, 2004).

Driving self-regulation has been defined as a compensatory process initiated by older adults to improve the fit between their changing physical, sensory and cognitive skills and the driving environment (Ball et al., 1998; Charlton, Oxley, Fildes, et al., 2006; Donorfio, D'Ambrosio, Coughlin, & Mohyde, 2009). Many older drivers voluntarily self-regulate their driving behaviour through a reduction in driving exposure and avoidance of difficult driving situations, including adverse weather conditions or at night (Charlton, Oxley, Fildes, et al., 2006). This practice has been viewed as a means of maintaining the mobility of older adults, whilst simultaneously reducing their crash risk (Baldock, Mathias, McLean, & Berndt, 2006a; Charlton, Oxley, Fildes, et al., 2006).

For driving self-regulation to reduce the crash risk of older drivers, it should be practised by those with greater functional impairment (Baldock et al., 2006a). While some findings show that older drivers can and do self-regulate their driving in a manner consistent with their skill level (Ball et al., 1998; Devlin & McGillivray, 2016; Keay et al., 2009; West et al., 2003), other evidence suggests that at least some older drivers do not self-regulate their driving adequately (Baldock et al. 2006a; Horswill, Anstey, Hatherly, Wood, & Pachana, 2011; MacDonald, Myers, & Blanchard, 2008).

Inherent in the definition of driving self-regulation is the notion that this behaviour is *compensatory*, that is, practiced in response to a perceived change in ability or level of confidence to perform specific driving tasks (Molnar, Eby, Charlton, et al., 2013; Molnar et al., 2015). Yet most studies have assessed driving self-regulation by asking drivers if they modify their driving (e.g., by driving less or avoiding driving in certain situations) with no reference to the reasons for this behaviour (Molnar et al., 2015). One would expect that any association between avoidance behaviour and objective ability would be diluted by the inclusion of non-compensatory driving behaviour, for example, changes in driving behaviour secondary to lifestyle change or for convenience.

Assuming the behaviour reported is a form of compensation, accurate awareness of and ability to evaluate one's own driving ability is thought to be a key factor in determining driving self-regulatory behaviour (Anstey et al., 2005). That is, an older adult must first be aware that a skill important for safe driving has declined in order to initiate these strategies (Rudman, Friedland, Chipman, & Sciortino, 2006). Several interpersonal, intrapersonal and environmental factors have been identified that influence the ability of older adults to self-monitor and adjust their driving behaviour (Rudman et al., 2006).

Research suggests that individuals with cognitive impairment, particularly executive function deficits, do not possess the mental flexibility, problem solving capacity and feedback utilisation skills necessary to be aware of their level of driving skill in general, and of the need for compensation in particular (Daigneault, Joly, & Frigon, 2002). This suggests that driving self-regulation may have its strongest impact among older drivers with largely intact cognitive skills. In normal ageing, cognitive processes such as processing speed, attention and executive functions begin to decline (Anstey et al., 2005). Investigation of the extent to which these changes influence the ability of older drivers to make informed decisions concerning when and in what circumstances they should drive would provide important information

concerning the use of self-regulation as a safety strategy within a community-based population of older adults.

Expressions of accurate awareness or insight into driving impairment may also be influenced by psychological and social factors (Clare, 2004a). For example, some older drivers may deny or minimise driving impairments in an effort to maintain their lifestyle, identity and sense of independence. Others may deny or underreport driving problems because of the transport needs of dependent others. To date, no study has explored the relative role of neuropsychological and psychosocial factors together in explaining individual differences in awareness and compensatory behaviour among older drivers.

This thesis had four aims (see Figure 1.1): 1) to develop and validate a measure of driving self-regulation that distinguishes compensatory from non-compensatory driving behaviour; 2) to distinguish between older drivers who possess the capacity to effectively evaluate their driving skills and those who do not; 3) to determine the influence of neuropsychological and psychosocial factors in explaining instances of unawareness in older drivers; and 4) to examine whether the degree of compensatory driving behaviour reported differs between older drivers with intact awareness and those with neuropsychologically and/or psychosocially based unawareness.

Adaptation to an Ageing System: Measuring Awareness and Self-Regulation in a Community-Based Sample of Australian Older Drivers

Aim 1: To develop and validate a measure of driving self-regulation that distinguishes compensatory from non-compensatory driving behaviour.

Aim 2: To distinguish between older drivers who possess the capacity to effectively evaluate their driving skills and those who do not.

Aim 3: To determine the influence of neuropsychological and psychosocial factors in explaining instances of unawareness in older drivers.

Aim 4: To examine whether the degree of compensatory driving behaviour reported differs between older drivers with intact awareness and those with neuropsychologically and/or psychosocially based unawareness.

Study 1 (Chapter 4)	**Study 2** (Chapter 5)	**Study 3** (Chapter 6)	**Study 4** (Chapter 7)
Purpose: To develop a measure of situational avoidance (strategic form of self-regulation). *Design:* Cross-sectional. $N = 399$ drivers aged 48 to 91 years (51.1% male). *Framework:* Rasch analysis of self-reported frequently avoided driving situations. *Thesis Aim:* 1	*Purpose*: To validate the Situational Avoidance Questionnaire and establish a cut-off score distinguishing compensatory behaviour. *Design:* Cross-sectional, subsample of Study 1. $N = 79$ drivers aged 55 to 86 years (45.6% male). *Framework:* Receiver operator curve analysis. *Thesis Aim:* 1	*Purpose*: To describe the awareness methodologies used and determine whether the measures are consistent with Toglia and Kirk's (2000) model of awareness. *Design:* Cross-sectional, subsample of Study 1. $N = 79$ drivers aged 55 to 86 years (45.6% male). *Framework:* Correlation analysis. *Thesis Aim:* 2	*Purpose*: To determine if typologies can be identified using awareness measures (Study 3) and examine whether the typologies differ on their responses to the SAQ (Studies 1 and 2). *Design:* Cross-sectional, subsample of Study 1. $N = 79$ drivers aged 55 to 86 years (45.6% male). *Framework:* Cluster analysis. *Thesis Aims:* 2 to 4

Figure 1.1. Outline of thesis aims and corresponding empirical studies.

Summary of Thesis Chapters

Chapters 2 and 3 comprise the literature review of the thesis. Chapter 2 describes the practice of driving self-regulatory behaviour among older adults, relevant driving theory and challenges or pitfalls in its measurement. Awareness theory and explanations for unawareness drawn from social, cognitive and neuropsychology theory are described in Chapter 3 and considered in the setting of what is known of the driving attitudes and behaviours of community-based, cognitively healthy older adults.

In **Chapter 4**, the development of the Situational Avoidance Questionnaire (SAQ) as a measure of driving self-regulation is described. Participant responses on the SAQ were subjected to Rasch analysis, establishing its reliability for assessing self-regulation at the strategic level of driving behaviour in both baby boomer and older adult generations. The contributions of this study also extend theoretically, clarifying the situational avoidance construct as unidimensional and cumulative or hierarchical in nature.

The second empirical study presented in **Chapter 5** validated the SAQ as a measure of compensatory driving behaviour. This is the first known study to establish a self-report driving questionnaire that defines a specific cut-off score to differentiate older drivers who are reporting situational avoidance for compensatory reasons from those who are not. Validation of this measure allowed for the investigation of awareness and its relationship with compensatory driving behaviour.

Chapter 6 describes the methodology used to assess awareness of hazard perception skills and explores the relationships between the different types and domains of awareness in light of existing theory. To date, this is the first application of Toglia and Kirk's (2000) theory of awareness, and a cognitive formulation of awareness measurement, across multiple driving domains within a sample of cognitively healthy older drivers.

The final study of this thesis is presented in **Chapter 7.** Cluster analysis was used to identify distinct typologies according to participants' metacognitive knowledge and online awareness of hazard perception skills and factors empirically related to awareness including executive function, denial/defensiveness, and driving discomfort. At a theoretical level, this study underscored the importance of assessing awareness across the different domains of driving. At a practical level, this study highlighted the need to consider the role of defensiveness in the expression of unawareness and its impact on the degree of compensatory situational avoidance reported.

The findings of this thesis and its conclusions are discussed in **Chapter 8.** From a theoretical perspective, this research contributes to an increased understanding of the nature of awareness and unawareness in a community-based sample of older drivers, the factors that influence it, and its relationship to compensatory driving self-regulation. At a practical level, this research is expected to inform educational interventions targeted at older drivers. Strengths and limitations of the thesis and future research directions are discussed.

Chapter 2 : Self-Regulation of Driving Behaviour

Driving self-regulation is thought to lie in the middle of a "cessation continuum" (p. 435), ranging from complete driving independence to driving cessation (Dellinger, Sehgal, Sleet, & Barrett-Connor, 2001). In the absence of an acute onset of disease or disability, older adults have been found to gradually decrease their driving mobility with advancing age (Donorfio, D'Ambrosio, Coughlin, & Mohyde, 2008; Koppel et al., 2017; Ross et al., 2009). Driving self-regulation has been defined as the voluntary and purposeful modification of driving behaviour with the intent of reducing the demands of the driving task (Ball et al., 1998; Charlton, Oxley, Fildes, et al., 2006; Donorfio et al., 2009). It is believed to be a means through which older adults can maintain their mobility while compensating for perceived changes in driving skill, and/or general feelings of discomfort or loss of confidence on the road (Anstey et al., 2005; Baldock et al., 2006a; Charlton, Oxley, Fildes, et al., 2006; Conlon, Rahaley, & Davis, 2017; Rudman et al., 2006; Wong, Smith, & Sullivan, 2015a). The exact strategies employed by older adults are constrained by the level of control they have over specific driving tasks. As such, differing degrees of self-regulatory behaviour are seen across the levels of Michon's (1985) and Rasmussen's (1987) hierarchical control models of driving behaviour (see Figure 2.1).
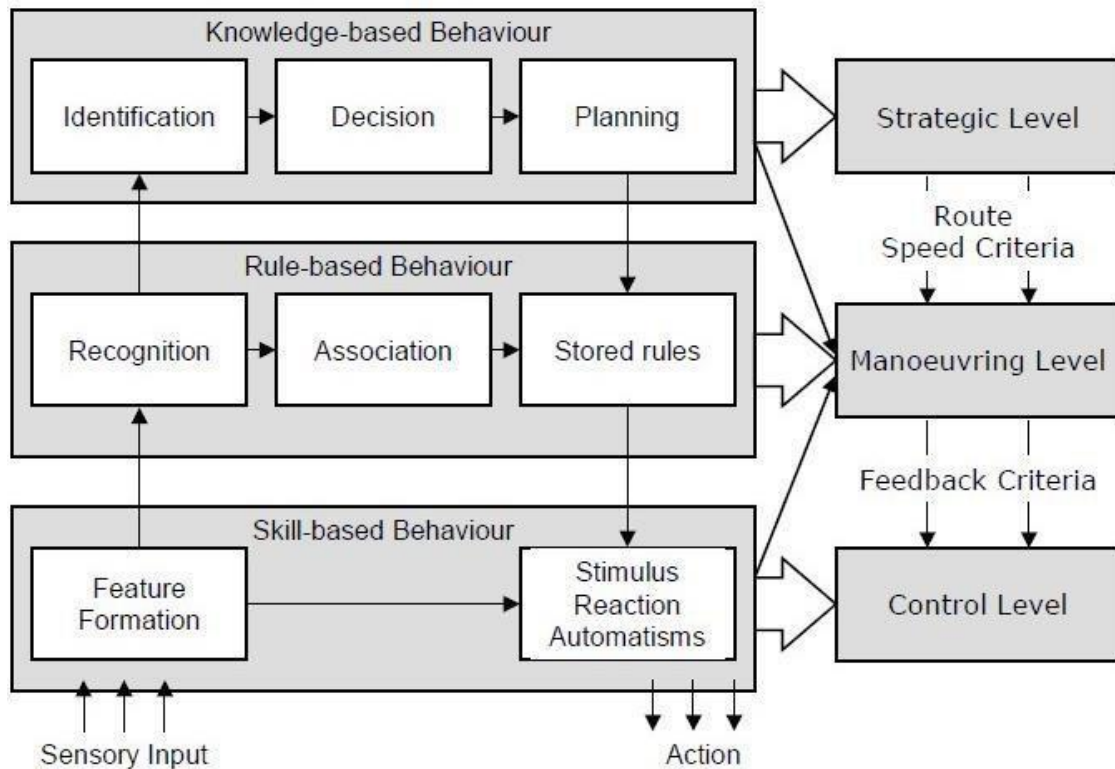
Figure 2.1. Hierarchical control model of driving behaviour according to Michon (1985) and Rasmussen (1987) modified from Donges (1999).

Strategic or knowledge-based driving behaviour is the highest level presented in each of the hierarchical models of driving behaviour. This level defines the general planning stage of a trip prior to getting into a car and includes the determination of trip goals (e.g., to minimise time) and route to be taken, and an evaluation of the relative costs and risks involved (Michon, 1985). Thus, strategic level decisions may include whether or not to drive in the rain, at night or in congested traffic. These decisions are generally not constrained by real time and are formed from information obtained from many sources (Michon, 1985). Appropriate decisions at this strategic level should lead to behaviour required when driving that is less taxing on an individual's driving skill (Ranney, 1994).

At a lower rule-based level, *tactical decisions* involve behaviour when actually driving (Michon, 1985), including choosing to drive more slowly, making a number of left-hand turns to avoid a right-hand turn, and avoiding in-car distractions such as the radio or use of a

mobile phone while driving (Molnar, Eby, Langford, et al., 2013; Smiley, 2004). Andrews and Westerman (2012) found that, relative to younger drivers, older drivers compensated for an age-related deficit in complex reaction time by adopting longer headways on a driving simulator. However, while these behaviours are mostly under the driver's control, they are also influenced by the presence of other drivers and roadway conditions and thus are data-driven (Michon, 1985; Rasmussen, 1983; 1987). For example, when negotiating a busy roundabout, the driver's behaviour is often influenced by the number of lanes to cross, other vehicles on the roundabout and those waiting to enter (Hakamies-Blomqvist, 1999).

Lastly, *operational or skill-based driving behaviour* refers to highly automated driving skills and second-to-second driving behaviour, for example, tasks of vehicle control (e.g., steering or accelerating) and visual search patterns employed in certain situations (Michon, 1985; Ranney, 1994). Operational behaviour is least amenable to self-regulation as many drivers are unaware of the details of these behaviours (Rasmussen, 1983; 1987), though there is some evidence to suggest that older adults employ different vehicle control strategies than younger drivers (Hakamies-Blomqvist, Mynttinen, Backman, & Mikkonen, 1999).

These hierarchical models of driving behaviour have been extended in more recent research to include a *life-goal level*, describing lifestyle decisions such as what kind of vehicle to drive and where to live in relation to practical and social needs (e.g., distance from local shops, medical centres, and family and friends) (Eby, Molnar & Kartje, 2009; Hatakka, Keskinen, Gregersen, Glad, & Hernetkoski, 2002). This represents a level higher than strategic behaviour and refers less to specific driving behaviour and more to a driver's general motives and attitudes toward life, which in turn, would affect how they approach the task of driving (Berg, 2006). An older driver who is concerned about the effects of ageing on driving ability may prioritise safety over the aesthetics of a vehicle or the maintenance of their lifestyle in making decisions such as where to live, what vehicle to drive or how to travel

(Molnar, Eby, Langford, et al., 2013).

When taken together, driving self-regulation by older adults occurs at life-goal, strategic and tactical levels as they have greater awareness of and control over these behaviours (Michon, 1985; Smiley, 2004). The specific self-regulatory strategies often employed by older adults include a reduction in driving exposure, avoidance of difficult driving situations, avoidance of specific driving manoeuvres, and trip planning strategies (Kostyniuk, Trombley, & Shope, 1998; Molnar et al., 2015; Smiley, 2004). Frequently avoided driving situations include driving at night or in bad weather, driving in areas of high traffic congestion, or driving on unfamiliar roads (Baldock et al., 2006a; Ball et al., 1998; Charlton, Oxley, Fildes, et al., 2006; Lyman, McGwin, & Sims, 2001; Molnar & Eby, 2008; Ragland et al., 2004).

Driving Self-Regulation and Outcomes

Prevalence rates of driving self-regulation are higher with older age; female gender; poorer self-reported health, cognition and vision; and motor vehicle crash involvement (Agramunt et al., 2016; Bergen et al., 2017; Charlton, Oxley, Fildes, et al., 2006; Charlton, Oxley, Scully, et al., 2006; Classen, Wang, Crizzle, Winter, & Lanford, 2013; De Raedt & Ponjaert-Kristoffersen, 2000; Donorfio, D'Ambrosio, et al., 2008; Fraser, Meuleners, Ng, & Morlet, 2013; Lyman et al., 2001; Marottoli et al., 1993; Meng & Siren, 2012; O'Connor, Edwards, Small, & Andel, 2012; Rimmo & Hakamies-Blomqvist, 2002). Older drivers with greater impairment on functional tests important for driving also tend to report more driving self-regulation than those who perform better on these tests (e.g., Anstey & Smith, 2003; Ball et al., 1998; Davis, 2010; Devlin & McGillivray, 2016; Freeman, Munoz, Turano, & West, 2006; Keay et al., 2009; Okonkwo, Crowe, Wadley, & Ball, 2008; Okonkwo, Wadley, Crowe, Roenker, & Ball, 2014; West et al., 2003; Wong, Smith, & Sullivan, 2012). Perhaps more importantly, the crash profile of older drivers reflects their typical self-regulation patterns, with underrepresentation in crashes occurring in difficult conditions (e.g., at night or

in bad weather) and those caused by risky internal states (e.g., intoxication or distraction from other activities, such as use of a mobile phone) (Classen, Lopez, Awadzi, & Garvan, 2007; Hakamies-Blomqvist, 1993; Langford & Koppel, 2006a).

Formalised forms of driving self-regulation such as graduated licensing programs, provide further support for the use of compensatory driving behaviour (Langford & Koppel, 2011; Marshall, Spasoff, Nair, & Van Walraven, 2002; O'Byrne, Naughton, & O'Neill, 2015). For example, Nasvadi and Wister (2009) found that an 11% reduction in at-fault crash rates could be obtained if mandatory restrictions were placed on older drivers in terms of their speed, area of travel or time of day of driving. Older drivers with restricted licenses retained their licenses for longer than those who were not restricted; supporting the notion that compensatory behaviour can promote continued, safe mobility (Nasvadi & Wister, 2009). Similarly, on evaluating the graduated licensing program implemented in Victoria, Australia, Langford and Koppel (2011) found that of the older drivers who were not allowed to drive at night, who were restricted to driving a specified distance from home, or who were allowed to drive in specified areas only, the relative crash rate of this group was smaller than that of older drivers with no restrictions placed on their licenses. While externally imposed, these programs have been shown to often reinforce decisions already made by the drivers themselves (Braitman, Chaudhary, & McCartt, 2010).

However, other studies have failed to find an association between older drivers' self-imposed driving restrictions and subsequent crash involvement or on-road driving performance. Specifically, these latter studies have found that: 1) some older adults failed to self-regulate their driving appropriately according to their objectively-defined impairments (Baldock et al., 2006a; Baldock et al., 2006b; Horswill et al., 2011; MacDonald et al., 2008; Okonkwo, Crowe, et al., 2008; Stalvey & Owsley, 2000); 2) some of those that did regulate their driving appropriately at initial testing did not continually adjust their driving behaviour

to compensate for increasing functional loss over time (Baldock, Thompson, & Mathias, 2008); or 3) some were involved in an at-fault motor vehicle accident despite reporting self-regulatory driving behaviour (Owsley, McGwin, Phillips, McNeal, & Stalvey, 2004; Ross et al., 2009). These inconsistent findings have prompted some authors to question just how well driving self-regulation has been measured (Molnar, Eby, Charlton, et al., 2013; Molnar, Eby, Langford, et al., 2013). Others have concluded that at least some older adults may not be able to accurately identify when and in what situations they should restrict their driving (e.g., Freund, Colgrove, Burke, & McLeod, 2005; Horswill, Sullivan, Lurie-Beck, & Smith, 2013).

Measuring Driving Self-Regulation

In much of the research, driving self-regulation has been conceptualised as the purposeful avoidance of driving situations pre-defined by researchers as challenging or potentially hazardous, and assessed using a self-report questionnaire (e.g., Baldock et al., 2006a, 2006b; Horswill et al., 2011; Molnar & Eby, 2008; Okonkwo et al., 2014; Sullivan, Smith, Horswill, & Lurie-Beck, 2011; Wong et al., 2012). This conceptualisation appears to have stemmed from early observations that older drivers with cataracts or other vision problems frequently reported avoidance of driving in visually challenging situations such as night driving or driving in bad weather (Ball et al., 1998; Janke, 1994a; Owsley, Stalvey, Wells, & Sloane, 1999). Decisions made at the strategic level such as *situational avoidance* also more easily lend themselves to assessment via questionnaire given they occur outside of specific driving events and are more likely to be applied consistently over time (Michon, 1985). As such, many studies have adopted the use of the Driving Habits Questionnaire (DHQ) or an extension of this tool (e.g., the Driver Mobility Questionnaire, DMQ, Baldock et al., 2006a), to measure driving self-regulation (e.g., Ackerman et al., 2011; Ackerman, Vance, & Ball, 2014; Baldock et al., 2006b; Okonkwo, Crowe, et al., 2008; Ross et al., 2009; Vance et al., 2006). A number of variations of these scales have been produced, with few studies

independently generating or reporting the psychometric properties of the scale used. In addition, more often than not, a total score is obtained suggesting that the situational avoidance construct is unidimensional (though this is contrary to the findings of Wong, Smith, & Sullivan, 2015b) and that avoidance of one situation is equivalent to avoidance of any other driving situation. However, the reasons or motivations underlying the avoidance behaviour reported are often not considered.

Molnar and colleagues (2013; 2013; 2015) have argued that it is essential to consider the motivations underlying driving self-regulation, as only behaviour that is practiced for compensatory reasons would be associated with objective measures of driving ability and indicators of awareness. When these researchers took into account motivations for avoidance of specific driving situations (e.g., driving on busy roads, driving in rush hour traffic, and planning out a route ahead of time), over 50 percent of drivers (all aged over 74 years) were found to avoid driving situations for non-compensatory reasons (Molnar, Eby, Charlton, et al., 2013). Common non-compensatory reasons for driving behaviour change among older adults include a change in lifestyle (e.g., retirement or having fewer activities to engage in), less need to travel under certain conditions due to greater flexibility in scheduling, and the financial costs of driving (Hakamies-Blomqvist & Wahlstrom, 1998; Meng & Siren, 2015; Molnar, Eby, Langford et al., 2013; Sullivan et al., 2011). Younger drivers also engage in avoidance behaviour supporting the assertion that, for some people, situational avoidance is related to reasons other than age-related declines in driving ability (Motak, Gabaude, Bougeant, & Huet, 2014; Naumann, Dellinger, & Kresnow, 2011). On this basis, it would be difficult to demonstrate the safety benefits of driving self-regulation if the behaviours measured do not reflect an older adult's effort to compensate for declines in driving skill. This also applies to the question of whether or not there exists a subset of older adults for whom inefficient use of compensation is explained by unawareness of changes in driving skill.

The Process of Driving Self-Regulation

Anstey and colleagues' (2005) Multifactorial Model for Enabling Driving Safety was developed to explain the components needed to identify crash risk among older adults (see Figure 2.2). This model explicitly separates "capacity to drive safely" from "actual driving behaviour" reflecting the belief, like Michon (1985) and Rasmussen (1987), that human choice plays an important role in determining driving behaviour. This model posits that an individual's capacity to drive safely is determined by their level of cognitive, sensory and physical skill (enabling factors), but self-monitoring beliefs (or insight into these enabling factors) determines the choices an individual makes about their driving behaviour, and thus, their ultimate safety on the road (Anstey et al., 2005). For example, an older driver with deficits in contrast sensitivity would continue to drive safely if he or she recognised this skill deficit and chose to avoid driving at night (the interaction between capacity to drive safely and self-monitoring behaviour).
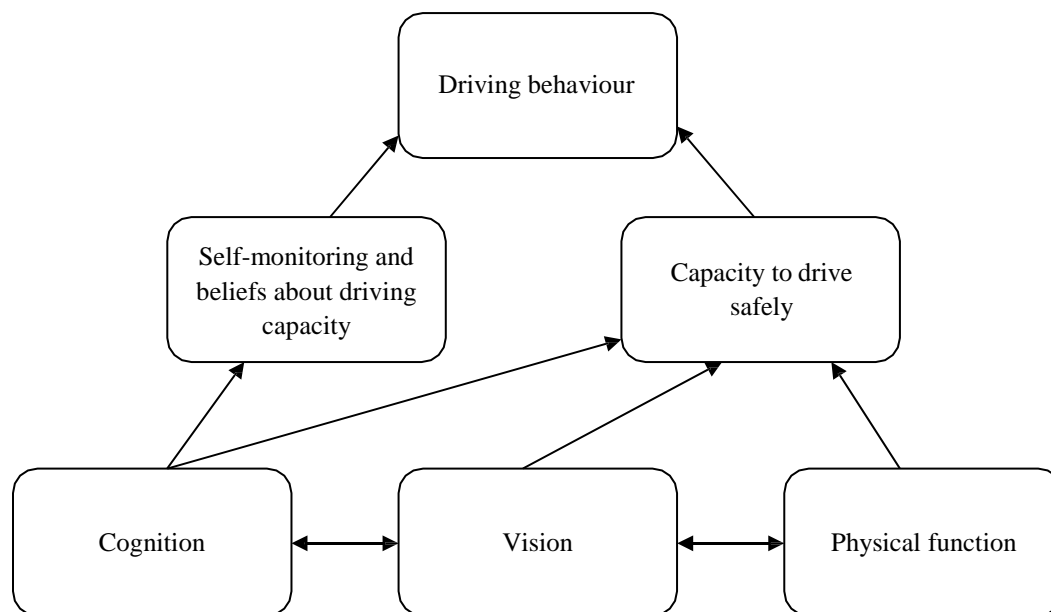
Figure 2.2. Anstey and colleagues' (2005) multifactorial model for enabling driving safety. Reprinted with permission from "Cognitive, Sensory and Physical Factors Enabling Driving Safety in Older Adults", by K. J. Anstey, J. Wood, S. Lord, and J. G. Walker, 2005, *Clinical Psychology Review, 25,* p. 60. Copyright 2005 by Elsevier.

In line with this model, qualitative studies of older drivers have found that the decision to begin to avoid certain situations when driving, or otherwise change driving habits, is often precipitated by an internal (e.g., self-assessment of driving skills) or external (e.g., a near-miss incident) cue suggesting that something about one's driving competence has changed (D'Ambrosio, Donorfio, Coughlin, Mohyde, & Meyer, 2008; Donorfio et al., 2009; Rudman et al., 2006). Yet for some drivers, this self-assessment or provision of feedback can result in the decision to modify driving or even cease driving altogether, while others may decide to leave their driving practices unchanged despite the inherent risks involved (Hakamies-Blomqvist & Wahlstrom, 1998; Nasvadi & Vavrik, 2007; Rimmo & Hakamies-Blomqvist, 2002; Ruechel & Mann, 2005; Wilkins, Stutts, & Schatz, 1999).

According to more recent models of driving self-regulation (e.g., Preliminary Model of Driving Self-Regulation, Rudman et al., 2006; Multilevel Older Persons Transportation and Road Safety Model, Wong, Smith, Sullivan, & Allan, 2014; Precaution Adoption Process Model of Driving Self-Regulation, Hassan, King, & Watt, 2015a) and theories of driving behaviour change (e.g., Stages of Driving Behaviour Change, Kowalski, Jeznach, & Tuokko, 2014), awareness of specific driving deficits, or at least a general perception of driving difficulty or loss of confidence on the road, is necessary but not sufficient for an older driver to self-regulate their driving. Other factors, such as the practical importance of driving, its symbolic meaning to the older adult, feedback and pressure from others, and the availability of alternate transportation options, interact with self-knowledge to influence an individual's readiness or willingness to self-regulate, and the appropriateness of the driving decisions made (Hassan et al., 2015a; Kowalski et al., 2014; Molnar et al., 2014; Rudman et al., 2006; Wong, Smith, & Sullivan, 2017). For example, Adler and colleagues (2000) found that some older adults with dementia continued to drive despite being aware of the risks of doing so because their spouse or family members depended on them to meet their mobility needs. This

suggests that intrapersonal, interpersonal and environmental factors influence how an older driver might express their awareness in everyday behaviour.

Awareness is a complex, multidimensional construct with no single clear definition or theoretical model (Markova, Clare, Wang, Romero, & Kenny, 2005). The phenomena of awareness elicited in a research study depends largely on the awareness concept and object of awareness selected by researchers, the measure/s used to capture this concept, and its association with factors that influence its expression (Markova et al., 2005). In clinical samples of drivers (e.g., stroke survivors or those with dementia), studies of awareness and driving behaviour have been grounded in established conceptual frameworks of awareness drawn from social, cognitive and neuropsychological theory (e.g., Cotrell & Wild, 1999; Gooden et al., 2017; Lundqvist & Alinder, 2007; Okonkwo et al., 2009; Patomella, Kottorp, & Tham, 2008; Wild & Cotrell, 2003). Driving self-regulation is believed to have its strongest impact within the population of older drivers who are in relatively good cognitive health, presumably because this group should have reasonable capacity for awareness (Daigneault et al., 2002; Hakamies-Blomqvist et al., 2004; Meng, Siren, & Teasdale, 2013). Use of established awareness frameworks within this population would help in testing this assumption.

Chapter 3 : Awareness – Concepts, Definitions and Models

The complexity of the awareness concept is illustrated by the range of terminology used to describe states of awareness or unawareness, including "insight", "anosognosia", and "denial". In social psychology and personality literature, self-awareness has been considered an individual difference variable describing to what extent a person attends to aspects of the self (Carver & Scheier, 1998). "Loss of awareness or insight" is commonly used by neuropsychological and psychiatric researchers and can be defined as an individual's loss of awareness of their psychological, physical, or social state (Lezak, 1995). Insight has also been viewed more broadly as incorporating two main components: 1) awareness of change; and 2) judgement concerning the impact of this change on everyday function (Markova et al., 2005). In comparison, the term "anosognosia" is used more often in clinical settings and was first introduced by Babinski (1914) to describe a lack of knowledge or awareness of an illness, or of disease-related deficits (as cited in McGlynn & Schacter, 1989). "Denial" is commonly associated with psychoanalytic theories and is defined as an active or motivated response of either refusing to acknowledge the presence of any difficulty or acknowledging a degree of difficulty yet refusing to accept its consequences (McGlynn & Schacter, 1989). Despite their different conceptual backgrounds and theoretical assumptions, many researchers have used these terms interchangeably making it difficult to determine: 1) what form or type of awareness has been measured; and 2) what may have contributed to unawareness (Markova et al., 2005). Each of these issues will be discussed.

Types of Awareness

The Pyramid Model of Awareness

In their work with patients with head injury, Crosson and colleagues (1989) identified three interdependent types of awareness: 1) intellectual awareness; 2) emergent awareness; and 3) anticipatory awareness (see Figure 3.1). *Intellectual awareness* is defined as an

individual's ability to understand that a particular function is impaired (Crosson et al., 1989). At the lowest levels, this requires an understanding that one is having greater difficulty when performing some activities and that there is a common cause of this difficulty across tasks. The highest level of intellectual awareness is required to understand the implications of one's deficits, for example, that vision problems may impede driving safety. *Emergent awareness* is the person's ability to recognise a problem when it is actually occurring, for example, inattention errors occurring when driving (Crosson et al., 1989). According to this model, to recognise errors during a task, a person must first be aware that a deficit exists. Thus, intellectual awareness is necessary but not sufficient for emergent awareness (Crosson et al., 1989). This suggests a person may have accurate knowledge that a driving skill is impaired but fail to recognise driving errors as they occur unless someone else points them out. Lastly, *anticipatory awareness* is the ability to anticipate that a problem will occur as the result of a deficit (Crosson et al., 1989). For example, that driving safety will be impaired at night due to poor contrast sensitivity. The ability to anticipate that a problem will occur requires knowledge that a problem exists (intellectual awareness) and the ability to recognise when this problem arises (emergent awareness) (Crosson et al., 1989). A person with a deficit in anticipatory awareness would be unable to realise that a given deficit will affect performance on a future task.
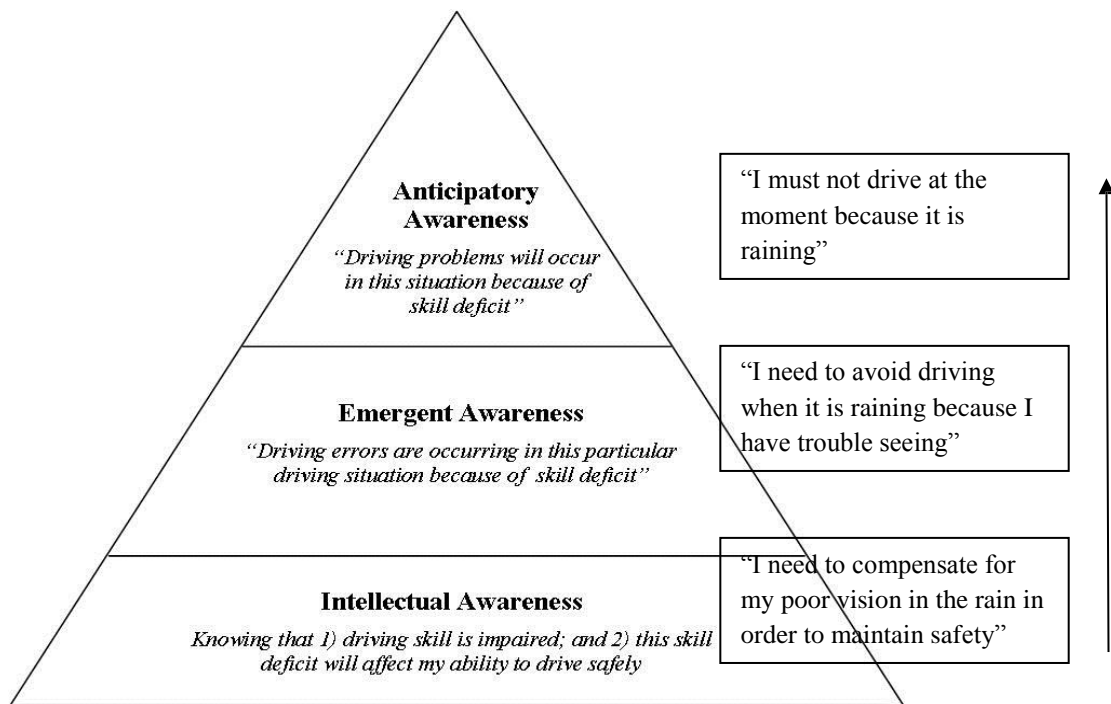
Figure 3.1. The Pyramid Model of Awareness (Crosson et al., 1989) and its association with driving self-regulation.

Crosson and colleagues' (1989) posit that the type of compensation that should be used by a particular individual depends on the kind of awareness deficit they exhibit (see Table 3.1). Like their proposed awareness model, these strategies are hierarchical. Most educational programs/interventions targeted at increasing awareness and driving self-regulation in older drivers have focused on increasing older driver's knowledge of age- and disease-related impairments in driving skill (e.g., Ackerman et al., 2011; Eby, Molnar, Shope, Vivoda, & Fordyce, 2003; Owsley, Stalvey, & Phillips, 2003; Owsley et al., 2004). Since knowledge is the basis of intellectual awareness, these programs are essentially targeting intellectual awareness alone (Crosson et al., 1989). Owsley and colleagues (2004) found that while their individually tailored educational session decreased driving exposure and increased situational avoidance, 23% of participants were still involved in a motor vehicle crash post-intervention (RR = 1.08 per 100 person-years; RR = 1.40 per 1,000,000 person-miles of travel). According to the Pyramid Model of Awareness (Crosson et al., 1989), the subset of older drivers who

incurred a motor vehicle crash despite reporting self-regulation may not have had the

prerequisite level of awareness needed to support use of the compensatory strategies taught in

the educational intervention.

Table 3.1. *Relationships between the Type of Awareness and Compensation (adapted from*

Crosson et al., 1989).

Awareness	Type of Compensation	Examples
Intellectual awareness only	*Situational compensation:* Life-goal, strategic and (some) tactical driving self-regulation applied habitually (applied even at times when not necessary).	• Moving to an area with more non-driving mobility options to reduce reliance on driving in general. • Consistent avoidance of driving at night, at peak hour or in bad weather. • Consistent avoidance of areas that require driving above a certain speed limit.
Emergent awareness intact	*Recognition compensation:* Tactical compensation in response to environmental feedback regarding driving error.	• Reducing speed • Allowing larger gaps • Double-checking mirrors • Changing planned route
Anticipatory awareness intact	*Anticipatory compensation:* Strategic and tactical driving self-regulation that is applied only in appropriate circumstances.	• Avoid driving in the rain on the motorway (high speeds) but drive in the rain in local, familiar areas that have a lower speed limit.

The Pyramid Model of Awareness (Crosson et al., 1989) has been referred to widely in

the literature given its direct implications for rehabilitation. However, it does not take into

account the individual's belief systems, explain how the different levels of awareness interact

or show why some levels of awareness can be observed in some situations but not in others

(O'Keefe, Dockree, Moloney, Carton, & Robertson, 2007; Toglia & Kirk, 2000). In light of

these issues, Toglia and Kirk (2000) extended the Pyramid Model of Awareness and

developed a more comprehensive model that draws upon concepts from cognitive psychology

(metacognition), neuropsychology, and social psychology (self-efficacy beliefs). Like

Crosson and colleagues' (1989) model, Toglia and Kirk's (2000) model was developed to

explain instances and types of unawareness in persons following brain injury. Despite their

reasons for development, the concepts in both models may contribute substantially to our

understanding of unawareness in older drivers.

Toglia and Kirk's Model of Awareness

Toglia and Kirk's (2000) proposed model of awareness is based on the concept of metacognition (see Figure 3.2). Metacognition involves two distinct but interrelated forms of awareness, metacognitive knowledge and online awareness (Flavell, 1979; Metcalfe & Shimamura, 1994).

METACOGNITIVE KNOWLEDGE
"KNOWING THAT"
Exists prior to a task/situation

ONLINE AWARENESS
"SITUATIONAL"
Activated within tasks/situations

Knowledge
- Knowledge about task characteristics
- Knowledge of strategies
- Knowledge of specific aspects within the domain of functioning
- Procedural knowledge of tasks

Self-Knowledge & Beliefs
(Intellectual Awareness)
- Perceptions of one's own mental functioning
- Identification and understanding of strengths and limitations
- Self-efficacy beliefs
- Beliefs regarding "why" one is having difficulty
- Beliefs regarding tasks, future and ability to function
- Affective states concerning knowledge and abilities

Conceptualisation & Appraisal of the Task or Situation
(Anticipatory Awareness)

Task Experience

Self-Monitoring of Current Cognitive State
(Emergent Awareness)
- Recognition of errors
- Adjusting performance (self-regulatory skills)

Self-Evaluation
- Beliefs / perception of performance

Figure 3.2. Awareness component of Toglia and Kirk's (2000) proposed model of awareness. Reprinted with permission from "Understanding Awareness following Brain Injury", by J. Toglia and U. Kirk, 2000, *NeuroRehabilitation, 15,* p. 60. Copyright 2000 by IOS Press.

Metacognitive knowledge includes knowledge and beliefs related to one's self that exists prior to an actual task or situation and is stored within long-term memory (Toglia & Kirk, 2000). It involves two interrelated aspects: 1) declarative or factual knowledge of task characteristics, cognitive processes and strategies in different areas of function (*knowledge*);

and 2) self-understanding of one's capabilities and limitations (*self-knowledge and beliefs*) (Toglia & Kirk, 2000). Thus, metacognitive knowledge is an extension of Crosson and colleagues' (1989) concept of intellectual awareness.

Metacognitive knowledge is developed from information obtained from a variety of sources over time, including past experiences in similar situations and reliable feedback from others (Toglia & Kirk, 2000). For example, when learning to drive, young adults develop knowledge of the driving task and strategies to improve their driving ability from their direct experience as well as from knowledgeable others. Although self-knowledge and beliefs are relatively stable from this initial formation point, they can change over time and are influenced by ongoing evaluations and perceptions of successes and failures (Bandura, 1977; Toglia & Kirk, 2000). Thus, with time and repeated driving exposure, adults develop an extensive knowledge base related to driving (e.g., procedural knowledge, knowledge about task characteristics and driving strategies) as well as increased self-understanding of how their skills have improved or declined over time.

Metacognitive knowledge influences behaviour via top-down processes such as conflict resolution, planning, resource allocation and inhibitory control (Fernandez-Duque, Baird, & Posner, 2000). The driving decisions of older adults, particularly strategic decisions (e.g., when and where to travel), would be informed by the content and accuracy of their metacognitive knowledge. An individual with inaccurate metacognitive knowledge may fail to avoid driving in situations experienced as challenging. They may also show biases in the processing and interpretation of incoming information when actually driving in that situation (Toglia & Kirk, 2000). Thus, inaccurate beliefs regarding one's abilities can also limit performance by disrupting online awareness.

Online awareness describes the ability to monitor performance "online" or within the stream of action and involves judgements about one's abilities in relation to the current

situation (Toglia & Kirk, 2000). Thus, whereas metacognitive knowledge exists prior to a task, online awareness is task- and time-specific and is relatively unstable (Toglia & Kirk, 2000). Online awareness comprises self-monitoring and self-regulatory processes. Self-monitoring involves appraisal of current task demands (anticipatory awareness) and detection of errors during a task (emergent awareness) (Toglia & Kirk, 2000). Online anticipatory and emergent awareness are highly dependent on intact cognitive perceptual skills necessary to integrate all aspects of an ongoing task (O'Keefe et al., 2007; Toglia & Kirk, 2000). Self-regulatory processes are initiated in response to perceived errors or changes in task demands throughout this self-monitoring process (Toglia & Kirk, 2000).

Previous experiences of success or failure on the same or a similar task influences an individual's expectations and anticipations regarding the current task outcome (*online anticipatory awareness*) (Toglia & Kirk, 2000). If an individual perceives the task as easy, they are unlikely to initiate a strategy or pay close attention to what they are doing (Toglia & Kirk, 2000). According to Gregersen (1996), in younger drivers, overestimation of driving skill contributes to higher accident involvement. An older adult who overestimates their ability may continue to drive (e.g., at night) when it is no longer safe to do so.

An individual's appraisal of a task prior to undertaking it, in turn, interacts with *online emergent awareness*, influencing whether or not they perceive a need for further self-monitoring and self-regulation (Toglia & Kirk, 2000). Online emergent awareness influences behaviour via bottom-up processes such as error detection and correction (Fernandez-Duque et al., 2000). Cognitively healthy individuals have the ability to internally evaluate their own performance, detecting errors in the absence of any external feedback (Fernandez-Duque et al., 2000). Inability to recognise and correct erroneous behaviour significantly affects an older adult's capacity to live independently in the community (Bettcher & Giovannetti, 2009). In terms of driving, an older driver's capacity to detect driving error is a necessary first step to

avoiding a motor vehicle crash.

At the conclusion of a task, self-evaluation requires the initiation of self-checking skills and the capacity to reflect back on performance and recognise discrepancies between actual and expected task outcomes (Toglia & Kirk, 2000; Stuss, 1991). An individual's assessment of the outcome of task performance, within the context of a particular situation, can restructure and shape stored knowledge and beliefs about one's abilities (metacognitive knowledge) (Toglia & Kirk, 2000). Thus, unlike Crosson and colleague's (1989) model, this framework predicts constant interactions between and within metacognitive knowledge and online awareness.

Explanations for Unawareness in Older Adults

Older adults may over-report, under-report or express accurate awareness of age- or disease-related declines in driving ability. There are three domains into which the common explanations for disordered awareness fall, including: 1) neurological, 2) psychological; and 3) social/cultural (Clare, 2004a; Ownsworth, Clare, & Morris, 2006). There is extensive literature emphasising a neurological explanation for unawareness, wherein it is viewed as a symptom of pathological changes in the brain (Clare, 2004a). This is derived primarily from work with people who have had a brain injury, however, cannot explain all instances of unawareness, both in persons with brain injury or dementia, and particularly in those without significant cognitive impairment (Clare, 2003; Weinstein, Friedland, & Wagner, 1994).

Age- and illness-related changes in the capacity to function independently in everyday life can constitute a threat to one's self-concept (Weinstein et al., 1994). In some individuals, this threat can lead to attempts to regain control and independence, which can affect the ways in which people communicate and account for their deficits (hence, the use of the term "denial") (Clare, 2003). The socially constructed nature of awareness and the influence of context can also determine the accuracy of communicated responses to questions regarding

functional status (Clare, 2003). Thus, instances of unawareness are not limited to those with cognitive impairment and may be explained by any one or a combination of these three domains (Ownsworth et al., 2006). Each of these domains and how they explain unawareness in older drivers will be discussed.

Neurological Accounts of Unawareness

Neurological accounts of unawareness consist of neuroanatomical and cognitive neuropsychological explanations. Neuroanatomical accounts of unawareness are based on the theory that loss of awareness is associated with focal lesions in areas proposed to mediate awareness or diffuse brain damage that disrupts the mechanism/s needed to maintain accurate awareness (McGlynn & Schacter, 1989). Thus, persons with neurologically based unawareness (anosognosia) are believed to lack the capacity to access the knowledge systems necessary to self-evaluate their strengths and limitations.

A number of studies have found that awareness deficits are associated with general cognitive decline, supporting the view that anosognosia may arise following diffuse rather than focal deficits (Piras, Piras, Orfei, Caltagirone, & Spalletta, 2016; Starkstein, Sabe, Chemerinski, Jason, & Leiguarda, 1996; Starkstein, Jorge, Mizrahi, & Robinson, 2006; Trudel, Tryon, & Purdum, 1998; Wilson, Sytsma, Barnes, & Boyle, 2016). In this view, with the development of disease or pathological processes, older adults' may exhibit marked cognitive decline that interferes with their capacity to develop and maintain awareness. In line with this, unawareness has been found in prodromal and very early stages of dementia (Chung & Man, 2009; Tremont & Alosco, 2011; Vogel, Hasselbalch, Gade, Ziebell, & Waldemar, 2005; Vogel et al., 2004; Wilson et al., 2015). Studies have also shown that anosognosia becomes worse with disease progression (Derouesne et al., 1999; Starkstein et al., 1996; Starkstein et al., 1997; Starkstein et al., 2006).

However, other studies have failed to find a relationship between level of awareness and

general cognitive decline (e.g., Clare & Wilson, 2006; Ownsworth, McFarland, & Young, 2002; Vogel, Waldorff, & Waldemar, 2015). Deficits in awareness have been observed in individuals with largely intact intellectual functioning following brain injury (McGlynn & Schacter, 1989), and some individuals with severe Alzheimer's disease recognise and acknowledge various impairments related to their illness (Reed, Jagust, & Coulter, 1993). Overall, awareness seems to be largely idiosyncratic and at times, domain-specific (Green, Goldstein, Sirockman, & Green, 1993; Okonkwo et al., 2009; Ott et al., 1996). These findings suggest that more specific mechanisms underlie levels of awareness.

The contribution of the right hemisphere in general, and right frontal and parietal areas in particular, to the experience of awareness has been emphasised (Cosentino et al., 2015; McGlynn & Schacter, 1989; Orfei et al., 2007; Reed et al., 1993; Starkstein, Fedoroff, Price, Leiguarda, & Robinson, 1992; Stuss, Picton, & Alexander, 2001; Vogel et al., 2005). Research on brain injury and stroke has underscored the role of right fronto-parietal or fronto-parietal-temporal areas in supporting various aspects of awareness of motor impairment, particularly awareness for left hemiplegia (Orfei et al., 2007; Starkstein et al., 1992). The role of the frontal lobes in mediating awareness has also been demonstrated by studies that have shown that individuals with frontal lesions or frontal hypoperfusion (particularly in the right hemisphere) present more often with anosognosia than individuals with intact frontal lobe functioning (Hoerold, Pender, & Robertson, 2013; Hornberger et al., 2012; Starkstein et al., 1995; Vogel et al., 2004).

Further support for the role of the frontal lobes in the experience of awareness is derived from cognitive neuropsychological models of awareness, with poorer performance on measures of executive functioning associated with increased levels of unawareness (Lysaker, Bell, Bryson, & Kaplan, 1998; Michon, Deweer, Pillon, Agid, & Dubois, 1994; Noe et al., 2005). Specific measures of executive functioning related to level of awareness include

reasoning (Ownsworth et al., 2002), idea generation or fluency (Mohamed, Fleming, Penn, & Spaulding, 1999; Ownsworth & Fleming, 2005), cognitive flexibility (Lysaker et al., 1998; Lysaker, Whitney, & Davis, 2006; Michon et al., 1994; Ott et al., 1996; Trudel et al., 1998), and error self-regulation (Bogod, Mateer, & MacDonald, 2003; Ownsworth & Fleming, 2005; Ownsworth et al., 2007).

Many studies investigating the role of cognition in influencing awareness of driving impairment and the initiation of driving self-regulation have used general cognitive screens such as the Mini Mental State Examination. Some of these studies have found that older adults with cognitive impairment reported more difficulty with driving than drivers without cognitive impairment and tended to drive less often in challenging situations (Braitman & Williams, 2011; Cotrell & Wild, 1999; Devlin & McGillivray, 2016; Festa, Ott, Manning, Davis, & Heindel, 2012; Freund & Szinovacz, 2002; O'Connor, Edwards, Wadley, & Crowe, 2010; O'Connor, Edwards, & Bannon, 2013). Other studies have found that poorer performance on the cognitive screen was associated with inaccurate evaluations of driving ability, including underestimating the level of difficulty experienced when driving (Ball et al., 1998; Dubinsky, Williamson, Gray, & Glatt, 1992; Lyman et al., 2001; Meng et al., 2013; Wood, Lacherez, & Anstey, 2013), overestimating capacity to drive safely (Baldock et al., 2008; Devlin & McGillivray, 2016; Hunt, Morris, Edwards, & Wilson, 1993; Okonkwo et al., 2009; Wild & Cotrell, 2003; Wood et al., 2013), and inappropriate use of self-regulatory driving strategies (Ball et al., 1998; Kowalski et al., 2012; Meng et al., 2013; Valcour, Masaki, & Blanchette, 2002; Wong et al., 2012).

For the most part, inconsistencies in this area are due to considerable variability across studies in terms of the characteristics of study participants (e.g., drivers with normal age-related cognitive change versus those with Mild Cognitive Impairment or dementia) and how awareness and driving self-regulation were measured. The reasons for driving self-regulation

have also not been considered making it difficult to determine whether the driving behaviour change reported across studies is a result of awareness and an intentional decision to initiate compensation rather than due to external reasons (e.g., in response to pressure from others or for lifestyle or convenience reasons). To date, no study has explored concurrently whether unawareness of driving ability in a community-based sample of older drivers is associated with a specific type of cognitive decline (e.g., in executive function), the nature of any awareness deficit that arises (e.g., global or domain-specific), and the relationship between executive functioning, awareness and compensatory driving behaviour.

Psychological Accounts of Unawareness

Psychological models of unawareness are based upon the recognition that declines in function can affect one's ability to carry out everyday roles, duties and social obligations, threatening an individual's sense of self and ability to maintain a meaningful existence (Clare, 2003; Weinstein et al., 1994). Thus, acknowledgement of deficits might be repressed or denied by individuals who experience them in order to minimise these threats to one's lifestyle and self-concept, and/or to avoid any embarrassment associated with these losses (Clare , 2003). In this way, denial can serve as an active coping strategy, protecting the individual against the development of depression that can occur when one is aware of their deficits (Ownsworth et al., 2007).

Persons who actively deny their deficits often react with defensiveness and hostility when confronted with them (Broberg & Willstrand, 2014), whereas persons who are unaware because of neurological impairment are less likely to display such reactions due to a failure to recognise a need to cope (Prigatano, 1996). However, like neurologically based unawareness, psychologically based unawareness can interfere with rehabilitation outcomes. The use of denial can prevent an individual from seeing the need for compensation (Crosson et al., 1989). In other cases, the person may recognise that deficits exist, but the use of

compensation may not fit into their self-concept or may be seen as socially undesirable (Crosson et al., 1989). Thus, a person using denial as a coping strategy may fail to self-regulate their behaviour at all, or may underreport difficulties and the use of self-regulation to maintain a favourable social image.

Weinstein and colleagues (1994) proposed that people were more likely to deny impairments associated with Alzheimer's disease if they had longstanding views of illness as a sign of weakness and a tendency toward perfectionism or high expectations of themselves. These authors referred to these persons as having features of a "premorbid denial personality" (e.g., conscientiousness, hard-working, efficient and organised with an emphasis on willpower and self-sufficiency). In this view, some individuals may have a natural predisposition to cope with age- or disease-related declines with denial rather than acceptance and adaptation.

Driving is of fundamental importance to all adults as a source of independence and self-worth (Eisenhandler, 1990). Driving cessation necessitates changes to one's personal and social identity and this change can be experienced as distressing (Pachana, Jetten, Gustafsson, & Liddle, 2016). Individuals who have ceased driving have been shown to be at greater risk of depression (Marottoli, Mendes de Leon, et al., 1997), social isolation (Taylor & Tripodes, 2001), low self-esteem and increased functional impairment (Marottoli et al., 2000; Oxley & Charlton, 2009). This may foster denial or defensiveness in response to enquiries about driving capacity in some older adults, especially among those more inclined to use denial as a coping strategy.

Older men have been shown to be more emotionally invested in driving and have a longstanding identity with operating a motor vehicle (Nasvadi & Wister, 2009). As a result, older men may deny or minimise the presence of driving impairment and/or refuse to give up or reduce their driving frequency in order to maintain their driving identity and self-esteem

(Adler & Rottunda, 2006; Donorfio et al., 2009; Nasvadi & Vavrik, 2007; Tuokko, McGee, Gabriel, & Rhodes, 2007). In a qualitative study of driving behaviour, older men and women appeared to differ significantly in terms of how they perceived driving. Men were more likely to perceive driving as a static skill within a changing environment, whereas women were more likely to view driving as an intrinsic skill that changed with age due to declining ability (Donorfio, Mohyde, Coughlin, & D'Ambrosio, 2008). However, while older women appear more accepting of the possibility of age-related changes in driving ability, they are also more likely to report significantly lower confidence and greater difficulty when driving than older men despite not differing from them in terms of actual driving ability (Charlton, Oxley, Fildes, et al., 2006; Hassan, King, & Watt, 2015b; Oxley & Charlton, 2009). Older women might actually over-report driving impairment and underestimate their driving ability, restricting their driving behaviour in the absence of functional reasons to do so (Keay et al., 2009; Rimmo & Hakamies-Blomqvist, 2002; Rosenbloom & Herbel, 2009; Siren, Hakamies-Blomqvist, & Lindeman, 2004).

Unwillingness to acknowledge driving limitations and to restrict one's driving may also be influenced by the degree and type of transportation alternatives available to an older adult (Donorfio et al., 2009; Stalvey & Owsley, 2000). Baldock and colleagues (2006a) found that 70% of their sample of older drivers reported that the greatest barrier to driving self-regulation was maintenance of their lifestyle. Older drivers who lack accessibility to public transportation services may be more likely to deny or minimise driving impairment and fail to self-regulate their driving in order to maintain their current lifestyle (Adler & Rottunda, 2006). In addition, some older adults are the principal drivers of their household and as a result, have a responsibility not only to themselves but also to others to continue to drive (Charlton, Oxley, Fildes, et al., 2006; Charlton, Oxley, Scully, et al., 2006; Donorfio, D'Ambrosio, et al., 2008; Oxley et al., 2005). Principal drivers may deny or minimise the

presence of driving limitations because of perceived pressure to continue to drive and to reduce the incongruity between perceived ability and actual driving behaviour.

Social / Cultural Accounts of Unawareness

Social and cultural models of unawareness are built on the theory that sociocultural contexts can impact the level of awareness individuals express towards their illness- or age-associated declines (Clare, 2004a). This includes the way in which the type of impairment is viewed in society as a whole, as well as the immediate social network and family context (Clare, 2008). Research has shown that people have well-defined expectations about age-related gains and losses typically experienced over the lifespan, with the general expectation that losses will outweigh gains as age advances (Heckhausen, Dixon, & Baltes, 1989). These ageing stereotypes at a societal level are often internalised by older adults, leading to negative self-stereotyping that can affect behavioural and functional outcomes (Barber, 2017; Robertson, King-Kallimanis, & Kenny, 2016). For example, Levy (1996) found older adults performed significantly better on a memory task and reported higher memory self-efficacy and more positive views of ageing when positive relative to negative stereotypes of ageing were implicitly activated. This effect did not occur in younger adults suggesting that the stereotypes evoked (wisdom and senility) were personally relevant and already internalised amongst the older adult participants.

Social beliefs regarding ageing drivers, particularly the negative connotations associated with "older drivers" in the media, may reduce the motivation or willingness of some older drivers' to report declines in their driving ability (Ferring, Tournier, & Mancini, 2015; Joanisse, Gagnon, & Voloaca, 2012; Rudman et al., 2006). Even more concerning are findings of a deleterious effect of stereotype threat on older drivers' performance while driving (e.g., longer brake reaction times and increased errors on a simulated driving task) (Joanisse, Gagnon, & Voloaca, 2013). Brelet and colleagues (2016) found that older drivers

who were exposed to information on their age-related decline and how this might increase their risk of motor vehicle crashes self-regulated their driving in a less strategic way and tended to drive, on average, faster than control participants who were not provided with this information. These authors proposed that the activation of a negative stereotype (i.e., fearing to confirm the stereotype of a 'bad' older driver in testing) taxes an older adult's working memory resources, with this fear competing with the primary task of driving.

These findings suggest caution should be applied in the use of feedback and educational programs to promote safe driving behaviour among older road users. External feedback can be received from a variety of sources including family, medical practitioners, other road users and involvement in near misses or actual crashes, as well as formal education programs (Hassan et al., 2015a; Kowalski et al., 2014; Rudman et al., 2006; Tuokko et al., 2014). At a group level, feedback regarding functional status has been found to prompt modification of driving behaviour, supposedly through fostering increased awareness of driving-related abilities (Ackerman et al., 2011; Ackerman et al., 2014; Ackerman, Vance, & Ball, 2016; Eby et al., 2003; Holland & Rabbitt, 1992; Horswill, Garth, Hill & Watson, 2017; Kua, Korner-Bitensky, Desrosiers, Man-Son-Hing, & Marshall, 2007; Molnar, Eby, Kartje, & St Louis, 2010; Owsley et al., 2003; Porter & Tuokko, 2011; Tuokko et al., 2007). However, individual differences exist in terms of whose feedback is listened to or valued, and in one's willingness to act on the information received and implement driving behaviour change (Ackerman et al., 2014; Hassan et al., 2015a; Owsley et al., 2003; Tuokko et al., 2007).

For example, the willingness of some older drivers to depend on others may influence the nature and accuracy of communicated responses to questions of impairment. While driving self-regulation may mean the maintenance of safe mobility, it does essentially involve curtailing driving to some extent. By limiting their driving, older adults' increase their dependence upon others to continue to have access to essential services and resources outside

of their home (e.g., medical care and grocery shopping) (Donorfio et al., 2009; Taylor & Tripodes, 2001). Nearly half of the sample in Baldock and colleagues' (2006a) study reported that they were unwilling to ask family or friends for help with transportation. Thus, some older adults may deny or minimise driving impairment in order to avoid feeling burdensome on their family members.

Summary: Awareness Typologies

An older adult's awareness of their capacity to drive safely represents perhaps the most important predictor of accurate driving self-regulation (Anstey et al., 2005). Awareness is not a single, unidimensional construct but rather is characterised by an interaction between two distinct levels or forms, metacognitive knowledge and online awareness (Toglia & Kirk, 2000) (see Figure 3.3). When rating their capacity for safe driving, older drivers may overestimate, underestimate or express accurate awareness of their driving ability at one or both levels of awareness. The type of awareness deficit observed is believed to be associated with differing degrees of compensation (Crosson et al., 1989; De Craen, Twisk, Hagenzieker, Elffers, & Brookhuis, 2007). For example, an older driver who underestimates their driving capacity (e.g., an older female driver) may report unnecessarily restrictive driving behaviours, whereas an older driver who overestimates their driving capacity (e.g., an older male driver or a driver with cognitive impairment) may report little to no driving self-regulation.

METACOGNITIVE KNOWLEDGE
"KNOWING THAT"
Exists prior to a task/situation

ONLINE AWARENESS
"SITUATIONAL"
Activated within tasks/situations

Domain of Concern
- Physical
- Cognitive
- Visual
- Interpersonal
- Emotional
- Functional

Knowledge
- Knowledge about task characteristics
- Knowledge of strategies
- Knowledge of specific aspects within the domain of functioning
- Procedural knowledge of tasks

Conceptualisation &
Appraisal of the Task or
Situation
(Anticipatory Awareness)

Task Experience

Influences
Specific to online awareness:
- Cognitive perceptual deficits
- Task difficulty and characteristics

Both forms of awareness:
- Cognitive deficits
- Emotional state
- Motivation
- Meaningfulness
- Value
- Context

Depth of Awareness
Explicit:
- Global
- Task specific
- Recognition across situations
- Implications across situations

Self-Knowledge & Beliefs
(Intellectual Awareness)
- Perceptions of one's own mental functioning
- Identification and understanding of strengths and limitations
- Self-efficacy beliefs
- Beliefs regarding "why" one is having difficulty
- Beliefs regarding tasks, future and ability to function
- Affective states concerning knowledge and abilities

Self-Monitoring of Current
Cognitive State
(Emergent Awareness)
- Recognition of errors
- Adjusting performance (self-regulatory skills)

Self-Evaluation
- Beliefs / perception of performance

RESPONSE TO FEEDBACK

Agrees (confirms self-belief)　　Perplexity　　Surprise　　Confusion　　Indifference　　Resistance　　Hostility　　Anger

Figure 3.3. Toglia and Kirk's (2000) complete model of awareness. Reprinted with permission from "Understanding Awareness following Brain Injury", by J. Toglia and U. Kirk, 2000, *NeuroRehabilitation, 15,* p. 60. Copyright 2000 by IOS Press.

Consistent with proposed models of driving self-regulation (e.g., Hassan et al., 2015a; Kowalski et al., 2014; Rudman et al., 2006), Toglia and Kirk's (2000) model of awareness recognises that processes both internal and external to the person interact with self-awareness, influencing their emotional responses and actual behaviour. Neuropsychological causes of unawareness influence the nature of the awareness deficit (i.e., domain-specific or global) whereas psychosocial explanations for unawareness more often influence the expression of awareness (Clare, 2003). For some older drivers, cognitive impairment may affect awareness of driving difficulty. The role and importance of driving to older adults, and barriers to the practice of driving self-regulation, suggest that unawareness of driving deficits may emerge in the form of denial in those without cognitive deficits.

In recognition of the multifaceted nature and causes of awareness or unawareness, a number of studies have moved away from simply identifying individuals as "aware" or "unaware" and instead have focused on identifying meaningful subgroups of individuals based upon their responses on measures of different awareness phenomena (Broberg & Willstrand, 2014; Clare et al., 2011; De Craen et al., 2007; Fleming, Strong, & Ashton, 1998; Ownsworth et al., 2007). These groups are referred to as awareness typologies. Some researchers have identified groups with varying levels of awareness (e.g., "low, moderate, high", Clare et al., 2011; "under- and overestimators", Broberg & Willstrand, 2014; De Craen et al., 2007). Others have included cognitive and psychosocial measures to identify groups with accurate awareness, and neuropsychologically and psychologically based unawareness (e.g., Fleming et al., 1998; Ownsworth et al., 2007).

To date, no study has determined the relative role of neuropsychological and psychosocial factors together in influencing the driving decisions of cognitively healthy older adults. Factors such as age-related change in executive function and degree of denial/defensiveness may differentiate between awareness typologies in an older driver

population, and group membership would be expected to predict differing degrees of compensatory driving self-regulation. The first step in testing this hypothesis involved the development of a questionnaire assessing one form of driving self-regulation, situational avoidance. This process is described in the next chapter.

Chapter 4 : Measuring Situational Avoidance in Older Drivers – An Application of Rasch Analysis

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Statement on Authorship Contribution:

As co-authors of the published paper entitled, "Measuring Situational Avoidance in Older Drivers: An Application of Rasch Analysis", we confirm that Jessica Davis has made the following contributions:

a) Formulation of the study hypotheses and critical review of the relevant literature;

b) Development of questionnaire items with direction and feedback from co-authors;

c) Collecting and entering the data into the statistical software package;

d) Analysing and interpreting the data under the direction of co-authors;

e) Writing the paper with direction and feedback from co-authors.

Furthermore, we agree to the inclusion of the paper in this research thesis for examination.

Jessica Davis

Elizabeth Conlon

Tamara Ownsworth

Shirley Morrissey   31/05/2017

Abstract

Situational avoidance is a form of driving self-regulation at the strategic level of driving behaviour. It has typically been defined as the purposeful avoidance of driving situations perceived as challenging or potentially hazardous. To date, assessment of the psychometric properties of existing situational avoidance questionnaires has been sparse. This study examined the contribution of Rasch analysis to the situational avoidance construct. Three hundred and ninety-nine Australian drivers (*M* = 66.75, *SD* = 10.14, range: 48 to 91 years) completed the Situational Avoidance Questionnaire (SAQ). Following removal of the item *Parallel Parking*, the scale conformed to a Rasch model, showing good person separation, sufficient reliability, little disordering of thresholds, and no evidence of differential item functioning by age or gender. The residuals were independent supporting the assumption of unidimensionality and in conforming to a Rasch model, SAQ items were found to be hierarchical or cumulative. Increased avoidance was associated with factors known to be related to driving self-regulation more broadly, including older age, female gender, reduced driving space and frequency, reporting a change in driving in the past five years and poorer indices of health (i.e., self-rated mood, vision and cognitive function). Overall, these results support the use of the SAQ as a psychometrically sound measure of situational avoidance. Application of Rasch analysis to this area of research advances understanding of the driving self-regulation construct and its practice by drivers in baby boomer and older adult generations.

Key words: Driving self-regulation questionnaire; older drivers; Rasch analysis.

Introduction

Maintaining independence, engaging in social and recreational activities, and accessing essential services outside of the home are all key determinants of quality of life (Gabriel and Bowling, 2004; Oxley and Whelan, 2008). For older adults, much of this relies on their

capacity to drive a motor vehicle (Oxley and Whelan, 2008). Driving is a complex skill dependent upon a combination of visual, cognitive and physical abilities (Anstey et al., 2005). Many of these component abilities are vulnerable to age- and disease-related decline and are thought to underlie the unique profile of older driver crashes (Anstey et al., 2005; Anstey and Wood, 2011; Cicchino and McCartt, 2015; Langford and Koppel, 2006a; McGwin and Brown, 1999). However, there is considerable variability in both normal and pathological ageing processes (Anstey and Low, 2004). This variability, combined with the negative consequences of driving cessation (e.g., Fonda et al., 2001; Marottoli, Mendes de Leon, et al., 1997; Marottoli et al., 2000; Oxley and Charlton, 2009; Ragland et al., 2005), has prompted the search for ways in which older driver safety may be balanced with their continued mobility (Berry, 2011; Dickerson et al., 2007; Hakamies-Blomqvist et al., 2004). One particularly promising strategy is 'driving self-regulation'.

Driving self-regulation refers to the process whereby older drivers voluntarily modify their driving practices in an attempt to reduce the perceived demands of the driving task (Ball et al., 1998; Charlton, Oxley, Fildes, et al., 2006; Donorfio et al., 2009). Although the evidence is mixed (e.g., Owsley et al., 2004; Ross et al., 2009), it has been argued that by avoiding challenging driving situations, older adults are actively involved in reducing their crash risk (Charlton, Oxley, Scully, et al., 2006; Hakamies-Blomqvist, 1993). Practically, a graduated reduction in driving among at-risk older adults would not only maintain their independence, but would also reduce the financial and social burden that would be present if the largest segment of Australia's population was denied access to a motor vehicle (Berry, 2011; Langford and Koppel, 2006b; Taylor and Tripodes, 2001). When we consider that the baby-boom generation, born between the years 1946 and 1966, are now entering late adulthood, these mobility benefits become particularly persuasive (Australian Bureau of Statistics, ABS, 2014; Dobbs, 2008).

Driving self-regulation can occur at all three levels of driving behaviour or decision-making (Michon, 1985; Rasmussen, 1983, 1987). The strategic or knowledge-based level involves planning of a trip, including the choice of trip goals and route (e.g., to minimise time or avoid a certain route), as well as an evaluation of the risks involved (Michon, 1985; Ranney, 1994). These plans are typically made prior to getting in the car. At the tactical level, drivers exercise manoeuvring control on a moment-to-moment basis, allowing negotiation of the traffic environment (Michon, 1985). Decisions at this level include gap acceptance in overtaking or merging, how to negotiate an upcoming intersection and what speed to adopt (Smiley, 2004). While under the drivers' control for the most part, these behaviours are also constrained by the traffic environment and other road users (e.g., entering an intersection is influenced by the presence of other drivers) (Smiley, 2004). Lastly, the operational level involves basic vehicle control and largely consists of automatic action patterns (e.g., accelerating, steering or braking) (Michon, 1985). These behaviours are least amenable to conscious self-regulation, though there is some evidence that older adults adopt different vehicle control (Hakamies-Blomqvist et al., 1999) and visual scanning (Charlton et al., 2005) practices than younger drivers. When considered together, appropriate decisions made at higher levels of this hierarchy are believed to result in on-road driving behaviour that is experienced as less taxing on the resources or overall skill level of a driver (Michon, 1985; Ranney, 1994).

A great deal of research has been conducted examining the characteristics and incidence of driving self-regulation (Braitman and McCartt, 2008; Braitman and Williams, 2011; Charlton, Oxley, Fildes, et al., 2006; D'Ambrosio et al., 2008; Marie Dit Asse et al., 2014; Molnar, Eby, Langford, et al., 2013; O'Connor et al., 2012), its association with indices of on-road safety (Baldock et al., 2006a; Baldock et al., 2006b; Ball et al., 1998; Keay et al., 2009; Molnar and Eby, 2008; Okonkwo, Crowe, et al., 2008; Owsley et al., 2004; Ross et al.,

2009), and factors that facilitate or serve as a barrier to the practice of driving self-regulation (Ackerman et al., 2011; Anstey et al., 2005; Lyman et al., 2001; Marottoli and Richardson, 1998; Molnar et al., 2014; O'Connor et al., 2010; Rudman et al., 2006; Wong et al., 2014). In the above-cited research, driving self-regulation has often been operationalised as the extent to which participants report avoidance of driving in situations pre-defined by researchers as challenging or potentially hazardous.

Conceptualisations of driving self-regulation at the strategic level of driving behaviour appear to have stemmed from observations that older drivers with cataracts or other vision problems frequently report not driving in visually challenging situations (e.g., at night or in bad weather) (Ball et al., 1998; Janke, 1994a; Owsley et al., 1999). Many studies subsequently adopted the use of the avoidance items from the Driving Habits Questionnaire (DHQ), or an extension of this tool (e.g., the Driver Mobility Questionnaire, DMQ, Baldock et al., 2006a), to measure driving self-regulation (e.g., Ackerman et al., 2014; Baldock et al., 2006b; Okonkwo, Crowe, et al., 2008; Ross et al., 2009; Vance et al., 2006). However, across studies these scales have been presented differently. While used with a similar general intention (i.e., to measure self-reported avoidance behaviour of older drivers), scale items have been deleted (e.g., *parallel parking,* Ross et al., 2009) and others added (e.g., *merging,* Oxley et al., 2003); response formats have varied (e.g., from a dichotomous yes/no response option in the DHQ (Owsley et al., 1999) to a 5-point Likert scale in the DMQ (Baldock et al., 2006a)); and the timeframe participants are asked to consider has lengthened (e.g., *during the past 3 months*, DHQ, Owsley et al., 1999; *during the past 6 months*, Oxley et al., 2003; *during the past year*, DMQ, Baldock et al., 2006a; no timeframe, Sullivan et al., 2011). These differences could contribute to the variability across studies in the rates of situational avoidance reported by participants (e.g., 8%, Baldock et al., 2006a; 80%, Ball et al., 1998).

Increased situational avoidance has been consistently associated with advanced age,

female gender, and poorer physical health, cognitive functioning, and emotional wellbeing

(Braitman and McCartt, 2008; Charlton, Oxley, Fildes, et al., 2006; D'Ambrosio et al., 2008;

Naumann et al., 2011; O'Connor et al., 2012; Rimmo and Hakamies-Blomqvist, 2002).

Driving confidence and perceived driving difficulty are among the strongest predictors of

situational avoidance in older drivers (Charlton, Oxley, Fildes, et al., 2006; Lyman et al.,

2001; MacDonald et al., 2008; Myers et al., 2008; Rudman et al., 2006). The most commonly

avoided driving situations include driving at night, in bad weather and in busy traffic

(Baldock et al., 2006a; Ball et al., 1998; Charlton, Oxley, Fildes et al., 2006; Ragland et al.,

2004). Rarely avoided situations include driving alone and turning across traffic (Baldock et

al., 2006a; Ball et al., 1998; Okonkwo, Crowe, et al., 2008).

In much of the research, an overall avoidance scale score is obtained. In producing such

a score, avoidance of one driving situation is assumed to be equal in weight or importance as

avoidance of any other driving situation. The use of summed or averaged scores further

assumes that the situational avoidance construct is unidimensional. A study by Wong, Smith

and Sullivan (2015b) conducted the first known factor analysis of the DMQ (Baldock et al.,

2006a) and additional situational avoidance items from Sullivan, Smith, Horswill, and Lurie-

Beck (2011). A two-factor solution was produced comprised of "external" (e.g., weather-

related) and "internal" (e.g., passenger-related) driving environments or situations. However,

differences in item frequency or ease of endorsement were found, which can be problematic

for factor analysis. When an item is difficult to endorse (or in this case, a situation was rarely

avoided by the sample), it may not correlate strongly with items that are easier to endorse,

even if these items are indicative of the same trait (Gorusch, 1974). In some instances, these

items may not load together on a single factor, instead forming factors based on item

difficulty or frequency of endorsement. The possibility that this occurred is suggested by the

low means and standard deviations for items loading on the "internal" relative to the

"external" factor; and two conceptual anomalies – 1) *driving other people's cars*, and 2) *driving on familiar roads*, that each loaded onto opposite factors to what would be expected based on theory (Wong et al., 2015b). When frequency of endorsement is considered, these conceptual anomalies 'fit' with the other items with which they loaded (e.g., *driving on familiar roads* was less frequently avoided consistent with all "internal" factor items).

Factor analysis is a correlational model, and scales conforming to this model require that a respondent with the representative characteristic endorse *all* items within the subscale that reflects that factor label. By its very nature, situational avoidance can be compensatory or non-compensatory (Molnar, Eby, Charlton, et al., 2013; Naumann et al., 2011), and compensatory avoidance may be the end result of one or more quite different functional failures (Baldock et al., 2006b; Freund and Colgrove, 2008). Thus, avoidance of one situation does not necessarily imply avoidance of another, particularly if items exist on a continuum. For example, the common avoidance of night driving has been assumed to stem from the fact that relative to young adults, vision in low light is affected in older adults with good eye health (Ball et al., 1998; Sloane et al., 1988). Avoidance of night driving is unlikely then to distinguish older adults at high risk of a motor vehicle crash. In contrast, it could be argued that avoidance of driving through, or turning at, major intersections would have greater predictive power given the higher incidence of older driver crashes at intersections (Cicchino and McCartt, 2015; Langford and Koppel, 2006a; Lyman et al., 2002), and the relative difficulty of avoiding situations related to infrastructure (Blanchard et al., 2010). Older drivers who report avoidance of intersections may be experiencing greater driving difficulty and might be expected to report avoidance of a number of more frequently avoided driving situations as well (e.g., night driving). If identified, these drivers may then be flagged for further assessment and/or intervention. The proposition, that (compensatory) situational avoidance is cumulative and occurs along a continuum, lends itself to Rasch analysis.

Developed by Georg Rasch (1960), Rasch analysis is the formal testing of a scale against a hierarchical implicational model. Item and person parameters are each generated with items ordered or scaled based on item difficulty (Andrich, 1988). The greater the number of positive responses obtained for each item, the lower the item difficulty. Whether a person endorses an item is assumed to be a logistic function of the distance between the item location (e.g., difficulty of the driving task) and the respondent's location (e.g., competence of the driver) on a linear scale (Tennant and Conaghan, 2007). For example, a person who endorses an item that reflects average driving difficulty would be expected to report being able to perform all items below that item on the scale (i.e., easier driving tasks) (Tennant and Conaghan, 2007).

The Current Study

Considerable variability exists between studies in the measurement of situational avoidance. This variability has led some to question just how well-targeted existing scale items are in measuring the situational avoidance construct, particularly given the changing traffic environment and potential for different driving habits among the new older driver population (i.e., the ageing baby-boomers) (Dobbs, 2008; Sullivan et al., 2011). Few studies have independently generated or reported the psychometric properties of the questionnaire they used, and to date, the dimensionality of driving avoidance scales has only been assessed using traditional or classical test theory (Wong et al., 2015b). These authors (Sullivan et al., 2011; Wong et al., 2015b) have suggested further examination of the construct and individual scale items using Rasch analysis.

This study examined the potential contribution of Rasch analysis to measuring situational avoidance in drivers within both baby boomer and older adult generations. The primary aim was to determine whether the driving situations assessed followed a specific hierarchical order of frequency of avoidance. In conforming to a Rasch model, the appropriateness of

using all driving situations to measure a single dimension of situational avoidance was also determined. Finally, an evaluation of the category scoring system, the fit of individual items, and an assessment of potential bias of items according to gender and age was undertaken.

Method

Participants

A convenience sample of 399 adults (204 males, 51.1%) was recruited from local community groups in regional Queensland, Australia. Participants included both baby boomer (*M age* = 58.27, *SD* = 5.77, *n* = 198, age range: 48 – 67) and current older adult (*M age* = 75.11, *SD* = 5.50, *n = 201,* age range: 68 – 91) samples (ABS, 2014)[1]. All participants reported possession of a current open drivers' license. Further sample details are provided in Table 4.1. This study had University Human Research Ethics Committee approval.

Table 4.1. *Characteristics and Scale Responses of Study Participants (N = 399).*

Characteristic	Mean (SD)	Range
Age	66.75 (10.14)	48 – 91
Years of education	12.52 (3.44)	6 – 28
Number of years driving	47.29 (9.82)	15 – 73
Number of days per week normally spent driving	5.77 (1.63)	1 – 7
CES-D Depression Total Score	6.17 (6.74)	0 – 50
Daily difficulty with cognition	2.21 (2.57)	0 – 13
Vision for safe driving	2.27 (0.57)	1 – 3
Total Driving Confidence	26.23 (6.39)	4 – 34
Total Driving Difficulty	7.98 (5.89)	0 – 29
Total Driving Avoidance	4.55 (5.18)	0 – 25
	Percentage (N)	
Driving space		
Drive anywhere	70.4% (281)	-
Drive regionally, around the Gold Coast	13.5% (54)	-
Drive locally	16.0% (64)	-
Change in driving habits in past 5 years		
Yes	28.3% (113)	-
No	70.7% (282)	-

Measures

Situational Avoidance Questionnaire.

Development of the Situational Avoidance Questionnaire was based on a review of the

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[1] Data was collected in 2013 explaining the age ranges of participants.

relevant literature on older driver self-regulation and crash characteristics of older adults. Items were drawn from or informed by existing driver behaviour questionnaires (Baldock et al., 2006a; Marottoli et al., 1998; Oxley et al., 2003; Owsley et al., 1999; Sullivan et al., 2011). Participants were asked to consider how they have felt driving in 17 situations in the last 6 months, and to rate their confidence in (0 = *not at all confident*, 1 = *moderately confident*, 2 = *very confident*), difficulty with (0 = *not difficult*, 1 = *a little difficult*, 2 = *very difficult*) and avoidance of (0 = *never*, 1 = *sometimes*, 2 = *always*) each situation. Pictures were provided with each question to provide a consistent decision-making criterion and thus helped participants respond to the same conditions (see Figure 4.1 for an example, Oxley et al., 2003). Total scores ranged from 0 to 34 on each subscale, with higher scores indicating higher confidence, perceived difficulty and frequency of avoidance, respectively. The 3-point response scale was selected to assess for variability in frequency of avoidance while also reducing the potential for misinterpretation (e.g., in determining the difference in avoidance frequency between "sometimes" and "often"). An earlier version of this measure was piloted and used in assessing older driver self-regulation (Davis, 2010). The current version was reviewed by a small convenience sample of 8 older drivers ranging in age from 60 to 82 years (4 males, 50%). All possessed a valid driver's license and reported driving at least once a week.

1. **How do you feel about merging into traffic?**

I am:	Merging into traffic is:	Do you avoid it?
❑ Very confident	❑ Not difficult	❑ Always
❑ Moderately confident	❑ A little difficult	❑ Sometimes
❑ Not at all confident	❑ Very difficult	❑ Never

Figure 4.1. Example item from the Situational Avoidance Questionnaire. All items are listed in Table 4.2.

The final measure also included questions pertaining to demographic information, self-rated visual function for safe driving (0 = *poor,* 1 = *fair*, 2 = *good*, 3 = *excellent*), and driving space. Driving space was assessed by asking participants to indicate what best describes their driving preferences on a three-point scale (0 = *I don't mind driving anywhere, for example from the Gold Coast to Brisbane or Byron Bay*, 1 = *I prefer to drive regionally, around the Gold Coast*, 2 = *I prefer to drive locally, in my immediate area of residence*).

Centre for Epidemiologic Studies Depression Scale (CES-D).

The CES-D (Radloff, 1977) is a 20-item measure designed to assess for current depressive symptoms. Four items are worded in the positive direction to assess positive affect (or the lack of it) as well as to reduce acquiescent bias. Participants are asked to rate on a 4-point response scale how often each symptom had occurred during the past week (0 = *rarely or none of the time (<1 day),* 1 = *some or a little of the time (1-2 days)*, 2 = *occasionally or a moderate amount of time (3-4 days)*, 3 = *most or all of the time (5-7 days)*). Total scores can range from 0 to 60, with higher scores indicating more depressive symptomatology. The CES-D is a psychometrically sound measure of depression in community-dwelling older adult populations (Himmelfarb and Murrell, 1983; Lewinsohn et al., 1997) and had high internal consistency in the current study (Cronbach's alpha = .84).

Subjective Cognitive Complaints Questionnaire (SCCQ).

The *Difficulties with Cognition* subscale is one of three scales of the SCCQ (Newson and Kemps, 2006) designed to assess the extent to which specific cognitive declines interfere with an older adults' daily functioning. It is comprised of 20 items covering five cognitive domains: 1) attention (2 items, e.g., concentrating on things you see, hear or read); 2) processing speed (2 items, e.g., being able to complete a task quickly); 3) working memory (2 items, e.g., recalling a phone number that was just looked up); 4) executive function (6 items, e.g., being able to solve problems); and 5) memory (8 items, e.g., remembering recent and

past events). For each item, participants were asked to rate the level of difficulty experienced in daily tasks as a result of problems experienced with the cognitive function on a 4-point scale, ranging from 0 (*no difficulty*) to 4 (*severe difficulty*). Total scores can range from 0 to 80, with higher scores suggesting greater difficulty in everyday activities because of cognitive concerns. This subscale had high reliability (Cronbach's alpha = .95) in the current sample.

Procedure

Eight hundred survey packages containing the abovementioned measures were distributed in reply paid envelopes to older persons participating in local community groups. The surveys returned ($n = 399$) represented a response rate of 49.88%. Informed consent was inferred from the return of a completed questionnaire.

Statistical Analysis

Data were fitted to the Rasch model using the RUMM2030 software (Andrich et al., 2010). Scale reliability was assessed using the Person Separation Index (PSI). The PSI is equivalent to Cronbach's alpha (Cronbach, 1951), only using the logit value (linear person estimate) as opposed to the raw score in the same formulae (Tennant and Conaghan, 2007). It is interpreted in a similar manner; with a minimum value of .70 recommended for research use and .85 for individual or clinical use (Tennant and Conaghan, 2007).

<div align="center">Results</div>

Rasch Analysis of Avoidance Items

Of the 399 questionnaires returned, 9 respondents failed to complete at least 50% of the situational avoidance items and were excluded from all further analyses. This left 390 valid respondents, well above the minimum sample size requirements (Linacre, 1994) and sufficient for an appropriate degree of precision independent of the distribution across the response options of each item (Pallant and Tennant, 2007). The latter is important given

known positive skew on driving avoidance questionnaires (i.e., a high number of respondents reporting little to no situational avoidance). Participant responses to the avoidance items of the SAQ are summarised in Table 4.2.

Table 4.2. *Responses to the Avoidance Subscale of the Situational Avoidance Questionnaire[1] (N ranges from 379 to 388).*

Item	Avoidance Mean	SD	*Never* (0) %	N	*Sometimes* (1) %	N	*Always* (2) %	N
1. Merging	0.16	0.38	79.9	319	14.5	58	0.5	2
2. Rain	0.36	0.49	62.2	248	33.3	133	0.5	2
3. Busy traffic	0.41	0.54	59.1	236	34.3	137	2.3	9
4. Small 1-lane roundabouts	0.05	0.22	91.2	364	5.0	20	0	0
5. Busy 2-lane roundabouts	0.09	0.29	87.2	348	9.0	36	0	0
6. Driving through intersections without lights	0.12	0.35	85.7	342	10.0	40	0.8	3
7. Right turns with lights but without a right arrow	0.09	0.28	88.2	352	8.3	33	0	0
8. Right turns without lights or stop/give way signs	0.14	0.36	83.5	333	12.5	50	0.5	2
9. Night	0.38	0.57	63.7	254	28.3	113	4.0	16
10. Night when wet	0.55	0.61	49.4	197	41.1	164	5.8	23
11. Night in busy areas with glare	0.45	0.59	58.1	232	33.3	133	4.8	19
12. Changing lanes	0.20	0.41	77.9	311	19.0	76	0.3	1
13. Highways/motorways	0.20	0.48	81.2	324	12.5	50	3.5	14
14. Unfamiliar routes, detours, or sign changes	0.31	0.51	69.2	276	26.1	104	2.0	8
15. Parallel parking	0.45	0.63	60.4	241	30.1	120	7.0	28
16. Congested traffic areas with many signs, cars, pedestrians, cyclists and buses	0.35	0.54	66.7	266	27.3	109	3.3	13
17. Long distances	0.31	0.60	73.7	294	16.3	65	7.0	28

[1] No age or gender interactions were found when analysis of differential responding was performed (see below).

The fit of the model was determined by the distributions of item and person parameters, and the measures of internal consistency obtained for each. Initial inspection of the fit of the data for all 17 items identified a significant chi-square interaction statistic ($p < .001$), and a fit residual standard deviation for items in excess of the recommended value of 1.5, which indicated deviation from the Rasch model.

The residual mean value for persons was -0.35 ($SD = 0.95$), indicating no serious misfit among respondents in the sample. Examination of the individual item fit revealed the

Parallel Parking item as showing significant misfit to model expectation (Fit Residual = 4.91, χ^2 (3, N = 256) = 65.64, p < .001). Consistent with previous research (e.g., Baldock et al., 2006a), this item failed to discriminate among persons across the continuum. Removal of this item resulted in a significant improvement in model fit. The chi-square interaction statistic became non-significant (p = .103) and item (M = -0.31, SD = 1.09) and person (M = -0.37, SD = 0.96) fit residual standard deviations dropped below 1.5.

The possibility of gender and age (baby boomer: 48-67 years vs. older adult: 68-91 years, ABS, 2014) differences in response to the 16-item Situational Avoidance Questionnaire was explored by analysis of differential item functioning (DIF) with a Bonferroni-adjusted p value of .001. None of the items showed probability values exceeding the adjusted alpha value in either analysis. This suggests that persons endorsing similar levels of situational avoidance respond consistently to each individual item irrespective of their age or gender.

Item response thresholds are based on the number of positive responses to an item (Andrich, 1988). If the model has two parameters, two thresholds are produced for each item. The first represents the position on the scale where there is a 50% chance that a score of 0 ('never avoid') or 1 ('sometimes avoid') will be found. The second threshold occurs where there is a 50% chance that the item will score a 1 ('sometimes avoid') or 2 ('always avoid'). If the score is above the threshold value, it is allocated to the highest response category (Andrich, 1988). It was expected that for a well-fitting model, highly restricted drivers would endorse avoidance of most driving situations presented, while non-restricted drivers would endorse those situations avoided by many older adults (e.g., night driving), if any. The response thresholds were ordered suggesting that this was largely the case for all items. However, category probability curves for most scale items showed that respondents did not reliably distinguish between, or equally endorse, the response options (i.e., the "always

avoid" response category was rarely endorsed), with the exception of responses to items:

Night, Night when Wet, Night in Busy Areas and *Long Distances.* The response scale was

recoded for all items but the aforementioned, collapsing responses in the 'sometimes' and

'always' categories. The chi-square interaction statistic remained non-significant ($p = .169$),

and item ($M = -0.32$, $SD = 1.01$) and person ($M = -0.32$, $SD = 0.83$) fit residual standard

deviations remained below 1.5. Collapsing the responses of selected items into dichotomous

categories produced a more logical sequence of all items from most avoided to least avoided

and improved targeting or sensitivity of the scale across respondents (see Figure 4.2).

```
-----------------------------------------------------------------------
LOCATION          PERSONS    ITEMS [uncentralised thresholds]
-----------------------------------------------------------------------
  5.0                       |
                            |
                            |
                            |
  4.0                       |
                            |
                            |
                            |
                            |
  3.0                       |
                            |
                      × |
                            |
  2.0                       | (4) 1-Lane Roundabout.1
                            | (11) Night in Busy Areas.2 (9) Night.2
                            |
                      × | (10) Night when Wet.2
                            | (7) RH Turn.1
  1.0                 × | (5) 2-Lane Roundabout.1
                            | (6) INT No Lights.1 (17) Long Distances.2
                            |
                      × | (8) RH Turns No Lights.1
                      × | (1) Merging.1
  0.0                ×× | (13) Highways/Motorways.1
                            |
                     ×× | (12) Changing Lanes.1
                     ×× | (17) Long Distances.1
                            |
 -1.0               ×× |
                    ××× | (14) Unfamiliar Routes.1
                            | (16) Congested Traffic Areas.1
                    ××× | (2) Rain.1 (9) Night.1
                            |
 -2.0            ××××× | (3) Busy Traffic.1
                            | (11) Night in Busy Areas.1
                 ××××× |
                            |
                     ×× | (10) Night when Wet.1
 -3.0                       |
                            |
                            |
                ×××××× |
                            |
 -4.0                 × |
   ×××××××××××××××××× |
                            |
                            |
 -5.0                       |
-----------------------------------------------------------------------
          × = 7 Persons
-----------------------------------------------------------------------
```

Persons reporting more avoidance

Persons reporting less avoidance

Items less frequently avoided

Items more frequently avoided

Figure 4.2. Item map for the 16-item Situational Avoidance Questionnaire. Response

categories recoded to 0 "not avoided" and 1 "sometimes or always avoided" for all items but

Night, Night when Wet, Night in Busy Areas, and Long Distances.

The mean person location value of -2.34 (SD = 1.91) is consistent with research in this area demonstrating that participants were reporting, on average, lower levels of avoidance than the average of scale items (which would be zero logits). While no items accurately measured the avoidance behaviour of the persons at the bottom of the graph (non-restricted drivers), the distribution of items spanned the range of person scores for those individuals of interest (i.e., those reporting situational avoidance). This suggests that the measure is relatively well targeted to drivers who report self-regulation in the form of situational avoidance.

With respect to reliability, the Person Separation Index (PSI) was .75, which indicated that the total situational avoidance scale has reasonable person separation reliability for research purposes. Reliability of the measure improved when extreme scores were removed (PSI increased to .80).

Finally, a principal components analysis of the residuals was undertaken to assess for multidimensionality. Analysis of the pattern of residuals showed that residuals for the *Night* items loaded together and separately from items assessing road or traffic conditions (e.g., merging, highways, busy traffic, and congested traffic areas). However, the proportion of statistically significant t-tests (p <.05) did not exceed the critical value of 5%, indicating local independence and the absence of multidimensionality.

Factors associated with Situational Avoidance

The associations between demographic and health-related information with the final Situational Avoidance Questionnaire total score were explored using the interval scores exported from the Rasch analysis (see Table 4.3). Consistent with previous research, the strongest associations were observed between confidence, perceived driving difficulty and situational avoidance. Drivers reporting lower driving confidence and greater difficulty when driving avoided more driving situations than did those who were more confident or who

perceived driving as less difficult. An increase in situational avoidance was associated with being older, female, driving less frequently and having a preference to drive in a more restricted space (i.e., regionally or locally in their own neighbourhood). Drivers who reported changing their driving habits in the past five years were also more likely to report higher levels of situational avoidance. Importantly, situational avoidance was also associated with indicators of general wellbeing. Drivers who identified difficulties with low mood, cognition or vision for safe driving reported greater avoidance behaviour.

Table 4.3. *Pearson Correlations between Situational Avoidance and Relevant Demographic and Health-Related Variables (N = 390).*

	Age	Gender (M=0, F=1)	Driving Frequency[1]	Changed Driving Habits[2] (N=0, Y=1)	Driving Confidence	Driving Difficulty	Driving Space	Depression	Self-Rated Vision	Difficulty with Cognition
Situational Avoidance	.23**	.27**	-.27**	.17*	-.65**	.65**	.40**	.22**	-.32**	.26**

  * p = .001

** p < .001

[1]Number of days per week normally spent driving, where higher scores indicate greater frequency of driving.

[2]Self-imposed changes in driving habits in the past 5 years.

Discussion

The current study investigated the psychometric properties of the Situational Avoidance Questionnaire (SAQ) and was the first to apply Rasch analysis to a driving self-regulation measure. The scale demonstrated acceptable reliability, with little disordering of thresholds, and no evidence of differential item functioning or multidimensionality. The *Parallel Parking* item was removed given its lack of discrimination among participants and all items, with the exception of four, were recoded into dichotomous yes/no categories to improve the mapping and targeting of items across person levels. The final 16 items conformed to a Guttman scaling pattern, indicating that the items could be ranked in order from most- to least-frequently avoided. Finally, in establishing initial construct validity, higher SAQ total scores were significantly associated with known characteristics of self-restricted older drivers, namely older age; female gender; a self-reported change in driving habits as well as reduced driving frequency and driving space; and poorer emotional, visual and cognitive functioning. Consistent with previous research (e.g., MacDonald et al., 2008), the strongest associations were found between situational avoidance, driving confidence, and perceived driving difficulty.

Establishing the hierarchical or cumulative nature of situational avoidance suggests that the "cessation continuum" (p. 435) proposed by Dellinger and colleagues (2001) may exist. These authors argued that situational avoidance (and driving self-regulation more generally) might represent the midpoint on a continuum spanning complete driving independence to driving cessation. They further proposed that the reasons for reducing or stopping driving reported by older drivers might depend on when the person is questioned or where they fall on this continuum. Kowalski and colleagues (2014) recently demonstrated that the process of moving along this continuum could be reasonably well conceptualised within the Transtheoretical Model of Behaviour Change (Prochaska and Velicer, 1997).

While the competence of drivers in the current sample and their reasons for situational avoidance are not known, it may be inferred that participants who reported consistently high levels of situational avoidance are experiencing greater difficulty on the road than their peers. That this avoidance reflects a compensatory strategy seems likely given the high degree of restriction indicated by these drivers and the association between increased driving avoidance, greater perceived driving difficulty and reduced health status (i.e., low mood, increased visual difficulties and greater difficulty with cognition). It was also noteworthy that the original 3-point response scale (*never, sometimes* and *always*) was more sensitive in distinguishing the driving behaviour of persons at this upper end of the continuum. For example, while few drivers reported *always* avoiding night driving, those who did also reported avoidance of most of the other driving situation items.

By comparison, a larger proportion of older adults in the current sample reported occasional avoidance of driving at night, in busy or congested traffic areas, or on unfamiliar routes. Avoidance of these situations did not imply avoidance of any other driving situation (e.g., merging, changing lanes, or driving for long distances). This behaviour may reflect a form of compensation for some respondents, either in response to a perceived (recent) decline, for example in contrast sensitivity (Ball et al., 1998; Keay et al., 2009; West et al., 2003); or as a more consistent compensatory strategy practiced throughout their driving history (Kowalski et al., 2014; Molnar, Eby, Charlton, et al., 2013; Naumann et al., 2011). It is also possible that, for other drivers, this behaviour reflects a lifestyle that includes greater freedom to choose when and where they drive (Ball et al., 1998). For instance, the decision to avoid peak hour traffic or congested traffic areas (e.g., CBDs) is one that arguably would be made by many drivers if their circumstances permitted it.

Parallel parking may be another example of a situation that some drivers always avoid if they are able to (e.g., 'consistent restrictors', Kowalski et al., 2014). However, unlike other

scale items, *Parallel Parking* did not follow the same cumulative pattern of the Rasch model. Drivers who were highly restricted did not necessarily report avoidance of parallel parking and yet some participants who were otherwise completely non-restricted reported 'always' avoiding it. Parallel parking has been rated as the driving situation least difficult to avoid (Baldock et al., 2006a), perhaps allowing drivers, regardless of their age or driving ability, to avoid this manoeuvre if they lack confidence in their ability to perform it successfully, either at a specific time or all of the time.

A critical aim of this study was to test for the presence of a higher-order construct, namely situational avoidance. The results suggested that all items (with the exception of *Parallel Parking*) can be summarised into a total score to provide a valid measure of this construct for both baby boomer and current older adult generations. Although not formally tested in this study, it is plausible that the higher the score on this measure, the more likely the avoidance reported is a form of compensation for perceived declines in driving skill. This idea is not new, and many studies have supported this notion (albeit with varying levels of explanatory power) (Ball et al., 1998; Keay et al., 2009; West et al., 2003). However, this study goes a step further by suggesting that avoidance of certain situations (e.g., intersections) or an absolute avoidance of night driving may be particularly revealing as potential risk indicators. A study is currently underway by the authors to examine the relationship between the SAQ and objective driving-related abilities. With further research and validation (i.e., sensitivity and specificity analyses), there is potential for specific situational avoidance items or an overall SAQ cut-off score to be used in clinical settings to identify older drivers who may need further assessment and/or intervention.

It remains to be determined whether other forms of driving self-regulation and other related constructs (e.g., perceived difficulty of driving situations) also conform to a hierarchical implicational model. Myers and colleagues (2008) established the hierarchical

nature of older drivers' perceived *comfort* in different driving situations during both day- and night-time driving. Higher levels of discomfort were associated with higher levels of reported avoidance of the situations assessed. This association was strongest for the scale specific to night driving, leading the authors to propose that comfort with driving at night may decline earlier than daytime driving comfort. This is consistent with the current study's ranking of SAQ items. Prospective research is needed to explore the proposition that situational avoidance (and ultimately, driving cessation) is the culmination of an unacceptable level of comfort on the road (Myers et al., 2008; Rudman et al., 2006).

Current research suggests that tactical compensation (e.g., allowing longer headways) may be distinct from strategic compensatory strategies, as hierarchical driving models suggest (Michon, 1985; Rasmussen, 1987), although this has not been confirmed with a statistical test of dimensionality. Relative to strategic compensation, rates of tactical compensation are higher in older driver samples and are often independent of functional driving ability (De Raedt and Ponjaert-Kristoffersen, 2000; Molnar, Eby, Langford, et al., 2013). The results of one study suggested that tactical compensation is practised by most drivers, and compared to strategic compensation, might actually decline with driving-related impairment due to difficulties in managing the mental workload of the driving task (De Raedt and Ponjaert-Kristoffersen, 2000). Applying Rasch analysis to questionnaires assessing other forms of driving self-regulation (e.g., tactical and life-goal level behaviour, Molnar, Eby, Langford, et al., 2013) may further clarify the complexities of the self-regulation concept.

This study had several limitations. First, as indicated above, the mapping of individual items reflects frequency of avoidance and the underlying reasons for this behaviour (e.g., situational difficulty or driving competence of persons sampled) can only be inferred given the absence of objective indices of driving. This also includes the absence of objective validation of self-reported driving habits through use of an in-vehicle assessment device (e.g.,

Blanchard et al., 2010). The relationship between these objective indices and the SAQ requires further investigation, alongside ongoing construct validation and testing of the SAQ against other factors known to influence situational avoidance or driving self-regulation more generally.

A further limitation pertains to the low levels of avoidance reported by participants in the current study. While this is consistent with previous research, the skewed distribution of scores likely interfered with the precision of item and person estimates, and reduced scale reliability. Investigation of this measure using a clinical sample of older drivers with established driving impairment would help in cross-validating the current findings.

The low levels of situational avoidance reported in the literature have been interpreted as indicating that driving self-regulation may be of limited effectiveness as a safe driving strategy given that few older drivers employ it voluntarily (e.g., Baldock et al., 2006b; Horswill et al., 2011). However, response or sampling biases are equally plausible interpretations given the frequent use of convenience samples, as was the case in the current study. Estimates of driving self-regulation also tend to be higher when tactical self-regulation or reductions in driving space are measured (e.g., 65%, Dellinger et al., 2001; up to 93%, Molnar, Eby, Langford, et al., 2013). This further supports the notion that *driving self-regulation* is a multidimensional construct, composed of different strategies occurring at strategic, tactical and operational levels of driving behaviour or decision-making.

Summary and Conclusions

Driving is more than a matter of convenience for many older adults, instead forming a fundamental part of their lifestyle, sense of independence, and identity (Donorfio et al., 2009; Eisenhandler, 1990; Rudman et al., 2006). Driving self-regulation is a means through which older adults may be able to compensate for age- and disease-related declines in driving skill whilst maintaining mobility (Oxley and Charlton, 2009). At the strategic level, one form of

driving self-regulation is situational avoidance, or the avoidance of challenging or potentially hazardous driving situations (e.g., at night or in wet weather). In the interest of establishing the safety and mobility benefits of situational avoidance, refinement of measures used to assess this construct is needed, together with evaluation of the individual, social and environmental factors that influence its practice.

The Situational Avoidance Questionnaire is a 16-item self-report measure designed to assess avoidance of potentially challenging driving situations. Items were selected from or informed by existing driving behaviour questionnaires and previous driver research. Rasch analysis suggested that the measure has sound psychometric properties and that the situational avoidance construct is unidimensional and hierarchical. Cross-validation of the present findings, exploration of the relationship between the SAQ and indices of driving ability, and development of norms for healthy drivers and various clinical populations (e.g., Mild Cognitive Impairment) is needed to enhance the clinical utility of the measure.

Chapter 5 : Identifying Compensatory Driving Behaviour among Older Adults using the Situational Avoidance Questionnaire

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Statement on Authorship Contribution:

As co-authors of the paper submitted for publication entitled, "Identifying Compensatory Driving Behaviour among Older Adults using the Situational Avoidance Questionnaire", we confirm that Jessica Davis has made the following contributions:

a) Formulation of the study hypotheses and critical review of the relevant literature;

b) Development of the measures with direction and feedback from the co-author;

c) Collecting and entering the data into the statistical software package;

d) Analysing and interpreting the data under the direction of the co-author;

e) Writing the paper with direction and feedback from the co-author.

Furthermore, we agree to the inclusion of the paper in this research thesis for examination.

Jessica Davis

Elizabeth Conlon   31/05/2017

Abstract

Objectives: Driving self-regulation is considered a means through which older drivers can compensate for perceived declines in driving skill or more general feelings of discomfort on the road. One form of driving self-regulation is situational avoidance, the purposeful avoidance of situations perceived as challenging or potentially hazardous. This study aimed to validate the Situational Avoidance Questionnaire (SAQ, Davis et al., 2016) and identify the point on the scale at which drivers practicing compensatory avoidance behaviour could be distinguished from those whose driving is unrestricted, or who are avoiding situations for other, non-compensatory reasons (e.g., time or convenience). *Method:* Seventy-nine Australian drivers (M_{age} = 71.48, *SD* = 7.16, range: 55 to 86 years) completed the SAQ and were classified as a *compensatory-restricted* or a *non-restricted driver* based on a semi-structured interview designed to assess the motivations underlying avoidance behaviour reported on the SAQ. *Results:* Using receiver-operator characteristic (ROC) analysis, the SAQ was found to have high diagnostic accuracy (sensitivity: 85%, specificity: 82%) in correctly classifying the driver groups. Group comparisons confirmed that compensatory-restricted drivers were self-regulating their driving behaviour to reduce the perceived demands of the driving task. This group had, on average, slower hazard perception reaction times, and reported greater difficulty with driving, more discomfort when driving due to difficulty with hazard perception skills, and greater changes in cognition over the past five years. *Conclusions and practical applications*: The SAQ is a psychometrically sound measure of situational avoidance for drivers in baby boom and older adult generations. Use of validated measures of driving self-regulation that distinguish between compensatory and non-compensatory behaviour, such as the SAQ, will advance our understanding of the driving self-regulation construct and its potential safety benefits for older road users. Key words: Driving self-regulation; older drivers; situational avoidance; hazard perception; ROC analysis

Introduction

Like other western countries, older adults comprise the largest and fastest growing segment of Australia's driving population (Australian Bureau of Statistics, ABS, 2016). Age- and disease-related declines in physical, cognitive and sensory abilities underlie the critical driving errors unique to older drivers (Anstey et al., 2005; Anstey & Wood, 2011; Cicchino & McCartt, 2015; McGwin & Brown, 1999), and their physical frailty contributes to a heightened risk of serious injury or death if involved in a motor vehicle accident (Koppel et al., 2011; Li et al., 2003). However, the relative crash risk of older drivers is not as high as one might expect based on the functional declines commonly experienced with age (Langford & Koppel, 2006b). One reason is that many older adults gradually and voluntarily modify their driving over time to compensate for declines in driving skills, often culminating in deciding to stop driving altogether (Hakamies-Blomqvist et al., 2004; Langford & Koppel, 2006b; Smiley, 2004). This behaviour has been referred to as *driving self-regulation*. The diversity in normal and pathological ageing (Christensen, 2001), coupled with the negative outcomes associated with driving cessation (e.g., Edwards, Perkins, Ross, & Reynolds, 2009; Fonda et al., 2001; Marottoli, Mendes de Leon, et al., 1997; Marottoli et al., 2000), have led some to conclude that ultimate responsibility must remain with the driver (Berry, 2011), and that ways to support and promote the practice of driving self-regulation by older drivers should form an integral part of any regulatory system (Hakamies-Blomqvist & Wahlstrom, 1998; Langford, 2006).

Driving self-regulation has been defined as a process initiated by older adults to improve the fit between perceived declines in driving skills and the driving environment (Ball et al., 1998; Charlton, Oxley, Fildes, et al., 2006; Donorfio et al., 2009). Examples include decisions concerning where to live or what vehicle to drive (Eby et al., 2009; Molnar, Eby, Langford, et al., 2013), as well as behaviours such as reducing driving exposure and driving

space (Charlton, Oxley, Fildes, et al., 2006; Lyman et al., 2001; Rosenbloom, 2004), avoidance of driving in situations perceived as challenging or more difficult (e.g., driving at night or in bad weather) (Ball et al., 1998; Baldock et al., 2006a; Keay et al., 2009; Molnar et al., 2014; West et al., 2003), driving more slowly or leaving longer headways while on the road (Andrews & Westerman, 2012; Charlton, Catchlove, Scully, Koppel, & Newstead, 2013; Molnar et al., 2014), and altered visual search patterns (Charlton et al., 2005). As such, it is composed of different strategies occurring across the hierarchical levels of driving behaviour or decision-making (Michon, 1985; Smiley, 2004).

The practice of driving self-regulation among older drivers has been associated with advanced age, female gender and reduced motor vehicle crash involvement (Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Ball et al., 1998; Braitman & McCartt, 2008; Conlon et al., 2017; Davis et al., 2016; Donorfio, D'Ambrosio, et al., 2008; Hakamies-Blomqvist & Wahlstrom, 1998; Molnar & Eby, 2008; Oxley et al., 2003; Ross et al., 2009; West et al., 2003). Drivers who report greater difficulty with driving or driving-related skills, reduced confidence and greater discomfort on the road are also more likely to report self-regulating their driving behaviour (Baldock et al., 2006a; Conlon et al., 2017; MacDonald et al., 2008; Molnar et al., 2014; Myers et al., 2008). Perhaps more importantly, the crash profile of older drivers reflects their typical self-regulation patterns, with underrepresentation in crashes occurring in difficult conditions (e.g., at night or in bad weather) and those caused by risky internal states (e.g., intoxication or distraction) (Hakamies-Blomqvist, 1993; Langford & Koppel, 2006a).

However, some studies have failed to find an association between driving self-regulatory behaviour, such as situational avoidance, and on-road driving performance or objective measures of ability (Baldock et al., 2006a; Baldock et al., 2006b; Okonkwo, Crowe, et al., 2008; Ross et al., 2009). For example, Horswill and colleagues (2011) found that self-

reported situational avoidance was not associated with mean hazard perception reaction time. Hazard perception has been identified as a critical skill for crash avoidance as one must first recognise a potentially hazardous situation in order to take evasive action (Horswill & McKenna, 2004). The hazard perception test is one of the few computer-based measures to predict crash involvement of drivers of all ages, suggesting it is an appropriate proxy measure of on-road safety (Horswill, Anstey, Hatherly, & Wood, 2010; see Horswill & McKenna, 2004, for a review). These findings have prompted research into whether older drivers are able to self-regulate their driving in a manner consistent with their actual driving ability.

According to existing driving self-regulation models (e.g., Anstey et al., 2005; Rudman et al., 2006; Wong et al., 2014) and theories of behaviour change (e.g., the Transtheoretical Model of Behaviour Change, Prochaska and Velicer, 1997), driving behaviour change is often predicated on an older adult's awareness of changes in driving-related skills and general beliefs about their ability to perform a specific task, for example, their confidence in their ability to drive safely at night. As they become aware of potential problems, either through self-assessment or via feedback from external sources, their driving practices may be adjusted (Ackerman et al., 2011; Eby et al., 2003; Kowalski et al., 2014; Rudman et al., 2006). The decision to change driving behaviour can also be influenced by attitudes toward driving (e.g., enjoyment of driving) and its perceived importance to one's lifestyle (Baldock et al., 2006a; D'Ambrosio et al., 2008; Donorfio, Mohyde, et al., 2008; Friedland & Rudman, 2009; Sukhawathanakul et al., 2015). Contextual factors further determine actual driving behaviour through, for example, the availability of suitable alternate transport options or the needs of dependent others (Charlton, Oxley, Fildes, et al., 2006; Donorfio et al., 2009; Stalvey & Owsley, 2000). Thus, intrapersonal, interpersonal and environmental factors work together to determine an older adult's readiness or willingness to self-regulate driving in the context of perceived changes in driving skill.

Driving behaviour may also be determined by other, non-compensatory reasons such as changes in lifestyle or for convenience (Kowalski et al., 2014; Molnar, Eby, Charlton, et al., 2013). For example, the greater freedom afforded by retirement might allow an older adult to choose to drive a longer route to avoid a congested city centre or wait until the rain stops to go to their local store. This type of behaviour does not fall within the scope of *driving self-regulation* as it is defined in road safety research, and failing to consider the reasons for changes in driving behaviour may have confounded the results of some previous studies (Molnar, Eby, Charlton, et al., 2013; Molnar et al., 2015). Specifically, one would not expect a significant relationship between avoidance for convenience reasons and measures of driving ability or crash involvement. The challenge for researchers lies in our ability to adequately capture the many reasons for driving behaviour change, with consideration of the idiosyncrasies in how these reasons are expressed or understood by older adults, and sensitivity to the fact that the reasons may be different for different driving behaviours (Dellinger et al., 2001; Molnar et al., 2015).

The results of our recent study suggest that drivers practicing compensatory driving self-regulation may be identified based on where they fall on the avoidance continuum measured using the Situational Avoidance Questionnaire (Davis et al., 2016). It was hypothesised that the higher the score on the SAQ avoidance scale, the more likely the avoidance reported was a form of compensation for perceived declines in driving skill. The aim of the current study was to test this hypothesis and to identify a SAQ cut-off score to distinguish older drivers more likely to be practicing compensatory driving behaviour from those reporting avoidance for non-compensatory reasons. To achieve this aim, drivers were classified as compensatory-restricted or non-restricted following a semi-structured interview in which they disclosed their reasons for situational avoidance reported on the SAQ. The sensitivity and specificity of the SAQ in classifying these two groups was determined through receiver operator curve

(ROC) analysis. Finally, the cut-off score was validated by comparing the groups on variables commonly associated with driving self-regulation in the literature (e.g., age, gender, driving confidence and self-reported cognitive difficulties).

Method

Participants

A sample of 79 adults (36 males, 45.6%), ranging in age from 55 to 86 years ($M = 71.48$, $SD = 7.16$), was recruited from a larger sample sourced from local community groups in regional Queensland, Australia. All participants reported possession of a current open drivers' license. They were screened for low-level visual difficulties using the Snellen Visual Acuity Chart (Snellen, 1862; cited in Bennett, 1965) and Pelli-Robson Contrast Sensitivity Test (Pelli, Robson, & Wilkins, 1988). All scored at or above their relative age norms for contrast sensitivity (Elliott, Sanderson, & Conkey, 1990) and above 6/12 corrected vision in their better eye on the Snellen chart (Austroads, 2016). This study had University Human Research Ethics Committee approval, with all participants providing informed consent.

Measures

Driving Behaviour and Beliefs Questionnaire

This questionnaire consisted of demographic items (e.g., age, gender, and driving exposure) and a number of scales to assess situational avoidance and beliefs about driving. Participants also described involvement in any motor vehicle incident in which they were the driver (at fault or not at-fault) over the past five years. The scales included:

Situational Avoidance Questionnaire (SAQ). Participants rated whether they avoided driving in 16 situations in the last 6 months (0 = *never*, 1 = *sometimes*, 2 = *always*). Responses were recoded to 0 = *never* and 1 = *sometimes or always avoided* for all items with the exception of *Night, Night when Wet, Night in Busy Areas* and *Long Distances* in accordance with the Rasch analysis previously conducted (Davis et al., 2016, see Appendix

B). These scores were summed to form an Avoidance Total score with a range of 0 to 20 and converted to an interval scale score using the Rasch Location Conversion Table (see Appendix C). Internal consistency of the scale was .85.

Participants also rated their confidence in and difficulty experienced when driving in each situation on the three-point scale (0 = *never*, 1 = *sometimes*, 2 = *always*). Total scores ranged from 0 to 32, with higher scores indicating higher confidence and greater perceived difficulty, respectively. Internal consistency for these scales was high (confidence: $\alpha = .93$; difficulty: $\alpha = .90$).

Subjective Cognitive Complaints Questionnaire (SCCQ). The SCCQ comprises three subscales that assess: 1) problems with cognition; 2) changes in cognition over the past 5 to 10 years; and 3) daily difficulties with cognition (Newson & Kemps, 2006). Items cover five cognitive domains: 1) attention (2 items, e.g., concentrating on things you see, hear or read); 2) processing speed (2 items, e.g., being able to complete a task quickly); 3) working memory (2 items, e.g., recalling a phone number that was just looked up); 4) executive function (6 items, e.g., being able to solve problems); and 5) memory (8 items, e.g., remembering recent and past events). Participants rated frequency of problems with (0 = *never* to 4 = *always*), changes in (0 = *no change* to 4 = *a large change*) and the level of difficulty experienced in daily tasks (0 = *no difficulty* to 4 = *severe difficulty*) for each item. Higher scores indicated greater subjective cognitive complaints on each subscale. Internal consistency in the current sample was high (problems with cognition: $\alpha = .90$; changes in cognition: $\alpha = .94$; difficulties with cognition: $\alpha = .91$).

Driving Discomfort. A 28-item driving discomfort questionnaire was developed based on a review of the relevant literature on driving self-regulation, awareness and hazard perception. Items were drawn from or informed by existing driving questionnaires and vision measures (e.g., Eby, Molnar, & Shope, 2000; Eby et al., 2003; Horswill, Waylen, & Tofield,

2004; Rubin et al., 2001; Sloane, Ball, Owsley, Bruni, & Roenker, 1992; Tun & Wingfield, 1995). Participants rated how often they felt uncomfortable when driving due to difficulties associated with hazard perception (e.g., predicting other road users' behaviour, 7 items), contrast sensitivity (e.g., seeing lane markings in the rain or at night, 10 items), divided attention (e.g., finding the right exit or street in an unfamiliar area, 6 items), and reaction time (e.g., braking fast enough to avoid a hazard, 5 items) skills. A 5-point response scale ranging from 0 = *never* to 4 = *always* was used, with higher scores indicating greater discomfort with driving. The scale had high internal consistency (α = .93).

Attitudes to Driving. Items assessing attitudes or beliefs toward driving were drawn from the Decisional Balance Scale (Tuokko, McGee, & Rhodes, 2006). Exploratory (*n* = 200) and confirmatory (*n* = 199) factor analysis of this scale produced two factors, *Affective Attitudes* (9 items) and *Importance of Driving* (6 items) (Rahaley, 2015). Each item was responded to on a 4-point scale ranging from 0 = *strongly disagree* to 3 = *strongly agree*. Higher scores on the affective attitudes subscale indicated more negative attitudes toward driving (e.g., '*I feel distressed while driving*'). Higher scores on the importance of driving subscale suggested greater value placed on driving or a necessity to continue driving (e.g., '*If I stopped driving, I fear I would become isolated*'). The internal consistency of attitudes was .84, and importance, .75.

Feedback from Others or the Environment. Items were drawn from or informed by existing driving questionnaires (Carr, Schwartzberg, Manning, & Sempek, 2010; Tuokko et al., 2006) to compose an 8-item scale to assess whether a driver felt they had received negative feedback about their driving from others (e.g., '*Some people think I should stop driving*') or the environment (e.g., '*I have experienced more near misses lately*'). The response scale ranged from 0 = *strongly disagree* to 3 = *strongly agree*. Positive items were reverse scored so that higher scores on the scale indicated greater perceptions of negative

feedback. Internal consistency of the scale was high ($\alpha = .83$).

Perceived Barriers to Driving Self-Regulation. Participants rated how strongly they agreed (0 = *strongly disagree* to 3 = *strongly agree*) that each of the seven items (e.g., lack of public transport) stopped them from changing when and where they drive (Stalvey & Owsley, 2000). Higher scores indicated a greater number of perceived barriers to the practice of driving self-regulation. Internal consistency of the scale was high ($\alpha = .81$).

Stages of Change. Participants' readiness to change their driving behaviour was assessed using an 11-item measure adapted from Stalvey and Owsley (2000). Items reflected each of the five stages of behaviour change, from precontemplation (e.g., *'Avoiding certain driving situations would be pointless for me'*) to maintenance (e.g., *'I have been thinking about giving up driving altogether'*) (Prochaska & Velicer, 1997). Participants responded on a 4-point scale (0 = *strongly disagree* to 3 = *strongly agree*). Higher scores indicated greater readiness to change driving behaviour. Internal consistency was high ($\alpha = .84$).

Laboratory Measures

Snellen Visual Acuity Chart. The Snellen chart assesses best-corrected distance visual acuity and consists of eight rows of individual letters decreasing in size (Bennett, 1965). Participants viewed the reduced size version of the chart at a distance of three metres. The last row read accurately indicated the visual acuity in that eye.

Pelli-Robson Contrast Sensitivity Test. The Pelli-Robson chart consists of eight rows of individual letters, with each row containing two sets of three letters (Pelli et al., 1988). Different letters are used on alternate forms of the same test. All letters are the same size but each successive triplet is presented with a contrast reduction of 0.15 log units. Log Contrast Sensitivity scores were determined by the last triplet of which at least two letters are correctly identified (Pelli et al., 1988). Scores were averaged across both sides of the chart to obtain a final contrast sensitivity score.

Reasons for Situational Avoidance. During a semi-structured interview conducted individually, participants provided reasons for avoidance behaviours reported on the SAQ. Qualitative responses fell into two broad categories reflecting *convenience* (e.g., avoidance of busy traffic areas or times to reduce trip duration) and *safety*. For some, safety reasons for situational avoidance related to specific skill deficits (e.g., change in a cognitive, physical or sensory ability), whereas for others, a more general sense of discomfort or loss of confidence. These response categories for situational avoidance are consistent with previous research (Meng & Siren, 2015; Molnar, Eby, Charlton, et al., 2013; Ragland et al., 2004).

If situational avoidance was not reported or reported for lifestyle or convenience reasons, participants were classified as *non-restricted* (see Table 5.1). If situational avoidance was practiced for safety reasons, the participants were classified as *restricted*. It was interesting to note that the reasons reported by most participants fell into one category or the other for all situations avoided. For those who reported different reasons for different avoidance behaviours, the proportion of lifestyle versus safety reasons was used to determine group membership. To check the validity of the classification process, a second researcher classified a randomly selected sample ($n = 27$) of interviews. Inter-rater reliability was high (Kappa $= .85$, $p < .001$).

Table 5.1. *Sample Characteristics of Restricted (n = 25) and Non-Restricted (n = 54) Drivers*

Classified According to Qualitative Responses.

Characteristic	Restricted	Non-Restricted
	Mean (SD)	Mean (SD)
Age	74.28 (5.47)	69.96 (7.22)
Years of education	13.36 (3.83)	13.91 (3.76)
Number of years driving	54.52 (6.63)	50.72 (8.46)
Number of days per week normally spent driving	5.44 (1.73)	6.09 (1.34)
SAQ Total Driving Confidence	20.16 (5.12)	26.96 (4.75)
SAQ Total Driving Difficulty	10.56 (5.04)	5.65 (4.15)
SAQ Total Driving Avoidance (Rasch score)	41.04 (12.92)	16.41 (15.36)
	Percentage (N)	
Male gender	40.0% (10)	48.1% (26)

QLD Hazard Perception Test. The QLD Hazard Perception Test was 17 minutes in

duration and contained 55 measured hazards within 34 video clips (Marrington, Horswill, &

Wood, 2008; Smith, Horswill, Chambers, & Wetton, 2009). Participants viewed un-staged

Queensland road scenes filmed from the driver's perspective on a 3M Microtouch M150 15"

LCD touch screen. They were instructed to anticipate potential traffic conflicts before they

occurred by touching the road user involved as quickly as possible. A traffic conflict was

defined as any situation in which the camera car was required to brake or take evasive action

to avoid a collision with another road user (e.g., a pedestrian crossing the road). The validity

of this test has been demonstrated by its ability to discriminate between novice and

experienced drivers (Wetton et al., 2010), and its association with increased age and measures

of cognition and vision in a sample of older drivers (Horswill et al., 2008). Participants'

response times were recorded, measured from the first possible moment the traffic conflict

was detectable. A total score was calculated by averaging standardised response times across

all hazards (raw scores were standardised into Z-scores using the overall sample mean and

standard deviation for each hazard). This process controlled for differences in hazard

duration. The overall standardised score was then converted back to an overall response time

(measured in seconds) using the mean and standard deviation across all hazards and participants.

Modified Telephone Interview for Cognitive Status (TICS-M). The TICS-M is a brief 13-item cognitive screen with scores ranging from 0 to 39, where higher scores indicate greater cognitive difficulty (Brandt et al., 1993; De Jager, Budge, & Clarke, 2003). While designed for administration over the telephone, it is also used in face-to-face interviews. The TICS-M has been shown to be more sensitive to mild deficits in cognitive performance in an older population than the Mini Mental Status Examination (MMSE) (De Jager et al., 2003).

Procedure

Participants on a laboratory register were contacted with a request to participate. Questionnaire packages, with an information sheet and consent form, were mailed to each person to complete prior to assessment at the University. The semi-structured interview, TICS-M, Pelli-Robson Contrast Sensitivity Test and Snellen Visual Acuity Chart were completed according to standardised conditions under a luminance of $100cd/m^2$. Participants were then seated in front of the touch screen to complete the QLD Hazard Perception Test at a viewing distance of approximately 45cm. Room lighting was reduced to a luminance of $0.5cd/m^2$ and participants were given time before and after this task to adapt to changes in lighting. Breaks were provided as needed during the assessment session.

Statistical Analysis

Receiver-operator curve (ROC) analysis determines the classification accuracy of a test, which is expressed in terms of sensitivity and specificity. Test sensitivity refers to the accuracy with which individuals with a specific characteristic are correctly identified by a diagnostic test. Test specificity refers to the accuracy with which individuals who do not possess a specific characteristic are identified as symptom-free. The ROC curve is a plot of a test's sensitivity (*y* axis) against its false positive rate (1 − specificity, *x* axis) at all potential

cut-off points (i.e., possible decision thresholds) (Zhou, Obuchowski, & McClish, 2002). The *area under the curve* (AUC) is a summary index representing the overall diagnostic accuracy of a test. The AUC can take values between 0.0 and 1.0, with higher scores indicating greater discriminability. For example, an AUC score of 0.5 suggests the test is performing no better than chance in accurately discriminating individuals with or without the target characteristic. By comparison, an AUC score of 0.9 would mean that if two persons were selected at random, there is a 90% chance that the affected person (e.g., the compensatory-restricted driver) scored higher on the test (Zhou et al., 2002). While what is considered a "good" AUC, sensitivity, or specificity value depends on the target characteristic and clinical application (e.g., the risk of fatality), a score of 0.8 or higher is generally considered clinically useful and a score of 0.9 and above is considered the gold standard (Hirsch & Riegelman, 1996).

In the current study, the semi-structured interview was used to classify drivers as *restricted* or *non-restricted* based on whether they expressed compensatory reasons for situational avoidance. ROC analysis of SAQ Avoidance Total Scores (Rasch converted) was undertaken to determine: (1) the ability of the SAQ avoidance scale to accurately identify drivers who may be experiencing difficulty on the road and who are practicing compensatory avoidance behaviour; and (2) the point on the SAQ at which maximum discriminability was found. Using this optimal cut-off score, group differences across objective and subjective measures related to driving self-regulation were explored to establish test validity. Analyses included a series of *t*-tests with Bonferroni correction (0.05/14) for a *p* value of .004. Pearson's chi-square analysis was used for dichotomous variables, gender and motor vehicle crash involvement in the past 5 years. Sample sizes varied with random missing data on some variables (e.g., motor vehicle crash involvement).

Results

ROC analysis of the SAQ

Receiver-operator curve (ROC) analysis of the SAQ produced an area under the curve (AUC) of 0.89 (95% *CI* = 0.81 to 0.96, *p* < .001). An avoidance score of 31 had both high sensitivity (85%) and high specificity (82%) in classifying drivers as compensatory-restricters (see Figure 5.1 and Table 5.2). Given that a value of 31 is unattainable on the Rasch converted scale, the next highest cut-off value, a Rasch converted score of 33, was used (see Appendix C). Using this score, participants were classified as compensatory-restricters (SAQ score ≥ 33) or non-restricted (SAQ score < 33) for all subsequent analyses.
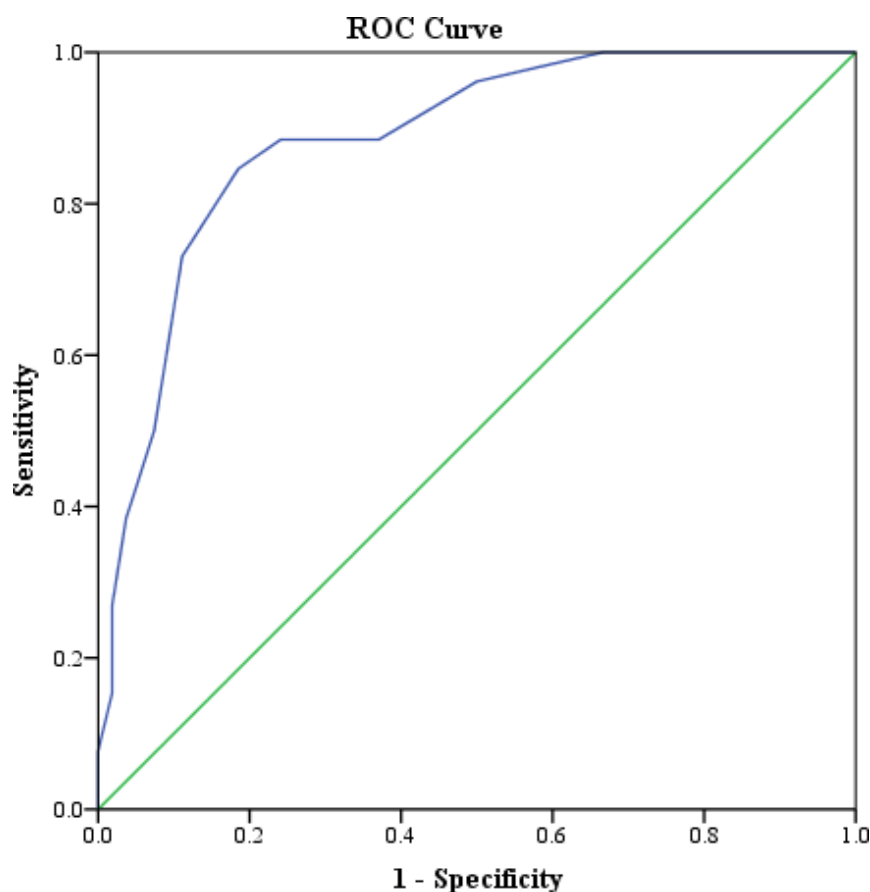
Figure 5.1. Receiver-operator curve for the avoidance subscale of the Situational Avoidance Questionnaire (Davis et al., 2016).

Table 5.2. *Sensitivity and Specificity Values for SAQ Avoidance Scores.*

SAQ Avoidance Score (Rasch conversion)	Sensitivity	1 - Specificity
26.50	.885	.241
31.00	.846	.185
35.00	.731	.111

Group Comparisons

No significant differences were found between groups in age or objective cognitive function on the TICS-M (see Table 5.3). Compensatory-restricters were more likely to be female, reported more changes in their cognition over the past five years, and endorsed poorer driving confidence and greater difficulty when driving. They also expressed more negative attitudes toward driving, indicated having received more negative feedback from others or the environment about their standard of driving, and overall, were further along in the process of behaviour change than non-restricted drivers. The groups did not differ in their ratings of the perceived importance of driving and barriers to driving self-regulation.

Importantly, non-restricted drivers were less likely to have been involved in a motor vehicle incident in the past five years and on the hazard perception test, were significantly faster in identifying potential traffic conflicts than the restricted group. Consistent with this, the compensatory-restricters reported greater discomfort when driving due to difficulties with hazard perception skills. These results validate the SAQ and the cut-off score of 33 as an indicator for compensatory driving behaviour.

Table 5.3. *Characteristic Differences between Restricted (n ranges = 27 to 32) and Non-Restricted (n ranges = 44 to 47) Drivers following ROC Analysis.*

Characteristic	Restricted	Non-Restricted	Significance[2]	Effect Size[3]
Demographics				
Age	73.75 (5.95)	70.02 (7.50)	$t(77) = -2.36, p = .021$	-
Gender				
Male	22.6% (7)	60.4% (29)	χ^2(N=79, df=1) = 10.87,	5.23
Female	77.4% (24)	39.6% (19)	$p = .001$*	
MVC in Past 5 yrs				
Yes	41.9% (13)	20.8% (10)	χ^2(N=71, df=1) = 4.94,	2.95
No	45.2% (14)	70.8% (34)	$p = .026$*	
Objective Abilities				
QLD Hazard Perception Test	3.95 (0.64)	3.56 (0.53)[1]	$t(76) = -3.03, p = .003$*	0.68
TICS-M	26.20 (3.57)	25.69 (3.22)	$t(76) = -.62, p = .513$	-
Subjective Abilities				
Driving Discomfort	44.77 (10.81)	31.68 (13.41)	$t(76) = -4.55, p <.001$**	1.07
Problems with Cognition	26.48 (9.48)	23.38 (10.96)	$t(77) = -1.30, p = .199$	-
Changes in Cognition	24.00 (11.89)	14.50 (12.11)	$t(77) = -3.43, p = .001$*	0.79
Daily Difficulties with Cognition	8.77 (6.30)	7.58 (8.83)	$t(77) = -.65, p = .517$	-
Driving Attitudes				
Driving Confidence	21.32 (5.38)	27.06 (4.90)	$t(77) = 4.89, p < .001$**	1.12
Driving Difficulty	10.58 (4.53)	5.02 (3.97)	$t(77) = -5.75, p < .001$**	2.01
Affective Attitudes	7.90 (3.49)	5.46 (3.20)	$t(77) = -3.20, p = .002$*	0.73
Importance of Driving	11.48 (2.99)	11.44 (2.88)	$t(77) = -.07, p = .945$	-
Feedback	6.23 (2.36)	4.44 (3.01)	$t(74) = -2.95, p = .004$*	0.66
Perceived Barriers	12.16 (4.17)	12.77 (4.02)	$t(77) = .65, p = .519$	-
Stages of Change	15.52 (4.20)	10.52 (4.34)	$t(77) = -5.06, p <.001$**	1.17

*$p <.05$; **$p <.001$

[1]Outlier (1.5SD above group mean) was removed.

[2] Bonferroni correction applied for all *t*-test analyses for a significance value of .004.

[3] Odds ratio was calculated for the chi-square analysis and Cohen's *d* was calculated for all *t*-test analyses.

Discussion

The current study aimed to validate the Situational Avoidance Questionnaire (SAQ, Davis et al., 2016) and identify the point at which drivers who are reporting difficulty on the road, and who are practicing compensatory driving behaviour, could be distinguished from those who are not. The SAQ demonstrated high diagnostic accuracy in classifying compensatory-restricted and non-restricted drivers, with a Rasch avoidance total score of 33 maximising

both sensitivity and specificity. The characteristics of those practicing situational avoidance for compensatory reasons replicate the findings of previous research, with the exception of the variable age (Anstey et al., 2005; Charlton, Oxley, Fildes, et al., 2006; Conlon et al., 2017; D'Ambrosio et al., 2008; Kowalski et al., 2014; Rudman et al., 2006). Considering the motivations behind situational avoidance in the classification process may have allowed for the variability in the ageing process to be reflected in the results (Molnar et al., 2015). In the present study, it was not age per se that prompted participants to consider compensation, but the increase in perceived and actual functional difficulty that can occur with age or with age-related disease. Based on their response patterns, drivers reporting avoidance of five or more situations on the SAQ were doing so in an attempt to reduce the perceived demands of the driving task.

The magnitude of group effects in the present study are consistent with previous research, suggesting that an individual's self-perceptions are stronger determinants of their self-reported driving behaviour than their objectively measured skills (Anstey et al., 2005; Baldock et al., 2006a; Molnar et al., 2014). This is not surprising given that situational avoidance is a self-determined behaviour, reliant on a driver's own understanding and experience of their abilities and the driving environment. However, of relevance is the correspondence between the subjective abilities and attitudes of the two driver groups and their performance on the objective tasks. Self-regulatory driving behaviour is proposed to be accurate or 'appropriate' only when subjective self-assessments match objective driving skills (Ackerman, Vance, Wadley, & Ball, 2010; Anstey et al., 2005; Baldock et al., 2006a). Compensatory-restricted drivers were 2.95 times more likely to report previous involvement in a motor vehicle incident, were slower to identify potential traffic hazards and subjectively, reported greater driving difficulty and more discomfort with driving due to impaired hazard perception skills. In comparison, the two groups performed similarly on the TICS-M and did

not differ in self-reported problems or daily difficulties with cognition. Interestingly, the compensatory-restricted driver group acknowledged greater self-perceived change in cognitive function over the past five years than the non-restricted group. Driving self-regulation has been proposed to need a trigger, an internal or external cue that indicates that one's driving skills have changed or have become a problem requiring a change in behaviour (Kowalski et al., 2014). This suggests that variables measuring *change* in skills over time may have stronger associations with driving self-regulatory behaviour, particularly in healthier, community-based older driver samples.

This study contributes to the driving self-regulation research through establishing a psychometrically sound and valid measure of situational avoidance that can distinguish compensatory from non-compensatory driving behaviour. Use of this measure in future research for further comparison between compensatory-restricted and non-restricted drivers would assist in identifying factors (both internal and external to the older driver) that facilitate or serve as a barrier to the practice of compensatory situational avoidance. In addition, it will allow more accurate estimation of the safety benefits of compensatory driving self-regulation among older road users. This is particularly important given that the actual safety benefits of driving self-regulation are unclear and one reason for this is that the motivation behind an older driver's behaviour change is often not considered.

This limitation notwithstanding, studies investigating the crash risk of older adults have consistently found a small subset of older drivers who have a significantly higher risk of motor vehicle crash involvement. The crash risk of this subgroup appears to persist despite reporting a significant reduction in driving frequency and space (Daigneault et al., 2002; Langford et al., 2006; Owsley et al., 2004). These findings have generally been interpreted in terms of degree of driver impairment. It may be relatively easy for an older driver to compensate for a single specific loss of function (e.g., a decline in contrast sensitivity).

However, if there is a cumulative decrease in several functions, an individual's self-monitoring and self-regulatory system may be overloaded (Hakamies-Blomqvist et al., 2004). Drivers with the greatest driving impairments are often those practicing a significant degree of driving self-regulation (e.g., a severe reduction in driving exposure), but for this extreme group, driving self-regulation may not be sufficient alone to offset their crash risk (Ball et al., 2006; Langford et al., 2006; Ross et al., 2009). If the single loss of function affects insight or judgement, then the effectiveness of any form of self-determined behaviour is also likely to be minimal (Hakamies-Blomqvist et al., 2004).

There is a need for research investigating the criteria or specific characteristics of drivers for whom self-regulation may be effective. Use of validated measures of self-regulation, such as the SAQ, will be of benefit here. We have a study currently underway examining whether specific groups of older drivers can be identified according to factors that influence an individual's capacity for and expression of awareness (e.g., cognitive ability), and whether these groups differ in degree of compensatory situational avoidance. In addition to awareness, future research should also consider degree and type of driving impairment in evaluating the safety benefits of driving self-regulation strategies, such as situational avoidance.

This study has several limitations. First, the use of a convenience sample has likely contributed to a bias toward a healthier, more cognitively intact sample of participants, meaning that lower levels of self-regulation may have been reported than what might be found in the general community. Indeed, some of the more severely restricted participants (and thus, likely those with greater functional impairments) in the research database declined the invitation to participate in the study for various reasons (e.g., convenience, confidence, or life stressors such as illness in the family). For some of those that did agree to participate, their self-reported driving practices may not reflect their actual driving behaviour. Further research is needed to validate the SAQ against objective data obtained with an in-vehicle

assessment device (e.g., Blanchard et al., 2010; Marshall et al., 2007; Thompson, Baldock, Mathias, & Wundersitz, 2016). Replication of the SAQ cut-off score within a broader sample of older drivers with more varied functional ability and degree of self-reported situational avoidance would also help in cross-validating the cut-off score identified.

In terms of crash data, research generally supports a reasonable level of agreement between self-reported and official crash data (McGwin, Owsley, & Ball, 1998; Marottoli, Cooney, & Tinetti, 1997). However, in this study, participants were also asked to describe the crashes they were involved in and for those that provided this qualitative data, inconsistencies in the definition of a "crash" were found. This is not necessarily a limitation. The purpose of this study was to determine the SAQ cut-off point at which compensatory driving behaviour could be reliably identified. We expect subjective degree of risk to differ naturally at the individual level. For some older drivers, a near miss could prompt serious consideration of the need for self-regulatory driving behaviour. For others, driving self-regulation may not be considered until actual crash involvement. Moreover, while crashes are a multi-determined event, the presence of adverse events in one's driving history can signal the potential contribution of functional deficits (Marottoli, Cooney, et al., 1997), further supporting the notion that the situational avoidance reported by the restricted group is likely to be compensatory.

Summary and Conclusions

The nature of the 'older driver problem' has changed in recent years from one of safety concerns alone to including concerns about their continued, safe mobility (Hakamies-Blomqvist et al., 2004). This has underscored the need for a more supportive rather than restrictive approach to the regulation of our older road users. Alongside screening measures, vehicle technologies and infrastructure changes, driving self-regulation has been proposed as a means through which the safe mobility of older adults may be maintained (Hakamies-

Blomqvist et al., 2004; Molnar, Eby, St Louis, & Neumeyer, 2007). However, the actual safety benefits of specific self-regulatory strategies, such as situational avoidance, are not well understood. This paper sought to validate the Situational Avoidance Questionnaire and identify the point at which compensatory avoidance behaviour could be identified. Considering the reasons or motivations behind self-reported situational avoidance is necessary as only truly compensatory behaviour will be associated with risk outcome measures (Molnar et al., 2015). As such, there is a need for further prospective research investigating the efficacy of different forms of driving compensation using validated measures such as the SAQ.

Practical Applications

This is the first known study to establish a self-report driving questionnaire that defines a specific cut-off score to differentiate older drivers who are reporting situational avoidance for compensatory reasons from those who are not. Future research investigating the safety benefits of driving self-regulation at the strategic level of driving behaviour should consider using the SAQ, a psychometrically sound measure of compensatory situational avoidance.

Acknowledgements

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Chapter 6 : Measuring Older Drivers' Metacognitive Knowledge and Online Awareness – Theory and Methods

Introduction

In the preceding two chapters, the development and validation of the Situational Avoidance Questionnaire (SAQ) was described, with specific emphasis on determining its ability to identify compensatory driving behaviour. Inherent in the definition of any form of self-determined compensation is the notion that an individual has the capacity to accurately self-monitor their ability in an area, recognise specific skill deficits and respond with appropriate compensatory changes to their behaviour (Crosson et al., 1989; Toglia & Kirk, 2000). Accordingly, increasing research attention has been paid to the importance of awareness as the necessary condition for *accurate or appropriate* driving self-regulation to occur (Anstey et al., 2005; Molnar et al., 2015; Rudman et al., 2006).

Toglia and Kirk's (2000) model characterises awareness as comprising two distinct but interdependent forms: metacognitive knowledge and online awareness. Metacognitive knowledge refers to knowledge and beliefs about one's abilities that are developed over time and informed by a variety of sources (Toglia & Kirk, 2000). Information at this level of awareness influences behaviour via top-down processes such as planning and conflict resolution (Fernandez-Duque et al., 2000). On this basis, life-goal and strategic decisions made prior to getting into the car, such as what car to drive and when and where to travel, would be informed by the content and accuracy of one's metacognitive knowledge (Eby et al., 2009; Michon, 1985).

By comparison, online awareness is activated within the context of a specific situation or task and involves appraisal of current task demands (anticipatory awareness), monitoring of task performance and recognition of errors (emergent awareness), and evaluation of one's performance at task completion (self-evaluation) (Toglia & Kirk, 2000). Accurate task

appraisal and self-monitoring when driving are considered to influence the allocation of resources and other tactical self-regulatory strategies such as speed of travel, headway between vehicles, and braking behaviour (Fernandez-Duque et al., 2000; Michon, 1985).

In the driving literature, there is no agreed upon method for assessing awareness of driving performance among older road users. A large proportion of studies have indirectly inferred awareness from the relationship between older drivers' self-regulatory practices and driving outcome measures, including measures of skills important for safe driving (e.g., vision, cognition, physical function or health status) (e.g., Ball et al., 1998; Baldock et al., 2006b; Baldock et al., 2008; Davis, 2010; Devlin & McGillivray, 2016; Fraser et al., 2013; Keay et al., 2009; Lyman et al., 2001; Okonkwo, Crowe, et al., 2008; Stutts, 1998; West et al., 2003) or on-road performance (Baldock et al., 2006a; Eby et al., 2003; Koppel et al., 2017). If an individual performs poorly on any of these outcome measures yet practices situational avoidance or other forms of driving self-regulatory behaviour, this behaviour is thought to reflect accurate awareness of one's capacity for safe driving. However, while this association may be considered an implicit manifestation of awareness, it does not necessarily signify explicit awareness (Clare, 2004a; Toglia & Kirk, 2000), particularly given that the reasons for driving self-regulation are not often considered.

Explicit awareness refers to self-knowledge and beliefs that exist within consciousness and can be expressed verbally (Clare, 2004a; Ownsworth et al., 2007). Studies assessing explicit awareness among older drivers have varied considerably in terms of the method of assessment (e.g., clinician versus performance-based discrepancy), object of awareness (e.g., driving ability or specific driving skills), and type of awareness assessed (e.g., metacognitive knowledge or a form of online awareness) (e.g., Broberg & Willstrand, 2014; Horswill et al., 2013; Kay, Bundy & Clemson, 2009; Lundqvist & Alinder, 2007; MacDonald et al., 2008; Ross, Dodson, Ackerman, & Ball, 2012; Wild & Cotrell, 2003). To date, no study has

explored both types of awareness, metacognitive knowledge and online awareness, concurrently in a sample of cognitively healthy older drivers. In order to understand the complex phenomenon of self-awareness, and in light of the proposition that driving self-regulation may have its largest impact for cognitively healthy older adults, awareness and its correlates must be understood in this population (Berry, 2011; Molnar et al., 2015).

Measuring Metacognitive Knowledge

Metacognitive knowledge can be assessed by comparing a person's self-ratings of ability with ratings of an informant (e.g., relative or clinician), or to performance on an objective test of the target ability (Clare, 2004b; Clare, Markova, Verhey, & Kenny, 2005). In the driving literature, the most common means of assessing self-knowledge is the use of a subjective questionnaire (Sundstrom, 2008). Self-ratings are compared to performance on objective tests that measure the same underlying construct as the questionnaire, such as components of driving skill, for example, visual, cognitive or physical function (Ackerman et al., 2010; Siren & Meng, 2013); or actual driving ability measured via an on-road test or simulated driving task (Eby et al., 2003; Marottoli & Richardson, 1998; Okonkwo et al., 2009; Wood et al., 2013). These self-ratings are obtained prior to task performance and without reference to the objective test itself.

Several researchers have used questions that elicit a global self-assessment by social comparison (e.g., "How would you rate your driving ability compared to others of the same age and/or same gender?") (Carberry, Wood, Watson, & King, 2006; Freund et al., 2005; Holland & Rabbitt, 1992). This approach relies on the accuracy of a person's subjective perception of the "average" older driver their same age and/or gender. Older adults, like younger drivers, tend to view themselves as less likely to be involved in an accident and/or as better drivers than their same-aged peers, irrespective of how well they performed on objective driving measures (Amado, Airkan, Kaca, Koyuncu, & Turkan, 2014; Carberry et

al., 2006; Holland & Rabbitt, 1992; Horwsill et al., 2004; Horswill et al., 2013; Ross et al., 2012; Tuokko et al., 2007; Wood et al., 2013). However, the self-rated driving ability of older drivers has been shown to change depending on who they were asked to compare themselves with, their level of driving experience (Holland, 1993), and their perceived accountability (McKenna & Myers, 1997). Thus, self-other comparisons depend, to some extent, on how the question is framed and the characteristics of the sample.

MacDonald et al. (2008) and Myers et al. (2008) noted that the positive self-bias evident for global self-assessments of driving ability was not found when older adults were asked to rate their driving on a multi-item measure of specific abilities. This finding was attributed to decreased ambiguity and increased correspondence between subjective items and the objective measure of the awareness object. It may be further explained by the domain specificity of awareness, particularly in cognitively healthy populations. According to Toglia and Kirk's (2000) model of awareness, dynamic interactions occur within and between metacognitive knowledge and online awareness to produce variations in awareness dependent upon the skill domain and situation in which the deficits arise. As such, older drivers may be aware of changes in some driving skills but not others, which may serve to confound results when "driving ability" as a whole represents the awareness object.

Measuring Online Awareness

Subjective estimates of ability that are obtained with reference to performance on a specific test at a specific point in time capture an individual's capacity to monitor their function *online*. A measure of *online anticipatory awareness* is obtained by comparing participants' performance predictions (obtained immediately prior to the test) to their actual task performance (Clare & Wilson, 2006; Toglia & Kirk, 2000). Freund and colleagues (2005) found that 65% of their sample of older drivers predicted that they would perform better on a simulated driving task than their same-age peers. Those who rated their skills as

better than that of other drivers were four times more likely to be judged as unsafe by a clinician following a simulated driving test relative to those who rated their ability as comparable to or worse than their peers (Freund et al., 2005). However, it is unclear whether the same results would have been found if participants had first received a brief practice trial on the driving circuit. Given that metacognitive knowledge informs online anticipatory awareness (Toglia & Kirk, 2000), some experience with the task context could have assisted participants to access what they were required to know of task characteristics in order to judge their strengths and limitations in that area.

Online emergent awareness is assessed by having participants rate their level of confidence or certainty that they were correct after each trial of a task (O'Keefe et al., 2007). Davis (2010) had self-restricted and non-restricted older drivers rate their peripheral localisation accuracy after each trial of tasks assessing divided and selective attention. Both groups had more difficulty detecting errors on the selective attention task than on the divided attention task, but the self-restricted driver group were consistently less aware of errors than the non-restricted driver group across both tasks. When the objective test has significant attentional demands, an individual will have fewer resources available to monitor, detect and respond to errors (Hart, Giovannetti, Montgomery, & Schwartz, 1998), particularly if they have poorer attention skills to begin with (Davis, 2010). Older drivers with poor online emergent awareness may be at greater risk of crash involvement as they are unaware that they failed to detect and respond to potential hazards in the driving environment.

Self-evaluation is measured by having participants rate how well they think they performed immediately following a task (O'Keefe et al., 2007). Some studies have shown that older drivers are better at evaluating their performance post-test than predicting how well they will perform prior to the test (online anticipatory awareness) (e.g., Boccara, Delhomme, Vidal-Gomel, Dommes, & Rogalski, 2010; Schoo, Van Zandvoort, Biessels, Jaap Kappelle,

& Postma, 2013). However, other studies have found this not to be the case. Horswill and colleagues (2011) had older drivers rate how confident they were that they had responded correctly throughout a hazard perception test. These authors found little to no correspondence between hazard detection performance and participants' self-evaluation of their accuracy, concluding that the older drivers in their sample did not possess insight into their hazard perception ability (Horswill et al., 2011). Unfortunately, the study used a hazard perception test designed to test reaction times to filmed traffic hazards and included a hit rate outcome variable only as a secondary measure. The lack of correspondence between the self-evaluation question and the design of the hazard perception test may have accounted for these results. They later rectified their methodology, this time asking participants to rate their speed of response compared to the average Brisbane driver for each hazard scene at the completion of the hazard perception test (Horswill et al., 2013). However, this self-evaluation measure still relied on participants' understanding of the hazard perception speed of "average Brisbane driver" and their ability to recall how quickly they responded to each hazard scene at the completion of the test.

Validity of the Toglia and Kirk (2000) Model

O'Keefe and colleagues (2007) assessed the cognitive ability of patients with brain injury and compared objective performance to three measures of awareness of cognitive ability: metacognitive knowledge, and online emergent and anticipatory awareness. Both forms of online awareness were strongly correlated ($r = .72$) but neither was significantly associated with metacognitive knowledge (O'Keefe et al., 2007). This finding supports Toglia and Kirk's (2000) characterisation of awareness as comprising two distinct forms.

Both forms of online awareness (particularly online emergent awareness) have been shown to be associated with accuracy on a task (Davis, 2010; O'Keefe et al., 2007), and thus are task-specific as proposed by the Toglia and Kirk (2000) model. This could explain why

individuals can accurately self-monitor their performance on some tasks but not others (domain-specific awareness) (Okonkwo et al., 2009; Stuss et al., 2001). According to Kruger and Dunning (1999), the skills that are required to perform competently in a particular domain are often the same skills necessary to evaluate competence in that domain. Thus, poorer self-monitoring skills would more often be observed on tasks that are more difficult, or in persons with greater impairment in the skill in question.

In addition to competence or task difficulty, other aspects of the task have been found to influence judgements of performance. For example, a general tendency towards underestimation of perceptual tasks has been found for persons of all ages and has been theorised to be a product of greater perceived difficulty judging 'what you see' relative to 'what you know' (Baranski & Petrusic, 1994; Kruger & Dunning, 1999). Ageing stereotypes can also be internalised by older adults, affecting self-perceptions and behaviour (Barber, 2017; Brelet et al., 2016; Ferring et al., 2015; Robertson et al., 2016). Studies have demonstrated that those who have been primed with negative self-stereotypes of ageing rated their subjective memory abilities as poorer than those with positive self-stereotypes and performed more poorly on tests of memory (Hess, Auman, Colcombe, & Rahhal, 2003; Hess, Hinson, & Hodges, 2009; Levy, 1996).

The Current Study

The aim of this chapter is to describe the measurement of metacognitive knowledge and online awareness across different domains of the hazard perception task. Hazard perception was selected as the 'object of awareness' for the present study given that it is an ecologically-valid measure of driving ability in older populations and one of the few computer-based tasks to be associated with critical safety outcomes of on-road driving performance and crash risk (Horswill et al., 2009; Horswill et al., 2010; see Horswill & McKenna, 2004 for a review). Selection of this task was also motivated by the ability to isolate distinct domains or

components of this broader skill. These components relate to visual (contrast sensitivity) and cognitive abilities (reaction time and divided attention) in older drivers (Horswill et al., 2008; 2009). Developing awareness measures specific to each of these objects of awareness allows for the investigation of differences in awareness levels within the broader domain of hazard perception. The two forms of awareness were also measured in relation to memory function to allow for the comparison of awareness in domains outside of driving-related skills. Three specific aims of this chapter are: 1) to describe the method of awareness assessment for memory (Logical Memory Test) and hazard perception (contrast sensitivity, divided attention, simple reaction time, and hazard perception); 2) to validate Toglia and Kirk's (2000) characterisation of metacognitive knowledge and online awareness as comprising distinct constructs; and 3) to describe and compare awareness ratios across memory and hazard perception skills.

Method

Participants

A sample of 79 adults (36 males, 45.6%), aged between 55 and 86 years ($M = 71.48$, $SD = 7.16$), was recruited from local community groups in regional Queensland, Australia (please see Chapter 4, *Participants* section for details of the complete study sample). All participants reported possession of a current open drivers' license and consistent with Australian licensing standards, had corrected vision in their better eye of equal to or better than 6/12 on the Snellen acuity chart (Austroads, 2016). This study had University Human Research Ethics Committee approval, with all participants providing written informed consent.

Measures

Functional Skills / Objects of Awareness

Logical Memory (LM) Test I and II, Wechsler Memory Scale (WMS-IV). This test measures the ability to encode, recall and recognise verbal information that is semantically

related (Wechsler, 2009a). Age- and education-adjusted norms are available for persons aged 16 to 90 years. Participants aged less than 65 years and those aged 65 to 69 years with more than 14 years of education were administered the Adult battery ($n = 22$). For all other participants, the Older Adult battery was administered ($n = 57$). In the immediate recall condition (LM I) of the Adult battery, two short stories were orally presented (Stories B and C). In the immediate recall condition (LM I) of the Older Adult battery, Story A was presented twice, followed by one presentation of Story B. Participants retold each story from memory immediately after hearing it. The delayed recall condition (LM II) assesses long-term narrative memory (Wechsler, 2009a). Participants recalled both stories presented 20 to 30 minutes earlier in the LM I condition. Responses were scored according to the standardised scoring procedure (Wechsler, 2009b). Both conditions have good internal consistency in a cognitively healthy sample aged 65 to 90 years (LM I = .86; LM II = .87).

Pelli-Robson Contrast Sensitivity Test. The Pelli-Robson chart consists of eight rows of individual letters, with each row containing two sets of three letters (triplets) (Pelli et al., 1988). Different letters are used on alternate forms of the same test. All letters are the same size but each successive triplet is presented with a contrast reduction of 0.15 log units. Log Contrast Sensitivity scores were determined by the last triplet of which at least two letters were correctly identified (Pelli et al., 1988). Scores were averaged across both sides of the chart to obtain a final contrast sensitivity score.

Functional Field of View (FFOV) Task. The FFOV assesses visual attention and measures the spatial area within which targets can capture attention outside of central vision without head or eye movements (Sanders, 1970). Stimuli for the task were generated using Macro Media Director, housed in a Dell Optiplex GX260 computer and projected onto a screen using a NEC NP500WS projector. The projected image measured 165 by 120cms in size and was viewed binocularly at a distance of 87.6cms. All stimuli measured 5° by 3° of visual

angle and included a central task and a peripheral target (see Figure 6.1). Participants judged

whether the central stimulus contained two vehicles that were the same or different, whilst

simultaneously determining the location of the peripheral target. The peripheral target (car)

appeared randomly in one of eight evenly distributed radial locations, all subtending 30º of

visual angle from the central stimulus. Participants completed one block of 12 valid (central

task correct) trials, with performance accuracy (DV) measured as the number of accurate

peripheral localisations made. Each trial had a stimulus duration of 100ms and began with a

central circle containing a fixation cross that was presented for 750ms prior to stimulus

presentation. Following each trial and before the response screen, a grated mask was

presented to prevent stimulus persistence.
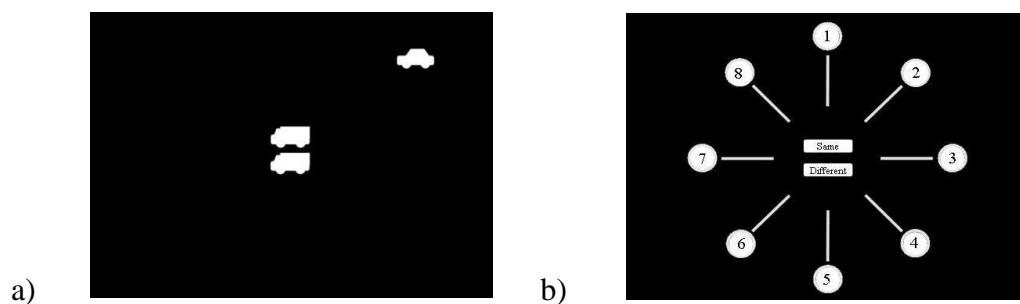
Figure 6.1. Stimuli for the FFOV task: a) divided attention screen; and b) response format.

The validity of this test has been demonstrated by its association with self-reported

difficulties in everyday activity and age-related declines in visual function (Wood &

Troutbeck, 1995). Older drivers have also been found to perform more poorly on this test

than younger drivers (Power & Conlon, 2017; Wood, 2002), with performance on the FFOV

accounting for increased errors on an on-road driving test among the older driver group

(Wood, 2002).

Simple Reaction Time Test. A test of simple reaction time was devised based on that used

by Horswill and colleagues (2008; 2009) given its demonstrated association with hazard

perception performance. Participants were required to press a keyboard space bar as quickly

as possible whenever the target, a blue solid circle measuring 2cm in diameter, appeared on a white background in the centre of a computer monitor. There were 16 trials presented over a 90 second period, with the target appearing at random intervals (though always in the same location). The target remained on screen until participants responded and was replaced with a fixation cross between each trial. Participant reaction times were recorded in milliseconds.

Queensland Hazard Perception Test. The QLD Hazard Perception Test contained 55 measured hazards within 34 video clips, lasting a total of 17 minutes in duration (Marrington et al., 2008; Smith et al., 2009). The video clips consisted of un-staged Queensland road scenes filmed from the driver's perspective and were presented on a 3M Microtouch M150 15" LCD touch screen at a viewing distance of approximately 45cm. Participants were instructed to anticipate potential traffic conflicts before they occurred by touching the road user involved as quickly as possible. A traffic conflict was defined as any situation in which the camera car was required to brake or take evasive action to avoid a collision with another road user (e.g., a pedestrian crossing the road). Participants' response times were measured from the first possible moment the traffic conflict was detectable. A total score was calculated by averaging standardised response times across all hazards (raw scores were converted into Z-scores using the overall sample mean and standard deviation for each hazard). This process controlled for differences in hazard duration. The overall standardised score was then converted back to an overall response time (measured in seconds) using the mean and standard deviation across all hazards and participants. The validity of this test has been demonstrated by its ability to discriminate between novice and experienced drivers (Wetton et al., 2010), and its association with age (older adults perform more poorly) and measures of cognition and vision in a sample of older drivers (Horswill et al., 2008).

Awareness Assessment Measures

Metacognitive Knowledge. Questionnaires assessing self-knowledge of hazard perception

ability, its component skills (contrast sensitivity, divided attention and simple reaction time) and memory function (Logical Memory Test [LMT]) were developed using items drawn from or informed by existing measures (e.g., Clare, Wilson, Carter, Roth, & Hodges, 2002; Eby et al., 2000; Eby et al., 2003; Horswill et al., 2004; Rubin et al., 2001; Sloane et al., 1992; Tun & Wingfield, 1995). Items on these questionnaires were selected or developed to closely parallel the functional skills being tested (see Table 6.1 for example items). Participants rated their ability in each skill area relative to another driver their age using a 5-point response scale (1 = *Much Worse,* 2 = *A Little Worse,* 3 = *About the Same,* 4 = *A Little Better*, and 5 = *Much Better*). Participants obtained an average score on each scale, with higher scores indicating a more favourable self-comparison. Internal consistency (Cronbach's alpha) for the scales ranged from .86 to .95.

Table 6.1. *Example Items from Self-Knowledge Questionnaires Assessing Hazard Perception*

Skills and Memory.

Awareness Object	Example Items
Driving-Related Skills	Stem - *"Compared to others my age:"*
Contrast Sensitivity (4 items)	• My ability to see lane markings in the rain is • My ability to read road signs at night, dusk or when it is raining is
Divided Attention (6 items)	• My ability to locate an unfamiliar business or find a new address while driving is • My ability to change into an adjacent lane (checking for other cars while monitoring cars in front) is
Simple Reaction Time (5 items)	• My reflexes are • My ability to respond quickly to potential hazards is
Hazard Perception (5 items)	• My ability to quickly spot potential hazards in traffic (e.g., a cyclist riding in your lane ahead) is • My ability to anticipate and be prepared for changing conditions is
Memory	
Immediate Recall (5 items)	Stem – *"You hear a short news story and a member of your family comes in the room just as the story finished and asks you what was said. Compared to others your age, your ability to remember:"* • The day the reporter said the event occurred is • The location mentioned in the story is
Delayed Recall (5 items)	Stem – *"Approximately half an hour later, another family member asks you what you heard about the news story. Compared to others your age, your ability to remember:"* • The day the reporter said the event occurred is • The basic details of the news story is

Accuracy of self-knowledge for each awareness object was determined by comparing

self-ratings of ability to objective test outcome. Guided by existing psychometric approaches

to awareness measurement (Anderson & Tranel, 1989; Clare et al., 2002; Marson et al., 2000;

Moritz, Ferahli & Naber, 2004; Okonkwo, Wadley, et al., 2008; Okonkwo et al., 2009), cut-

off scores derived from normative data were used to place the objective test scores on the

same metric as the questionnaire (see Table 6.2). Comparison data included age-based norms

for the Pelli-Robson contrast sensitivity test (Mantyjarvi & Laitinen, 2000) and Logical

Memory Test (Wechsler, 2009b), the average performance of a Queensland-based cognitively

healthy adult sample stratified by age (FFOV divided attention, Davis, 2010; Brown, 2009; Simple Reaction Time and Hazard Perception Tests, Horswill et al., 2009). See Appendix D for a further description of comparison data used.

Table 6.2. *Formulation of Metacognitive Knowledge Awareness Ratios.*

Metacognitive Knowledge	Metric for Comparison				
	1	2	3	4	5
Estimated Score[1]	Much worse than others my age	A little worse than others my age	About the same as others my age	A little better than others my age	Much better than others my age
Actual Performance[2]	1.5 SD below the mean	Scores between 1 and 1.5SD below the mean	Mean ± one standard deviation	Scores between 1 and 1.5 SD above the mean	Scores more than 1.5 SD above the mean

[1] Average score on the metacognitive knowledge questionnaires for each object of awareness.
[2] Test performance was compared to normative or comparison data.

A *metacognitive knowledge awareness ratio score* was generated for each object of awareness using the formula suggested by Barrett, Eslinger, Ballentine, and Heilman (2005):

$$\text{Awareness ratio} = \frac{\text{Estimated} - \text{Actual Performance}}{\text{Estimated} + \text{Actual Performance}}$$

By including both estimated and actual scores in the denominator, an awareness ratio could be computed that allowed for identification of under- and overestimation of ability (Barrett et al., 2005). Obtained scores range from -1 to +1, whereby accurate self-knowledge is denoted by a score of 0. Participants who overestimated their ability obtained a self-knowledge awareness ratio score that was positive, whereas those who underestimated their ability obtained an awareness ratio score that was negative.

Online Anticipatory Awareness and Self-Evaluation. Consistent with previous research (O'Keefe et al., 2007; Mallon, 2006; Toglia & Kirk, 2000), prior to commencing each task (but after practice, verbal description of the test or an instruction video, see *Procedure*), participants predicted how well they would perform on the test relative to an individual within the same age group as themselves. These predictions were made using a visual

analogue scale where the position of the 'average driver' in the relevant age group was determined by normative data for the same test (see Figure 6.2). The use of this comparison point allowed participants to make a more concrete prediction of ability that did not rely on subjective perceptions of the "average driver". Each participant received an *online anticipatory awareness ratio score* by comparing actual test performance with anticipated test performance.
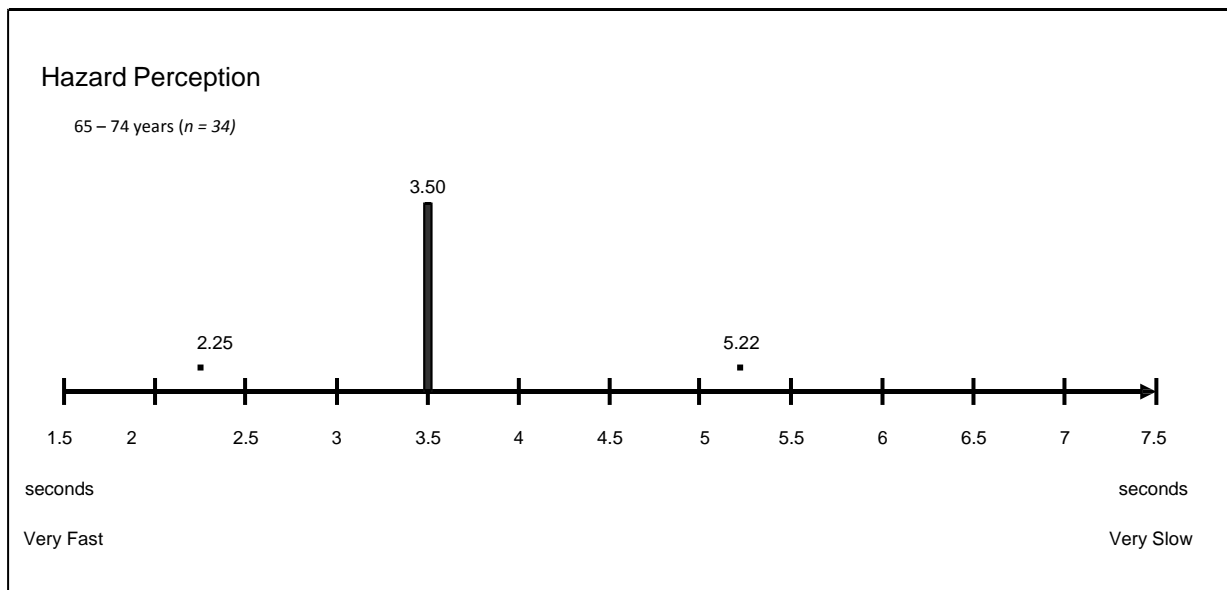
Figure 6.2. Visual analogue scale used for pre- and post-test performance predictions. The scale presented depicts the mean and range of hazard perception scores for drivers aged 65 to 74 years (Horswill et al., 2009).

After completing each test, participants evaluated their performance by rating, on the same visual analogue scale, how well they believed they actually performed. Post-test estimations were compared to actual test performance using the awareness ratio (range: -1 to +1, where 0 = accurate awareness) to obtain a *self-evaluation score* (see Table 6.3).

Table 6.3. *Formulation of Online Awareness Ratio Scores.*

Online Awareness	Anticipatory Awareness	Emergent Awareness*	Self-Evaluation
Estimated Score	Predicted score prior to test	Predicted score after each trial of FFOV	Predicted score at completion of test
Actual Performance	Objective test score	Objective score on each FFOV trial	Objective test score

*Online emergent awareness was calculated for the FFOV divided attention task only. The online emergent awareness ratio final score was calculated as the average of emergent awareness ratios across the 12 trials of the FFOV.

Online Emergent Awareness. Online emergent awareness refers to the ability to monitor one's performance throughout a task and detect errors as they occur (Toglia & Kirk, 2000). The FFOV divided attention task was used as the objective test given that emergent awareness could be assessed without interrupting performance on the primary task. After each forced-choice judgement of peripheral target location, participants rated their level of confidence or certainty that the peripheral target had been correctly localised using a 5-point scale (0% *"Not at all confident/certain"* to 100% *"Completely confident/certain";* mid-scale response options: 25%, 50% and 75%). Actual accuracy was coded on the same metric (see Figure 6.3). For example, if a participant reported seeing a peripheral target at Location 3, but it had actually appeared at Location 5, the performance score would be coded as 50%. This procedure controlled for a potential bias toward overestimation when the awareness ratio equation includes objective test scores of 0 (Barrett et al., 2005). Actual accuracy and self-ratings of accuracy for each trial were compared using the awareness ratio to obtain an *online emergent awareness score* (see Table 6.3).
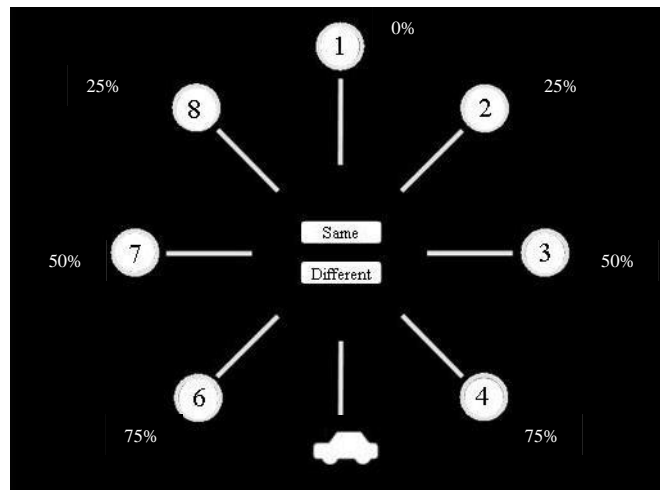
Figure 6.3. FFOV response screen depicting how objective performance was scored in the calculation of the emergent awareness ratio.

Procedure

Potential participants were contacted to arrange a testing session at the University. All testing was conducted individually following a detailed explanation of the tests to be conducted. This ensured each participant had a clear understanding of the aspects of performance they would be asked to rate, accessing relevant knowledge of task characteristics, previous experiences and perceived abilities. The Logical Memory Test, Pelli-Robson Contrast Sensitivity Test and Snellen Visual Acuity Chart were completed (in the order outlined) according to standardised conditions under a luminance of 100cd/m². Room lighting was then reduced to a luminance of 0.5cd/m² for the FFOV, Simple Reaction Time and Hazard Perception Tests (in this set order). Participants were given time for dark adaptation prior to commencing the tasks. Practice trials were conducted prior to the experimental trials for each of the tasks with the exception of the Hazard Perception Test. For the latter, participants watched a detailed instruction video.

Participants completed the metacognitive knowledge questionnaires prior to commencing each of the objective tests. For all objective tests, participants completed the online awareness measures in the following order: 1) online anticipatory awareness question prior to starting

each respective test but following the test practice or instruction video; 2) online emergent awareness question after each trial of the FFOV divided attention subtest; and 3) self-evaluation question after completing each corresponding test. Testing took approximately one hour, with a break provided at the halfway point (and at any time requested by the participant). At the completion of testing, room lighting was returned to normal and participants were given time to let their eyes adjust before leaving the laboratory.

Statistical Analysis

Data were explored using descriptive statistics and correlational analysis for the purpose of describing the outcome measures and evaluating their consistency with awareness theory.

Results

Descriptive Statistics

Means and standard deviations for the objective tasks (memory, contrast sensitivity, divided attention, reaction time and hazard perception) and self-knowledge, pre- and post-test prediction scores and self-ratings obtained during the FFOV divided attention task are presented in Table 6.4. A score of 3 on the metacognitive knowledge questionnaires for each task indicated a tendency to rate oneself as "the same" as others one's own age. Across all tasks, participants tended to rate themselves as having a similar level of skill/ability as others in their age group (metacognitive knowledge). When predicting how well they would perform prior to completing each task, most participants tended to make more conservative estimations initially (anticipatory ratings) and higher (and generally more accurate) self-ratings at the completion of the test (self-evaluation scores). This was particularly true of anticipatory and self-evaluation scores on the Delayed Recall condition of the Logical Memory Test.

Table 6.4. *Descriptive Statistics for Objective Performance, Metacognitive Knowledge,*

Anticipatory and Self-Evaluation Ratings for Each Functional Task.

Variable	Mean (SD)	Range
Logical Memory		
LMT Adult 16 – 69 years		
LMT Adult Immediate (scaled score)	11.89 (2.21)	7 – 14
LMT Adult Delayed (scaled score)	12.89 (2.47)	7 – 16
Anticipatory – Immediate Recall	14.26 (3.28)	8 – 20
Self-Evaluation – Immediate Recall	13.53 (3.84)	6 – 19
Anticipatory – Delayed Recall	9.47 (3.20)	4 – 15
Self-Evaluation – Delayed Recall	10.42 (3.66)	4 – 16
LMT Older Adult 65 – 89 years		
LMT Older Adult Immediate (scaled score)	11.08 (2.30)	4 – 16
LMT Older Adult Delayed (scaled score)	10.70 (2.72)	4 – 16
Anticipatory – Immediate Recall	7.80 (2.25)	2 – 11
Self-Evaluation – Immediate Recall	8.30 (2.75)	4 – 14
Anticipatory – Delayed Recall	6.63 (3.15)	1 – 14
Self-Evaluation – Delayed Recall	7.50 (3.29)	2 – 14
Metacognitive Knowledge total score: Immediate Memory	3.18 (0.59)	1.40 – 4.80
Metacognitive Knowledge total score: Delayed Memory	3.10 (0.61)	1.40 – 4.80
Pelli-Robson Contrast Sensitivity		
Objective test score (dB)	1.96 (0.07)	1.65 – 2.25
Anticipatory score	1.90 (0.10)	1.55 – 2.05
Self-Evaluation score	1.94 (0.10)	1.65 – 2.15
Metacognitive Knowledge total score	3.35 (0.64)	2.00 – 5.00
Functional Field of View – Divided Attention		
Objective test score (number correct/12)	10.13 (2.10)	2 – 12
Anticipatory score	8.61 (1.67)	5 – 12
Self-Evaluation score	8.35 (2.05)	4 – 12
Emergent score (average across 12 trials)	9.30 (2.29)	2 – 12
Metacognitive Knowledge total score	3.41 (0.61)	1.83 – 4.83
Simple Reaction Time Test		
Objective test score (in milliseconds)	338.04 (43.80)	250 – 499
Anticipatory score	296.30 (49.15)	182 – 514
Self-Evaluation score	300.73 (51.90)	200 – 514
Metacognitive Knowledge total score	3.48 (0.64)	2.00 – 5.00
Hazard Perception Test		
Objective test score (in seconds)	3.75 (0.64)	2.47 – 5.60
Anticipatory score	3.47 (0.49)	2.50 – 5.00
Self-Evaluation score	3.52 (0.56)	2.00 – 5.50
Metacognitive Knowledge total score	3.49 (0.62)	2.00 – 5.00

Comparison between Current Sample Data and Normative Data for the Driving Skill Tasks

Across awareness tasks, participants judged their performance relative to an age-based criterion based on data from a comparison sample for each of the tasks (see Appendix D). Thus, accuracy of these self-ratings depended not only on each individual's capacity for self-monitoring but the appropriateness of the comparison sample. For the memory tasks, the mean performance of the sample fell within one standard deviation of age-based norms (see Table 6.4). The 95% confidence interval of the means for the study sample and comparison sample for each of the driving tasks are shown in Table 6.5. With the exception of Pelli-Robson Contrast Sensitivity, participants in the current sample performed similarly to those in the comparison samples suggesting the age-based criterions were an accurate representation of the "average driver" in each respective age group.

Table 6.5. *95% Confidence Intervals of the Mean for Driving Tasks across the Study and Comparison Samples.*

Task	Current Sample		Comparison Sample	
	95% CI for Mean	Range	95% CI for Mean	Range
Contrast Sensitivity (dB)				
55 – 59 (*n* = 6)	1.93 – 2.00	1.95 – 2.03	1.86 – 2.02	-
60 – 75 (*n* = 51)	1.94 – 1.99	1.65 – 2.25	1.79 – 2.01	-
76+ (*n* = 22)	1.94 – 1.98	1.95 – 2.10	1.75 – 1.83	1.65 – 1.95
Divided Attention (correct/12)				
55 – 64 (*n* = 13)	9.52 – 11.71	7 – 12	10.46 – 11.87	8 – 12
65 – 74 (*n* = 41)	9.33 – 10.86	2 – 12	9.15 – 10.61	5 – 12
75+ (*n* = 25)	9.26 – 10.59	5 – 12	6.86 – 9.88	3 – 12
Simple Reaction Time (milliseconds)				
55 – 59** (*n* = 6)	246.97 – 319.38	228 – 327	249.90 – 287.56	182 – 384
60 – 74** (*n* = 48)	286.03 – 304.86	246 – 499	280.03 – 334.25	200 – 609
75+ (*n* = 25)	304.28 – 329.31	231 – 380	297.07 – 343.43	248 – 514
Hazard Perception (seconds)				
55 – 59** (*n* = 6)	2.82 – 3.98	2.47 – 4.01	3.07 – 3.61	2.58 – 4.83
60 – 74** (*n* = 48)	3.46 – 3.78	2.69 – 5.47	3.29 – 3.71	2.25 – 5.22
75+ (*n* = 25)	3.68 – 4.15	2.86 – 5.44	3.65 – 4.15	2.77 – 4.97

** In Horswill et al.'s (2009) study, the youngest group ranged from 35 to 55 years of age. Data from this sample were used as a comparison for participants aged 55 to 59 in the current study. Participants aged 60 to 74 years in the current student were provided the comparison data of Horswill et al.'s (2009) 65 to 74 year group. Participants were informed of this discrepancy.

Relationships between Functional Tasks

Slower response times to hazards on the Hazard Perception Test were associated with slower response times to targets on the Simple Reaction Time Test. There was no significant association between hazard perception reaction time and Pelli-Robson contrast sensitivity or number of errors on the divided attention subtest of the FFOV (see Table 6.6).

Table 6.6. *Associations between Functional Tasks, Pelli-Robson Contrast Sensitivity, FFOV Divided Attention, Simple Reaction Time and Hazard Perception Reaction Time (n = 79).*

Functional tasks	1.	2.	3.
1. Hazard Perception	-		
2. Contrast Sensitivity	-.021	-	
3. Divided Attention	.001	.038	-
4. Simple Reaction Time	.436**	-.055	-.034

**p <.001

Relationships between Metacognitive Knowledge and Online Awareness

The associations between objective test performance and corresponding metacognitive knowledge total scores, pre- and post-test predictions and performance ratings during the FFOV (emergent awareness) are presented in Table 6.7. In the memory and divided attention domains, metacognitive knowledge was not associated with prediction or self-evaluation scores. For the remaining domains (contrast sensitivity, simple reaction time and hazard perception), moderate associations were observed. Specifically, participants who rated themselves as 'better than others their own age' on the metacognitive knowledge questionnaires were also more likely to rate themselves favourably relative to their actual performance on the online indices (i.e., prediction and post-test self-evaluations of faster reaction time and higher contrast sensitivity scores). For all functional tasks, the strongest associations were observed between anticipatory and self-evaluation scores. These findings support Toglia and Kirk's (2000) theoretical distinction between metacognitive knowledge and online awareness.

Table 6.7. *Associations between Objective Scores, Metacognitive Knowledge and Online*

Ratings for all Objects of Awareness (N = 79).

Domains	1.	2.	3.	4.
Logical Memory Immediate				
1. Objective Score	-			
2. Metacognitive Knowledge	.130	-		
3. Anticipatory	.327**	.186	-	
4. Self-Evaluation	.523***	.121	.719***	-
Logical Memory Delayed				
1. Objective Score	-			
2. Metacognitive Knowledge	.094	-		
3. Anticipatory	.762***	.204	-	
4. Self-Evaluation	.775***	.184	.844***	-
Contrast Sensitivity				
1. Objective Score	-			
2. Metacognitive Knowledge	.059	-		
3. Anticipatory	.074	.440***	-	
4. Self-Evaluation	.152	.333**	.694**	-
Divided Attention				
1. Objective Score	-			
2. Metacognitive Knowledge	.095	-		
3. Anticipatory	.426***	.058	-	
4. Self-Evaluation	.579***	.145	.653***	-
5. Emergent	.623***	.160	.426**	.722***
Simple Reaction Time				
1. Objective Score	-			
2. Metacognitive Knowledge	-.004	-		
3. Anticipatory	.275*	-.318**	-	
4. Self-Evaluation	.257*	-.365***	.888***	-
Hazard Perception				
1. Objective Score	-			
2. Metacognitive Knowledge	-.106	-		
3. Anticipatory	.270*	-.318**	-	
4. Self-Evaluation	.277*	-.355***	.867***	-

*$p < .05$; **$p < .01$; ***$p < .001$

Metacognitive knowledge scores were not significantly associated with objective test performance across any of the functional tasks. For the Logical Memory test, associations between objective scores and anticipatory and self-evaluation scores were stronger on the Delayed condition (anticipatory, $r = .76$; self-evaluation, $r = .78$) after exposure to the task during the Immediate Recall condition (anticipatory, $r = .33$; self-evaluation, $r = .52$). Similarly, participant self-ratings of performance during the FFOV divided attention task

(emergent ratings) had the strongest association with objective test performance. These findings suggest that, regardless of the domain or awareness object assessed, the strength of the correlations between the objective test score and the self-ratings of performance increased with temporal proximity to and experience on the objective test.

Awareness Ratios across Functional Domains

Average metacognitive knowledge and online awareness ratios, with 95% confidence intervals, for each functional domain are presented in Figure 6.4. Most participants demonstrated accurate self-knowledge of their memory for details of a short story and their capacity to drive in conditions of reduced contrast (e.g., in wet weather or at night), performing objectively in the average range and rating themselves as consistent with the 'average person' their age. However, while they also typically demonstrated accurate online awareness for contrast sensitivity, on average, most participants tended to underestimate their performance when asked how many elements of the Logical Memory Test story they anticipated they would, and actually did, recall.

Similarly, participants underestimated their performance on the divided attention subtest of the FFOV (online awareness), though on average, tended to overestimate how well they drive in conditions requiring divided attention (e.g., looking for a new street address while driving). This discrepancy between metacognitive knowledge and online awareness was only found for the divided attention task. Given differences between the current sample and comparison data for the age group 75 years and older on the FFOV, 95% confidence intervals for the mean were calculated without this age group. The pattern across the different forms of awareness remained the same for the younger age groups, including the dissociation between metacognitive knowledge and online awareness.

Lastly, a general tendency toward overestimation was observed across both types of awareness for the Simple Reaction Time test and the Hazard Perception Test. This was particularly true of metacognitive knowledge awareness ratios for these tasks.
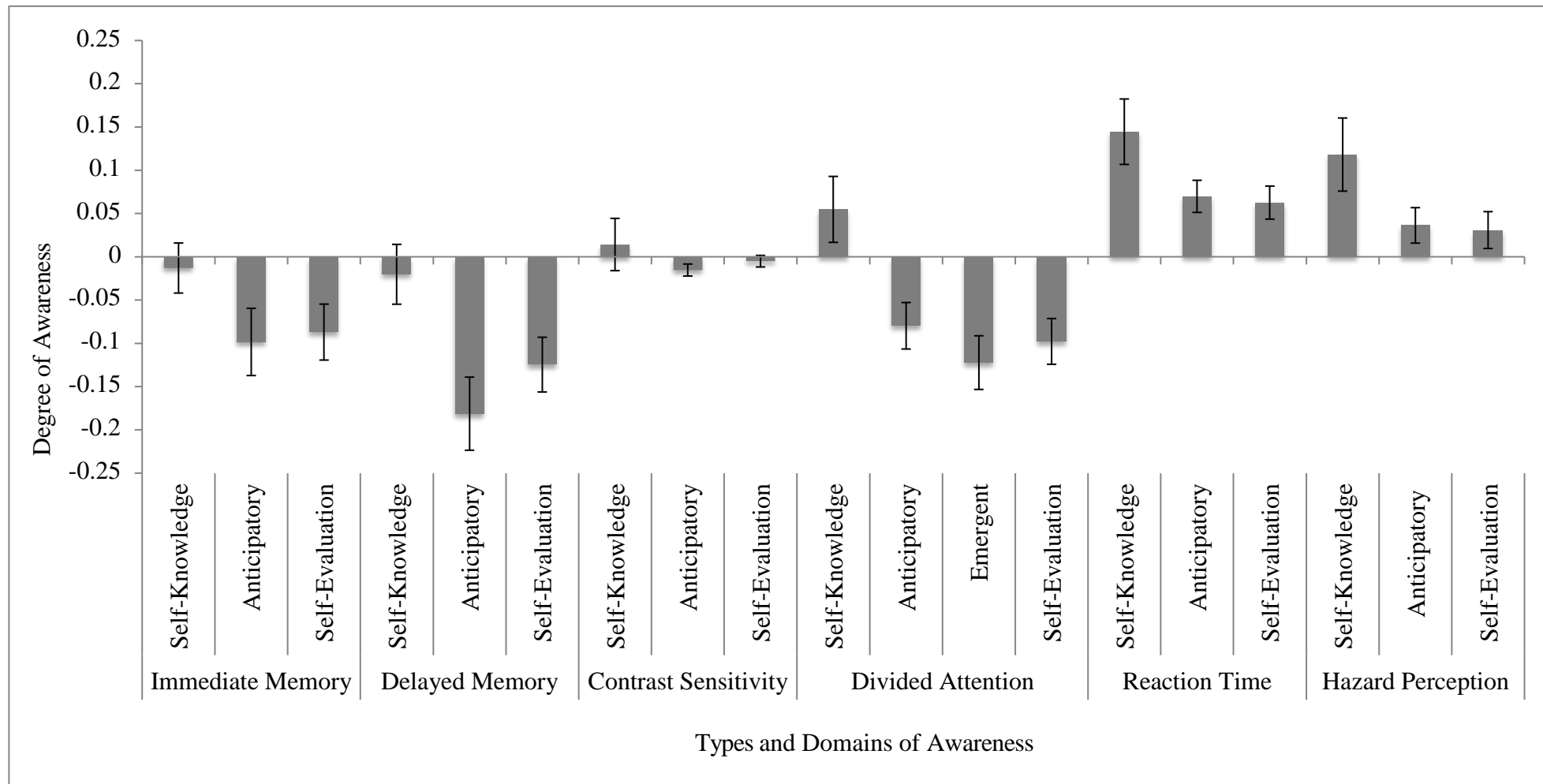
Figure 6.4. Mean awareness ratios across the types (self-knowledge and online awareness) and domains (functional tasks) of awareness. Error bars depict the 95% confidence interval for the mean (*n* = 79).

Discussion

The purpose of this chapter was to describe the methodology of awareness assessment, confirm the distinction between metacognitive knowledge and online awareness, and explore differences in performance across domains of memory and driving (hazard perception). A cognitive formulation of awareness was used, investigating the capacity of community-based older drivers to accurately monitor and evaluate their performance (Clare et al., 2005). Specifically, awareness was operationalized as the discrepancy between participants' self-rating and their actual performance on objective measures of hazard perception skills and memory function. Variation in the temporal order of the self-ratings and degree of specificity to the objective test allowed for assessment across the two levels of awareness, metacognitive knowledge and online awareness. Finally, inclusion of estimated and actual performance scores in the denominator of the awareness ratio allowed both underestimation and overestimation errors to be identified (Barrett et al., 2005). Overestimation errors within the driving domain are of particular importance given their association with crash involvement across all age groups (Freund et al., 2005; Gregersen, 1996; Wood et al., 2013).

For all tasks, stronger associations were observed between indices of online awareness than between metacognitive knowledge and online awareness scores. This supports the distinction between metacognitive knowledge and online awareness (Toglia & Kirk, 2000). When people are asked to rate their ability without reference to a specific task, they are doing so by drawing upon a range of past experiences and beliefs about ability that are stored in long-term memory (Toglia & Kirk, 2000). This knowledge store is susceptible to influence by internal and external factors that determine the expression of awareness, that is, how accurately one perceives or chooses to disclose, the challenges they are having in a particular area (Ownsworth et al., 2006; Rudman et al., 2006; Toglia & Kirk, 2000).

Online anticipatory judgements about test performance are also drawn (to a lesser extent) from this general knowledge store, but are further determined by the nature of the task and the test environment (Toglia & Kirk, 2000). This was reinforced in the present study by ensuring that participants were given the opportunity to practice or at least learn about the task to be completed prior to rating how well they thought they would perform. As would be predicted based on theory (Toglia & Kirk, 2000), the strongest associations were found between objective test performance and self-evaluation and online emergent scores given temporal proximity and participant experience at completion of the test.

Most participants rated themselves similarly to their same-aged peers on the memory metacognitive knowledge questionnaire, and performed in the average range on the Logical Memory Test. However, average online awareness ratios for the memory domain demonstrated a tendency towards underestimation, particularly for the delayed memory subtest. Troyer and Rich (2002) found that age-related stereotypes about memory were not elicited when older adults were asked to make self-other comparisons but did emerge in the evaluation of individual performance. It is possible that in making comparisons with others on memory function, older adults are already operating within the ageing stereotype. By comparison, the opposite is often observed in the driving literature, with older adults showing a tendency toward a positive self-bias when comparing driving performance to others of the same age (Carberry et al., 2006; Holland & Rabbitt, 1992; Horswill et al., 2013). This positive self-bias was found for metacognitive knowledge awareness ratios for all driving tasks in the present study, with the exception of contrast sensitivity.

While most participants also rated their performance accurately on the contrast sensitivity test, there was a tendency toward underestimation on the divided attention subtest and overestimation on the simple reaction time and hazard perception tasks on the online awareness measures. To accurately self-evaluate one's performance, a person must be able to

generate a representation of their performance and compare results with previous expectations or goals (Toglia & Kirk, 2000). In rating performance on a general screen of contrast sensitivity such as the Pelli-Robson chart (Pelli et al., 1988), the decrease in contrast when moving across the triplets appears to have been sufficiently well defined for participants to be aware when they could no longer identify the letters. In comparison, for perceptual tasks such as divided attention, there is some uncertainty regarding ability and this uncertainty increases with particular task characteristics (e.g., difficulty level or unfamiliarity) (Holland & Rabbitt, 1992). The peripheral target on the divided attention subtest is either seen or one is unsure, and it is not necessarily known that the target has been inaccurately localised. This uncertainty was reflected in the tendency toward underestimation or low confidence in accuracy on the online awareness indices of this task. With the test of simple reaction time and to a lesser extent, the hazard perception test, there is an identifiable target that requires a response. The question becomes not "did you see it?" but rather, "how quickly did you see it?" – a much more difficult estimation to make. Despite this difficulty, the lack of uncertainty in the judgement of reaction time (i.e., the fact that the target is always present) appears to have resulted in increased predictions of and confidence in accuracy.

These findings should be interpreted in light of the various potential limitations of the methodology presented in this chapter. The aim was to assess awareness within a healthy, community-based sample. Nonetheless, there is likely a selection bias toward largely unimpaired older adults that may explain the reduced variability observed across some of the objective measures. Replication of the relationships between the two forms of awareness and differences across awareness domains within a larger sample with a more varied range of abilities on the objects of awareness in question would assist in validating the findings observed.

It is also important to acknowledge that while the performance-based discrepancy method allows for an objective assessment of the awareness object, it is not without its pitfalls (Clare, 2004b; Clare et al., 2005). This includes the reliance on the comparison sample being an accurate representation of the study sample as well as the difficulty comparing laboratory-based measures to questionnaires assessing aspects of everyday driving ability (Clare et al., 2005). Regardless of the particular form of awareness assessment, it is also recognised that the results obtained for each individual reflect only a partial indicator of the awareness phenomenon for each domain at each time of assessment (Markova & Berrios, 2001; Markova et al., 2005). Future research incorporating multiple methods of awareness assessment (e.g., informant ratings of driving performance) would allow for a more complete understanding of an individual's level of awareness in each area assessed (Clare, 2004b; Clare et al., 2011).

Lastly, individual differences in awareness levels within and between domains were not determined. Individual variability in degree of awareness or unawareness and factors that might contribute to these differences in awareness levels are key areas of interest. It is expected that meaningful subgroups of individuals can be identified based upon their performance across the awareness measures and that these subgroups differ on important outcome measures such as compensatory driving behaviour measured via the Situational Avoidance Questionnaire (SAQ, Davis et al., 2016). For example, participants who overestimate their hazard perception skills might be expected to report low levels of situational avoidance whereas those who demonstrated intact awareness and deficits on the objective measures may report higher levels of situational avoidance. This hypothesis will be examined using cluster analysis in the next chapter.

Based upon the findings of this chapter, simple reaction time and hazard perception were selected as the objects of awareness for inclusion in the cluster analysis. Simple reaction time

was the only objective measure significantly associated with hazard perception performance. The lack of association between hazard perception and contrast sensitivity may be explained by minimal variability on the measure of contrast sensitivity. Whereas the non-significant findings for the divided attention task in the present study may be explained by the use of a divided attention measure (FFOV) that assesses accuracy under time-limited conditions relative to the reaction time measure (UFOV) used by Horswill and colleagues' (2008; 2009). These findings, alongside differences between the comparison sample and current study means on the Pelli-Robson Contrast Sensitivity test, have prompted the exclusion of these measures in the cluster analysis.

Chapter 7 : Multi-Domain Assessment of Awareness, Awareness Typologies and

Driving Self-Regulation among Older Drivers – An Application of Cluster Analysis

Introduction

The capacity of older adults to self-monitor their performance in everyday tasks, and detect and correct errors as they occur, is essential to support their ability to live independently (Bettcher & Giovannetti, 2009). In the domain of driving, while capacity for safe driving is reliant on an older driver's cognitive, sensory and motor skills, their actual driving behaviour is determined by their awareness of and ability to monitor for changes in these driving skills (Anstey et al., 2005). As driving becomes more difficult due to age- or disease-related declines, older adults are assumed to compensate for these declines through a reduction in driving exposure or avoidance of challenging driving situations (e.g., at night or in bad weather) (Charlton, Oxley, Fildes, et al., 2006). Research in this area is of growing importance given the potential safety and mobility benefits of voluntary driving self-regulation (Berry, 2011; Molnar et al., 2015). This, in turn, has prompted investigation of approaches for distinguishing between older drivers who possess the capacity to accurately self-monitor their driving and those who do not.

Most studies that have assessed the relationship between awareness and driving self-regulation among older drivers have focused on one form of awareness only (either metacognitive knowledge or one form of online awareness), and have found that older drivers vary in their capacity to accurately self-rate their driving ability (e.g., Broberg & Willstrand, 2014; Carberry et al., 2006; De Craen et al., 2007; Devlin & McGillivray, 2014; Freund et al., 2005; Horswill et al., 2011; Horswill et al., 2013; MacDonald et al., 2008; Ross et al., 2012; Wood et al., 2013). Some older drivers overestimate their driving ability and continue to drive despite not having the necessary driving skills to do so safely (e.g., Broberg & Willstrand, 2014; De Craen et al., 2007; Freund et al., 2005). The opposite has also been

observed, with mobility being negatively affected as a result of premature driving cessation or unnecessary driving self-regulation in the setting of low confidence in driving ability (e.g., Hakamies-Blomqvist & Wahlstrom, 1998; Siren et al., 2004; Siren & Meng, 2013). Older women in particular have been found to report low confidence in driving, restricting their driving behaviour or ceasing driving earlier than men despite not differing from them in terms of functional ability (Hassan et al., 2015b; Keay et al., 2009; Meng & Siren, 2012; Rimmo & Hakamies-Blomqvist, 2002; Rosenbloom & Herbel, 2009; Siren et al., 2004).

Many researchers have tended to view self-efficacy or driving confidence and awareness as separate phenomena, investigating their individual contributions to driving self-regulation. Decreased confidence when driving in certain situations, such as at night, is often the strongest predictor of avoidance of driving in those situations (Charlton, Oxley, Fildes et al., 2006; Conlon et al., 2017; MacDonald et al., 2008; Marottoli & Richardson, 1998; McCarthy, 2005; Myers et al., 2008; Rudman et al., 2006). However, Toglia and Kirk (2000) propose that awareness and self-efficacy are linked in that an individual's awareness of their level of functioning shapes their belief or confidence in their ability to perform a particular task. Someone who underestimates the extent that a skill has declined is more likely to report high confidence in his or her ability to perform a task reliant on that skill (Bandura, 1977), reducing the likelihood of compensatory behaviour. Self-efficacy beliefs are also reported to provide an index of the depth of awareness or unawareness (Toglia & Kirk, 2000). For example, an individual may inaccurately report little to no change in function in a particular domain ("poor awareness"), yet also report little confidence or certainty that they could perform the task well, indicating that their awareness beliefs are malleable or lack conviction (Toglia & Kirk, 2000).

In assessing driving confidence, Myers and colleagues' (2008) reported that their sample felt "comfort level" better captured the broad concept of self-confidence as it relates to

driving. The association between driving discomfort and degree of driving self-regulation has been confirmed in a number of studies (Blanchard & Myers, 2010; Jouk et al., 2014; MacDonald et al., 2008; Meng et al., 2012; Meng et al., 2013; Molnar, Eby, Langford, et al., 2013; Rudman et al., 2006; Siren & Meng 2013; Tuokko et al., 2016; Wong et al., 2012), and more recently, has been considered an implicit form of awareness in the driving domain (Meng et al., 2012; Meng et al., 2013).

In addition to self-efficacy beliefs, models of driving self-regulation have proposed other factors internal (e.g., emotional investment in driving) and external (e.g., availability of alternate transport) to the older driver that influence their experience and/or expression of explicit awareness and the practice of compensatory driving behaviour (Hassan et al., 2015a; Kowalski et al., 2014; Rudman et al., 2006; Wong et al., 2014). Many of these factors map onto the three domains comprising the common explanations for disordered awareness in neurological populations: neurological, psychological and social/cultural (Clare, 2004a; Ownsworth et al., 2006).

Neurological explanations for unawareness view awareness deficits as a symptom of age- or disease-related changes in the brain (Clare, 2004a). Neuroanatomical explanations ascribe the role of different brain regions to the experience of awareness, with specific emphasis on the role of the frontal lobes (Hoerold et al., 2013; Hornberger et al., 2012; McGlynn & Schacter, 1989; Reed et al., 1993; Stuss et al., 2001; Vogel et al., 2005). In support of this, poor performance on measures of executive function has consistently been associated with increased levels of unawareness (Lysaker et al., 1998; Michon et al., 1994; Noe et al., 2005; Ownsworth et al., 2002). According to Stuss (1991), deficiencies in executive function reduce one's capacity for flexibility, planning and problem solving, critical skills required for self-monitoring and self-regulation. Measures of executive functioning related to awareness include reasoning (Ownsworth et al., 2002), idea generation

or fluency (Mohamed et al., 1999; Ownsworth & Fleming, 2005), cognitive flexibility (Lysaker et al., 1998; Lysaker et al., 2006; Michon et al., 1994; Ott et al., 1996; Trudel et al., 1998), and error self-regulation (Bogod et al., 2003; Ownsworth & Fleming, 2005; Ownsworth et al., 2007).

In the driving literature, the relationship between cognitive status and awareness of driving ability has typically been assessed using a cognitive screen such as the Mini Mental Status Examination. While some of these studies demonstrate that older drivers with cognitive impairment report greater difficulty with driving and self-regulate their driving accordingly (Braitman & Williams, 2011; Cotrell & Wild, 1999; Devlin & McGillivray, 2016; Festa et al., 2012; Freund & Szinovacz, 2002; Kowalski et al., 2012; O'Connor et al., 2010; O'Connor et al., 2013), other studies have found cognitive impairment to be associated with overestimation of driving ability and minimal use of compensatory strategies (Ball et al., 1998; Dubinsky et al., 1992; Gooden et al., 2016; Lyman et al., 2001; Meng et al., 2013; Valcour et al., 2002; Wong et al., 2012; Wood et al., 2013). To date, no study has explored concurrently whether unawareness of driving ability in a community-based sample of older drivers is associated with a specific type of cognitive decline (e.g., in executive function), the nature of awareness deficit that arises (e.g., global or domain-specific), and the relationship between executive functioning, awareness and compensatory driving behaviour.

Expressions of accurate awareness or insight into driving impairment are also influenced by psychological and social factors, such as feedback from others or the environment regarding driving ability. Driving is of fundamental importance to all adults as a source of independence and self-worth (Eisenhandler, 1990). Recognition of declines in driving ability or feedback about negative changes to one's driving from others can constitute a threat to one's lifestyle and self-concept and may prompt the use of denial as an active coping strategy (Clare, 2003; De Raedt & Ponjaert-Kristoffersen, 2000; Ross et al., 2012; Weinstein et al.,

1994). Defensive denial has been shown to protect against the emotional distress (e.g., depression) that can occur when one is aware of their deficits and the associated consequences (e.g., the possibility of driving cessation) (Fleming et al., 1998; Ownsworth et al., 2002; Ownsworth et al., 2007). Older men in particular have been shown to be more emotionally invested in driving and have a longstanding identity with operating a motor vehicle (Nasvadi & Vavrik, 2007; Nasvadi & Wister, 2009). High emotional investment in driving may prompt older men to deny or minimise the presence of driving impairment and underreport or underuse compensation strategies in order to maintain their driving identity and self-esteem (Ackerman et al., 2010; Donorfio et al., 2009; Nasvadi & Vavrik. 2007; Tuokko et al., 2007).

In addition to its symbolic meaning, the practical importance of driving to one's lifestyle and the availability of alternate transportation options has been theorised to influence the practice of driving self-regulation among older adults (Baldock et al., 2006a; Broberg & Willstrand, 2014; Charlton, Oxley, Scully et al., 2006; Hassan et al., 2015a; Kowalski et al., 2014; Leavasseur et al., 2016; Molnar et al., 2014; Rudman et al., 2006; Stalvey & Owsley, 2000; Wong et al., 2017). To date, no study has determined whether barriers to the practice of driving self-regulation might also explain instances of unawareness in older drivers. For example, older drivers who lack easy access to public transport, who are worried about burdening family or friends, or who are the principal or only drivers of their household, may deny or minimise the presence of driving impairment in order to continue to drive and to reduce the incongruity between perceived ability and actual driving behaviour.

In summary, individual variability in levels of awareness among older drivers may be attributed to neurological and/or psychosocial factors that influence its experience and/or expression (Clare, 2004a; Markova et al., 2005; Ownsworth et al., 2002). Self-awareness is also generally considered to be a continuous rather than a dichotomous construct that varies

across different objects of awareness (Pachana & Petriwskyj, 2006; Toglia & Kirk, 2000). As such, older drivers may be aware of age-related changes in some driving skills but not others. In recognition of the multifaceted nature of awareness and causes of unawareness, a number of studies have moved away from simply identifying individuals as "aware" or "unaware" (Broberg & Willstrand, 2014; Clare et al., 2011; Ownsworth et al., 2007). Instead, they have sought to identify meaningful subgroups of individuals based upon their responses on measures of different awareness phenomena (Broberg & Willstrand, 2014; Clare et al., 2011; Fleming et al., 1998; Ownsworth et al., 2007). These groups are referred to as awareness typologies and have been formed using a cluster analytic approach.

Ownsworth and colleagues (2007) investigated the emotional and psychosocial outcomes of four distinct awareness typologies of persons with acquired brain injury, classified as such based upon measures of awareness of deficits, executive function (error self-regulation) and denial/defensiveness (the Marlowe-Crowne Social Desirability Scale). The *poor self-awareness group* ($n = 12$) was characterised by poor awareness and impaired error self-regulation, indicating neuropsychologically based awareness deficits. The *high defensiveness group* ($n = 13$) performed well on the tests of executive function but appeared to minimise their symptoms and their responses on a measure of defensiveness indicated a strong desire to present themselves in a favourable light. Therefore, this group displayed psychologically based awareness deficits (i.e., denial). The *high symptom-reporting group* ($n = 15$) demonstrated a tendency to magnify symptoms and a low desire to present a favourable self-image. Finally, the *good self-awareness group* ($n = 44$) had moderate symptom reporting, normal defensiveness and good error self-regulation.

The poor self-awareness group and the high symptom reporting group experienced greater emotional distress and lower interpersonal relations than the good self-awareness and high defensiveness groups at initial assessment (Ownsworth et al., 2007). This supports previous

research suggesting that intact awareness contributes to better rehabilitation outcomes and psychosocial adjustment (Crosson et al., 1989; Katz, Fleming, Keren, Lightbody, & Hartman-Maeir, 2002; Ownsworth & Fleming, 2005). Yet this study also suggests that individuals who use denial as a coping strategy adjust just as well as those with good self-awareness (Ownsworth et al., 2007). Whether the groups differed in use of compensatory behaviour was not investigated. Previous research suggests that individuals who overestimate their abilities (those who are highly defensive or neuropsychologically unaware) are more likely to resist initiating compensatory behaviour and attempt to maintain their premorbid lifestyle (De Craen et al., 2007; Lam, McMahon, Priddy, & Gehred-Schultz, 1988; Ownsworth, 2005).

To date, no study has determined the relative role of neurological and psychosocial factors in influencing awareness levels and driving decisions of cognitively healthy older adults. Similar awareness typologies as those found by Ownsworth and colleagues (2007) may be found within this population and may be associated with differing degrees of compensatory situational avoidance.

The Current Study

Awareness is defined in this research as an accurate or realistic appraisal of one's hazard perception skills for driving at the time of assessment. The aim of this study was to identify distinct typologies or awareness subgroups using hazard perception and simple reaction time awareness indices (described in Chapter 6) and factors previously found to be related to awareness, including executive function, denial/defensiveness, and driving discomfort. The following five awareness typologies were predicted:

1. *Good Self-Awareness* Groups: Older drivers who had good metacognitive knowledge and online awareness of their hazard perception and simple reaction time skills, low to normal levels of defensiveness, and performed in the average range for their age on tests of executive function. This group was expected to further divide into two groups

based on their objective hazard perception performance. Those who performed poorly on this test (the *"Good Self-Awareness, Impaired"* group) were expected to report more discomfort with driving and greater compensatory situational avoidance compared to those who performed better on this test (the *"Good Self-Awareness, Unimpaired"* group).

2.   A *High Symptom Reporting* Group: Older drivers who underestimated how well they performed on the awareness indices, reported low to normal levels of denial/defensiveness and high levels of driving discomfort, and performed in the average range for their age on tests of executive function. This group was expected to report high levels of compensatory situational avoidance despite not differing from the Good Self-Awareness, Unimpaired group on the objective driving tasks.

3.   A *High Defensiveness* Group: Older drivers who overestimated how well they performed on the awareness indices, reported high levels of denial/defensiveness and low driving discomfort, and performed in the average range for their age on tests of executive function. This group was expected to report little to no compensatory situational avoidance.

4.   A *Poor Self-Awareness* Group: Older drivers who overestimated how well they performed on the awareness indices, reported low to normal levels of denial/defensiveness and low levels of driving discomfort, and performed in the below average range for their age on tests of executive function. This group was also expected to report little to no compensatory situational avoidance.

The characteristics or profiles of the typologies identified through cluster analysis were examined. The groups were expected to differ on gender, emotional distress (depression), perceived barriers to driving self-regulation, readiness to change their driving behaviour and degree of negative feedback received from others and the environment. Awareness of

memory ability was also examined across groups to determine whether the observed awareness deficits were global (i.e., related to both hazard perception and memory) or domain specific.

Method

Participants

The sample of 79 adults (36 males, 45.6%) recruited from the larger community-based sample (please see Chapter 4, *Participants* section for a description of the complete sample), ranging in age from 55 to 86 years ($M = 71.48$, $SD = 7.16$), was used in this study (please see Chapter 5, *Participants* section for further details).

Measures

Awareness Measures

The objects of awareness selected for the cluster analysis included the Hazard Perception Test (HPT) and the Simple Reaction Time (SRT) test. These outcome measures and corresponding awareness indices are described in Chapter 6. Participants also completed a 12-item questionnaire assessing degree of discomfort experienced when driving due to difficulties associated with hazard perception (e.g., predicting other road users' behaviour, 7 items) and reaction time (e.g., braking fast enough to avoid a hazard, 5 items) skills. A 5-point response scale ranging from 0 = *never* to 4 = *always* was used, with higher scores indicating greater discomfort with driving. The scale had high internal consistency ($\alpha = .87$) and was considered an indicator of implicit awareness in the present study.

Driving Behaviour and Beliefs Questionnaire

This questionnaire consisted of demographic items (e.g., age, gender, and number of drivers available in the household) and a number of scales to assess situational avoidance, beliefs about driving and self-perceptions. Many of these scales have been described in Chapters 4 and 5, including: Situational Avoidance Questionnaire (SAQ), Feedback from

Others or the Environment, Perceived Barriers to Driving Self-Regulation, Attitudes toward

Driving (Importance of Driving subscale), Stages of Change, and the Centre for

Epidemiologic Studies-Depression Scale (CES-D). An additional scale included in the

questionnaire package was the:

Marlowe-Crowne Social Desirability Scale (MC-SDS). The MC-SDS measures

defensiveness or the tendency to deny problems due to the desire to present oneself in an

overly favourable light (Crowne & Marlowe, 1960). The short form consists of 20 true/false

items with scores ranging from 0 to 20 (high defensiveness). The MC-SDS has been used to

examine the personality characteristics of defensiveness and self-deception in various

populations (Lane, Merikangas, Schwartz, Huang, & Prusoff, 1990; Ownsworth et al., 2007).

Internal consistency in the current sample was .78.

Cognitive Measures

Modified Telephone Interview for Cognitive Status (TICS-M). The TICS-M is a brief 13-

item cognitive screen with scores ranging from 0 to 39, where high scores indicate greater

cognitive difficulty (Brandt et al., 1993; De Jager et al., 2003). While designed to be

administered over the telephone, it is also used in face-to-face interviews. The TICS-M has

been shown to be more sensitive to mild deficits in cognitive performance in an older

population than the Mini Mental Status Examination (MMSE) (De Jager et al., 2003).

Trail Making Test (TMT). The TMT assesses visual scanning, sustained concentration

and cognitive flexibility and is proposed to be sensitive to early cognitive decline (Lezak,

1995). The stimulus sheets contain randomly distributed numbered and lettered circles. In

Part A of the test, participants drew lines connecting consecutively numbered circles. In Part

B, participants drew lines alternating between the numbered and lettered circles consecutively

(e.g., 1-A, 2-B). The completion time in seconds for each condition comprised the total score.

The TMT B-A difference score was obtained as it is thought to be a purer measure of the

executive function components of the TMT (Strauss, Sherman, & Spreen, 2006). Age-adjusted norms for persons aged 20 to 89 years were used (Tombaugh, 2004).

D-KEFS Verbal Fluency Test, Category Fluency. In this test of semantic fluency, participants generated words belonging to a designated semantic category as quickly as possible in two trials lasting 60 seconds each. A total Category Fluency raw score was obtained by summing the total correct responses for each trial. Semantic fluency has high sensitivity in identifying early cognitive decline (Cunje, Molloy, Standish, & Lewis, 2007). This test has good test-retest reliability for persons aged 50 to 89 years ($r = .82$) and age-adjusted norms for persons aged 8 to 89 (Delis, Kaplan, & Kramer, 2001a).

D-KEFS Verbal Fluency Test, Category Switching. This condition assesses cognitive flexibility, idea generation, verbal inhibition and error self-regulation (Delis, Kaplan, & Kramer, 2001b). Participants generated words belonging to two semantic categories, alternating between the two categories. Total number of words accurately listed in 60 seconds comprised the outcome score. This test has lower than desirable test-retest reliability ($r = .60$), attributed to the loss of novelty upon repeat administration (Delis et al., 2001b).

D-KEFS Design Fluency Test, Category Switching. This test assesses non-verbal inhibition, initiation of problem solving, and creativity in drawing new designs (Delis et al., 2001a). Participants were presented with a page of 35 squares, each containing five filled and five empty dots. Participants made a different design in each square by connecting the dots using four straight lines, alternating between the filled and empty dots. The total score was the number of correct, original designs completed in 60 seconds and converted into a scaled score. Like its verbal counterpart, Design Fluency has lower than desirable test-retest reliability ($r = .60$) (Delis et al., 2001b).

Symbol Digit Modalities Test (SDMT). The SDMT assesses perceptual and motor speed and complex visual scanning (Lezak, 2012; Smith 1982). Participants used a coded key to

match nine abstract symbols with numerical digits. The final score is the correct number of substitutions in 90 seconds, with scores ranging between 0 and 110. Test re-test reliability is .80 and age-adjusted norms exist for persons aged 18 to 74 (Smith, 1982) and 75 to 85 years and older (Kiely, Butterworth, Watson, & Wooden, 2014).

Digit Span Backwards (WAIS-IV, Wechsler, 2008). Digit span assesses attentional capacity, verbal working memory and cognitive flexibility (Lezak, 2012). Participants were required to recall a sequence of numbers in the reverse order to which they were presented. Digit Span has good test-retest reliability ($r = .93$) and age-adjusted norms for persons aged 16 to 90 years (Wechsler, 2008).

Procedure

As noted in previous chapters, a convenience sample of participants was obtained from a research database of individuals who had expressed interest in participating in research at Griffith University. The questionnaire, along with a study information sheet and consent form, was mailed to participants to be completed prior to individual testing at the University. All tests were conducted according to standardised procedures. Please refer to Chapter 6, *Procedure* section for a description of experimental and awareness measure procedures.

Statistical Analysis

A square root transformation was performed to reduce significant positive skew on the CES-D depression total score. One female participant was removed from all analyses at the outset due to missing data on the cognitive variables, leaving 78 participants for both factor and cluster analyses. All analyses were conducted using SPSS 23.0. A principal components analysis with varimax rotation was conducted on the six cognitive tests with the aim of determining whether a meaningful cognitive factor could be produced for use in the cluster analysis. All raw scores were standardised according to normative data then converted into Z-scores based on the sample mean and standard deviation for each test.

Cluster analysis is a multivariate statistical technique designed to identify homogenous groups within sets of data (Hair, Black, Babin, & Anderson, 2009). The aim was to identify relatively distinct groups of participants based on the "natural" structure among responses on the awareness variables (Hair et al., 2009). The cluster analysis was performed in three stages according to the guidelines provided by Hair and colleagues (2009), including: 1) partitioning, 2) interpretation, and 3) validation / profiling. Cluster analysis variables that share a significant proportion of their variance were identified in initial exploration of the data, with variables dropped or combined if necessary. Potential clustering variables used in the partitioning stage are listed in Table 7.1.

Table 7.1. *Clustering Variables Trialled in Partitioning Stage of Cluster Analysis.*

Measure	Description
Explicit Awareness	

Metacognitive Knowledge
  - Hazard Perception
  - Simple Reaction Time
	Discrepancy between objective test score and self-ratings of ability compared to others one's own age.

Online Awareness
  - Hazard Perception
  - Simple Reaction Time
	Discrepancy between objective test score and prediction and self-evaluation of task performance on objective test.

Cognitive Ability	
Executive Control Index	Factor score of performance on tests: Trail Making Test, Verbal Fluency, Design Fluency, Symbol Digit Modalities Test, and Digit Span Backwards.
Psychosocial	
Marlowe-Crowne Social Desirability Score (MC-SDS)	Total score on MC-SDS short form (range = 0 to 20).
Implicit Awareness	
Driving discomfort	Total score on 12-item scale assessing degree of discomfort experienced when driving due to difficulties with hazard perception and reaction time (range = 0 to 48).

Raw scores for these variables were converted to standardised scores to avoid scaling artefacts (Hair et al., 2009). A hierarchical agglomerative clustering method was used with Ward's method to divide cases into clusters. Squared Euclidean distance was used to measure inter-object similarity given that derivation of clusters in the present study should consider

both the magnitude of differences between observations (e.g., degree of awareness deficit) as well as the pattern of performance across the clustering variables (e.g., the relationship between defensiveness and explicit awareness variables). Two to five cluster solutions were specified in order to yield the most clinically meaningful interpretation of the data. Three factors were examined in the partitioning stage of each solution, namely, percentage change in clustering coefficients, degree of separation or overlap between clusters using scatterplots (SPSS discriminant analysis), and the clinical meaningfulness of cluster centroids.

In the interpretation stage, a series of independent groups one-way ANOVAs were conducted to identify group differences on each clustering variable. Effect sizes (η^2) were used to compare the contribution of each variable to cluster separation. In the validation and profiling stage, the consistency and validity of the cluster solution was determined using non-hierarchical cluster analysis using an optimisation method to divide cases into clusters. The percentage of individuals who were re-classified using this method determined the veracity of the initial cluster solution. The cluster profiles were further examined by comparing the groups on demographic variables, driving attitudes and behaviour, objective test performance and awareness of memory function using either ANOVA or a chi-square test. Bonferroni correction was applied for post-hoc analyses with alpha level set at .01 to account for the multiple comparisons conducted in each analysis.

Results

Cluster Variables

The results of the principal components analysis with varimax rotation are presented in Table 7.2. Initial inspection of the distributions of items and item correlations revealed that the Category Switching condition of the D-KEFS Verbal Fluency test had negligible correlations with any other variable but the Category Fluency condition of the same test. This condition was removed from further analysis, leaving five remaining cognitive tests. A single

factor was extracted with an eigenvalue greater than one, accounting for 46.13% of the variance. Assumptions of the analysis, including sampling adequacy (KMO = .74) and sphericity ($p < .001$), were met. Internal consistency for the five cognitive tests was .70. Together, these tests measure common components of executive function important for self-regulation including attentional control, self-monitoring, cognitive flexibility, and fluency or idea generation (Lezak, 2012). The factor was labelled *Executive Control.*

Table 7.2. *Correlation Matrix and Factor Loadings for Cognitive Tests (N = 78).*

Executive Tests	1	2	3	4	5
1. TMT (B-A)	-				
2. VF Category Fluency	.397***	-			
3. VF Category Switching	.218	.353***	-		
4. DF Category Switching	.257*	.418***	.182	-	
5. SDMT	.432***	.318**	.185	.300**	-
6. Digit Span Backwards	.350**	.186	.069	.269*	.320**
Principal Component Analysis	Factor Loadings				
1. TMT (B-A)	.734				
2. VF Category Fluency	.603				
3. DF Category Switching	.690				
4. SDMT	.652				
5. Digit Span Backwards	.708				
Eigenvalue	2.31				
% of total variance	46.13				

*$p < .05$; **$p <.01$; ***$p <.001$

The correlations between cluster variables are presented in Table 7.3. Given their high correlations, online anticipatory awareness and self-evaluation ratios within each domain were combined to reduce the number of variables in the cluster analysis. In addition, given that the metacognitive knowledge and online awareness scores for the Hazard Perception Test remained moderately associated, one awareness score from each domain (Hazard Perception and Simple Reaction Time) was included in the cluster analysis to increase the degree of unique variance available and reduce redundancy. The solution that produced the most clinically meaningful cluster centroids included the Simple Reaction Time Metacognitive

Knowledge score and the Hazard Perception Online Awareness composite score, alongside the remaining cluster variables listed. This solution is described in the next section.

Table 7.3. *Correlations between Potential Cluster Variables (N = 78).*

Cluster Variables	1	2	3	4	5	6	7	8	9	10
1. SRT Metacognitive Knowledge	-									
2. SRT Anticipatory	.394**	-								
3. SRT Self-Evaluation	.364**	.874**	-							
4. SRT OA Composite	.412**	.967**	.971**	-						
5. HP Metacognitive Knowledge	.340**	.231**	.348**	.328**	-					
6. HP Anticipatory	.117	.316**	.272*	.303**	.691**	-				
7. HP Self-Evaluation	.155	.352**	.334**	.350**	.660**	.903**	-			
8. HP OA Composite	.139	.343**	.308**	.331**	.679**	.975**	.977**	-		
9. Defensiveness (MC-SDS)	.124	.069	.193	.148	.068	.024	.121	.076	-	
10. Discomfort	-.032	-.230*	-.161	-.186	-.055	-.096	-.186	-.145	-.326**	-
11. Executive Control Index	-.167	.091	.045	.050	-.076	-.073	-.100	-.090	-.058	-.079

$* p < .05$; $** p < .01$; SRT = simple reaction time; HP = hazard perception

Cluster Solution

In the partitioning stage of the cluster analysis, 2 to 5 cluster solutions were examined. The greatest separation between clusters was observed for the four-cluster solution (see Figure 7.1), which was also demonstrated in the percentage of change in the clustering coefficient. The percentage change in the clustering coefficient was 19% going from 2 to 1, 15% going from 3 to 2, 15% going from 4 to 3, and 13% going from 5 to 4 clusters. Examination of group raw scores across the clustering variables indicated that this partitioning was clinically meaningful (see Table 7.4).
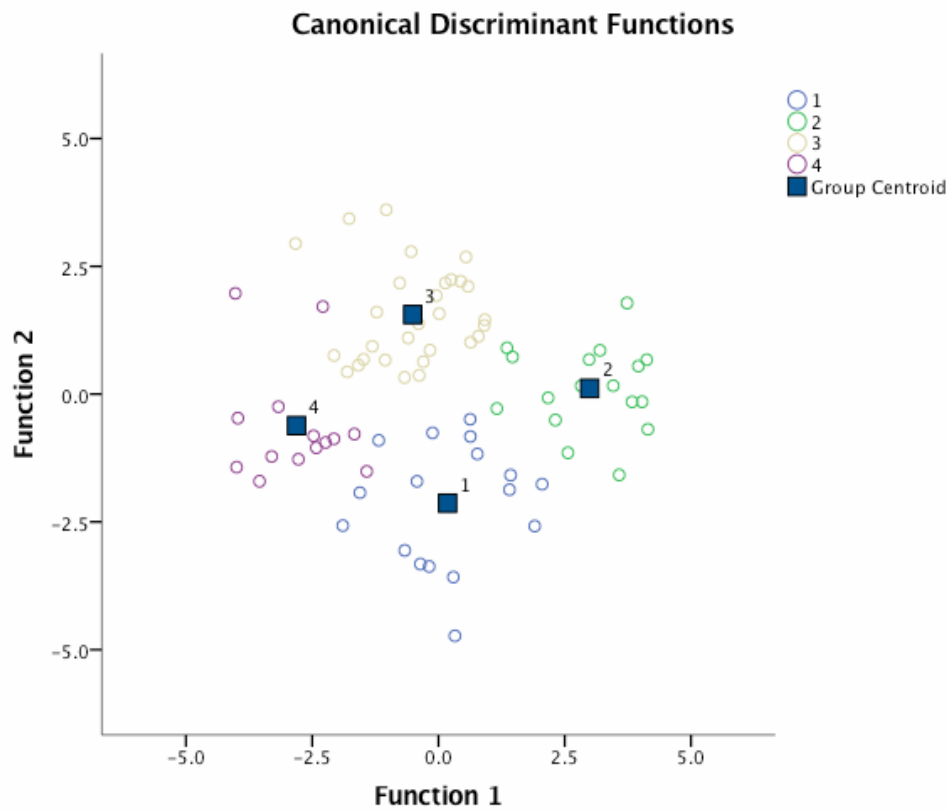

Figure 7.1. Scatterplot of the four-cluster solution showing cluster separation and group centroids ($N = 78$).

Table 7.4. *Means and Standard Errors on each Cluster Variable for the Four-Cluster Solution (N = 78).*

Cluster Variables*	Standardised Scores				F	p	η^2
	Group 1 ($n = 18$)	Group 2 ($n = 17$)	Group 3 ($n = 29$)	Group 4 ($n = 14$)			
SRT MK	0.25 (0.22)	0.87 (0.28)	-0.43 (0.87)	-0.66 (0.17)	13.11	<.001	0.35
HP OA	-0.34 (0.19)	0.93 (0.20)	-0.60 (0.15)	0.57 (0.17)	17.02	<.001	0.41
ECI	-0.98 (0.18)	-0.43 (0.15)	0.59 (0.13)	0.69 (0.20)	24.44	<.001	0.50
MC-SDS	-0.74 (0.16)	0.99 (0.11)	0.45 (0.11)	-1.17 (0.16)	50.36	<.001	0.67
Discomfort	0.20 (0.22)	-0.74 (0.27)	0.03 (0.82)	0.61 (0.24)	5.90	.001	0.19

*Cluster variables: Simple Reaction Time Metacognitive Knowledge (SRT MK); Hazard Perception Online Awareness (HP OA); Executive Control Index (ECI); Marlowe-Crowne Social Desirability Scale (MC-SDS); Driving Discomfort (Discomfort).

A one-way ANOVA was conducted to determine whether all clustering variables made significant contributions to cluster separation and to examine group differences across these variables. Results indicated that there were significant between-group differences on all cluster variables, with effect sizes suggesting that the measures of defensiveness (Marlowe-Crowne Social Desirability Scale, MC-SDS) and executive function (Executive Control Index, ECI) were the strongest contributors to cluster separation (see Table 7.4). Post-hoc analyses demonstrated that Groups 1 and 2 were more likely to overestimate their reaction time skills for driving (SRT Metacognitive Knowledge) relative to Groups 3 and 4 ($p < .001$). By comparison, Groups 1 and 3 underestimated their performance on the Hazard Perception Test relative to Groups 2 and 4 ($p < .001$), who tended to overestimate their performance on this test. On the ECI, Groups 1 and 2 performed more poorly on the cognitive measures than Groups 3 and 4 ($p < .001$). Groups 1 and 4 showed the lowest levels of defensiveness on the MC-SDS relative to the other two groups ($p < .001$). Group 2 scored more highly on defensiveness than Group 3 ($p = .007$). Group 2 showed the lowest level of discomfort with driving relative to the remaining groups ($p < .001$).

A non-hierarchical (K-means) cluster analysis was conducted to validate this solution. The cluster centroids were similar, however, 16.6% of participants ($n = 13$) changed group

membership. The majority of participants who changed group membership moved from Group 3 (the largest group) to Group 2 ($n = 4$, 30.8%), or from Group 1 to Group 3 ($n = 6$, 46.1%). Group 4 remained largely stable from the initial analysis. Some level of instability in the cluster solutions is not unexpected given the sample of healthy older adult volunteers.

To externally validate the original cluster solution, comparisons between clusters on the remaining awareness ratios from the driving (Hazard Perception Metacognitive Knowledge [HP MK] and Simple Reaction Time Online Awareness [SRT OA]) and memory domains were conducted (see Table 7.5). There were no significant between-group differences on any of the awareness ratios in the memory domain (p ranged from .194 to .612). By comparison, Group 2 significantly overestimated their performance on the Simple Reaction Time test relative to all other groups ($p < .001$). Groups 2 and 4 significantly overestimated their hazard perception skills for driving (HP MK) relative to Groups 1 and 3 ($p < .001$), who tended to underestimate their hazard perception skills. These results are consistent with the groups' performance across the clustering variables establishing external validity and meaningfulness of the original cluster solution.

Table 7.5. *Means and Standard Errors on each Validation Variable for the Four-Cluster Solution (N = 78).*

| Validation variables* | Standardised Scores | | | | F | p | η^2 |
	Group 1 ($n = 18$)	Group 2 ($n = 17$)	Group 3 ($n = 29$)	Group 4 ($n = 14$)			
HP MK	-0.35 (0.18)	0.77 (0.30)	-0.38 (0.14)	0.27 (0.23)	7.12	<.001	0.22
SRT OA	-0.31 (0.19)	0.85 (0.26)	-0.17 (0.15)	-0.16 (0.25)	6.38	.001	0.21
IM MK	0.28 (0.25)	0.40 (0.31)	-0.12 (0.14)	-0.28 (0.27)	1.41	.248	-
IM OA	0.08 (0.24)	0.25 (0.40)	-0.21 (0.35)	-0.10 (0.14)	0.61	.612	-
DM MK	0.16 (0.24)	0.19 (0.26)	0.04 (0.18)	-0.49 (0.25)	1.50	.221	-
DM OA	-0.10 (0.26)	0.48 (0.28)	-0.12 (0.17)	-0.11 (0.18)	1.61	.194	-

*Validation variables: Hazard Perception Metacognitive Knowledge (HP MK); Simple Reaction Time Online Awareness (SRT OA); Immediate Memory Metacognitive Knowledge (IM MK); Immediate Memory Online Awareness (IM OA); Delayed Memory Metacognitive Knowledge (DM MK); Delayed Memory Online Awareness (DM OA).

The characteristics of each awareness typology are presented in Table 7.6. The groups

did not differ significantly on age, gender, and principal driver status. They also did not differ

in performance on the general cognitive screen (TICS-M) and degree of depressive

symptoms, perceived negative feedback, self-rated importance of driving and barriers to

driving self-regulation. Group 3 performed significantly faster on the hazard perception test

relative to all other groups ($p < .001$). Group 2 performed significantly slower than all other

groups on the Simple Reaction Time test ($p < .001$) and reported the lowest level of

situational avoidance ($p = .001$). Group 4 reported the highest level of situational avoidance

($p < .001$). Consistent with this, Groups 2 and 3 were least ready to change their driving

behaviour relative to Groups 1 and 4 ($p = .004$). Groups 1 and 4 reported significantly more

changes to their cognition in the past five years relative to Groups 2 and 3 ($p < .001$).

Table 7.6. *Characteristics of the Awareness Typologies (N = 78).*

Characteristics	1: Impaired but Not Restricted (n = 18)	2: High Defensiveness (n = 17)	3: Good Self-Awareness, Unimpaired (n = 29)	4: Good Self-Awareness, Impaired (n = 14)	F / χ^2	p	η^2
Age	68.56 (7.82)	71.94 (8.18)	72.86 (5.45)	70.86 (7.14)	1.48	.227	-
% Male	44.4 (8)	47.1 (8)	48.3 (14)	42.9 (6)	0.14	.987	-
% Only driver in household	33.3 (6)	41.2 (7)	34.5 (10)	21.4 (3)	1.38	.710	-
HP reaction time (secs)	3.64 (0.47)	4.14 (0.72)	3.45 (0.51)	3.96 (0.63)	6.02	.001	.20
SRT reaction time (ms)	344.90 (43.20)	365.07 (53.41)	324.03 (31.85)	311.25 (24.33)	6.02	.001	.20
TICS-M	24.67 (2.74)	25.18 (3.80)	26.17 (3.50)	27.50 (3.01)	2.23	.091	-
Avoidance[1]	21.89 (18.41)	12.94 (17.16)	25.45 (16.91)	40.69 (13.35)	6.72	<.001	.23
Depression[2]	2.17 (1.27)	1.14 (1.07)	1.82 (1.19)	2.14 (1.27)	2.53	.064	-
Feedback	5.39 (2.99)	4.53 (3.20)	5.17 (2.71)	5.36 (3.05)	0.31	.818	-
Readiness to Change	13.71 (3.29)	11.18 (5.18)	11.79 (3.71)	15.08 (4.19)	3.07	.033	.11
Barriers to SR[3]	11.18 (3.26)	13.24 (3.87)	12.48 (4.10)	14.50 (3.84)	2.07	.112	-
Importance of Driving	11.24 (2.22)	10.27 (3.56)	11.62 (2.78)	12.79 (3.19)	1.85	.145	-
Changes to Cognition	26.44 (11.65)	8.81 (10.36)	14.48 (10.06)	24.86 (13.09)	9.89	<.001	.29

[1] Outlier (1.5SD above group mean) removed from Group 2. [2] Variable square root transformed to reduce negative skew. [3] Outlier (1.5SD above group mean) removed from Group 1.

Interpretation of the Cluster Solution

The awareness indices for reaction time and hazard perception tasks varied between Groups 1 and 4 (see Tables 7.4 to 7.6), with a tendency toward underestimation errors on the hazard perception test for Group 1 and overestimation errors for Group 4. In general, the opposite pattern was observed for the simple reaction time test (with exception of the online awareness index for simple reaction time for Group 1). When considered in context of the other characteristics, these two groups demonstrated domain-specific awareness. Both groups demonstrated the lowest levels of defensiveness on the MC-SDS, reported significantly more changes to their cognition than the other two groups, greater discomfort with driving due to changes in hazard perception and reaction time skills and were most ready to change their driving behaviour. However, Group 1 also demonstrated significantly poorer performance on the executive function tests than Group 4 but did not report compensatory situational avoidance. Group 4 was the only group to obtain an average situational avoidance score above the cut-off score of 33, suggesting compensatory situational avoidance (see Chapter 5 for a description on how this cut-off score was obtained). As such, Group 1 was labelled "impaired but not restricted" and Group 4 was labelled "good self-awareness, impaired".

Group 2 consistently overestimated their hazard perception and simple reaction time skills and demonstrated significantly slower objective performance on these measures relative to the other groups. They performed more poorly on the executive function measures than Groups 3 and 4. Despite these objective difficulties, this group reported lower driving discomfort and situational avoidance than all other groups. They also exhibited a significantly higher level of defensiveness on the MC-SDS, reflecting a desire to present themselves in an overly favourable light. While self-reported depressive symptoms did not differ significantly across groups, Group 2 was noted to score the lowest on this measure. This trend is consistent with the findings of Ownsworth and colleagues (2007) and the hypothesised role of denial as

a protective factor against emotional distress and the development of depression. Accordingly, this group was labelled the "high defensiveness" group.

By comparison, Group 3 consistently underestimated their hazard perception and simple reaction time skills and performance on the objective driving measures and performed, on average, faster than the other groups on these measures. Group 3 also reported lower readiness to change their driving behaviour relative to the groups who performed more poorly on the cognitive and/or driving measures. They scored below the cut-off of 33 on the SAQ indicating the absence of compensatory situational avoidance behaviour. They performed in the average to above average range on the executive function measures and reported little change in their cognitive skills in the past five years. This is somewhat inconsistent with what might be expected of a group who underestimates their abilities and is more consistent with older drivers who are unimpaired and who demonstrate intact self-awareness. Accordingly, this group was labelled the "good self-awareness, unimpaired" group.

When all of these results are taken together, three of the five hypothesised awareness typologies were observed in the current sample and performed consistent with predictions on their degree of compensatory situational avoidance, objective test performance and readiness to change driving behaviour. Groups encompassing older drivers who underestimate their ability (*High Symptom Reporting*) or those demonstrating neuropsychologically based unawareness (*Poor Self-Awareness*) did not emerge.

Discussion

This study used cluster analysis to produce four distinct typologies of older drivers according to awareness of their hazard perception and simple reaction time skills, and factors previously found to be related to awareness including executive function, denial/defensiveness and driving discomfort. It is the first study to consider both metacognitive knowledge and online awareness across multiple driving domains or objects of

awareness, whilst concurrently investigating potential explanations for unawareness. The Good Self-Awareness, Unimpaired group demonstrated good executive function skills, normal defensiveness, average driving discomfort and a tendency to underestimate their hazard perception and reaction time skills. The High Defensiveness group overestimated their driving-related skills, reported low levels of driving discomfort and showed a tendency to present themselves in an overly favourable light. Finally, the Good Self-Awareness, Impaired group and Impaired but Not Restricted groups were characterised by accurate domain-specific awareness (simple reaction time and hazard perception, respectively), high driving discomfort, and low defensiveness. However, despite demonstrating greater difficulty on the executive control index, the Impaired but Not Restricted group did not report compensatory situational avoidance. The Good Self-Awareness, Impaired group was the only driver group to obtain a mean SAQ score above 33 indicating self-reported practice of compensatory situational avoidance.

It was hypothesised that a High Symptom Reporting group would emerge in the present study comprised of older female drivers who underestimate their driving ability, report greater discomfort with driving, and a high degree of situational avoidance. However, consistent underestimation of performance was not associated with driving discomfort or situational avoidance as observed within the Good Self-Awareness, Unimpaired group. When taken together with their performance across the objective tasks and typology characteristics, conservative estimations of skill may be a product of this groups' competence on the objective tasks. Kruger and Dunning (1999) hypothesised that the tendency for high-performing individuals to underestimate their performance may be attributed to the false-consensus effect (Ross, Greene, & House, 1977). In making comparisons to same-aged peers, these participants may have assumed that because they performed so well, their peers must have also performed well. This might explain why underestimation errors were not associated

with unnecessary use of situational avoidance, given that this false-consensus effect would not be expected if this group were to rate their absolute, rather than relative ability, in each driving domain. That is, in rating absolute ability, this group would be expected to demonstrate accurate self-assessments of their skill level.

Level of skill on the object of awareness is just one potential contributor to degree of metacognitive or online awareness. Motivational or self-serving biases that impact information processing and/or the responses an individual provides to questions of impairment can also produce awareness deficits in the form of denial or defensiveness (Clare, 2003; Clare, 2004a; Weinstein et al., 1994). The High Defensiveness group demonstrated a consistent tendency toward overestimation of ability across all types and objects of awareness assessed and were least willing or ready to change their driving behaviour as per their self-report. Relative to underestimation errors, overestimation errors are of greater concern in the driving domain given their association with crash risk in drivers of all ages (Broberg & Willstrand, 2014; De Craen et al., 2007; Gregersen, 1996). When mean hazard perception latencies are compared, the 690ms slower average of the High Defensiveness group relative to the Good Self-Awareness, Unimpaired group equates to an additional 11 metres of stopping distance when travelling at 60 kilometres per hour (all other factors equal). The Good Self-Awareness, Impaired group performed similarly to the High Defensiveness group on the hazard perception test. However, this group also reported significant compensatory situational avoidance, potentially offsetting their increased crash risk (provided their self-reported behaviour corresponds to actual driving practices, e.g., Blanchard & Myers, 2010). Investigation of the safety benefits of situational avoidance using measures that distinguish compensatory from non-compensatory behaviour is needed to confirm this assertion.

Contrary to predictions, the High Defensiveness group was comprised of an approximately equal number of men and women. Thus, older women were just as likely as

older men in the current study to report high levels of defensiveness in the setting of poor performance on tests of simple reaction time and hazard perception. Previous research has attributed the narrowing of the gender gap in driving behaviour to changes in generational experience with driving and household structure (D'Ambrosio et al., 2008; Hassan et al., 2015b; Rosenbloom & Herbel, 2009). New generations of older women are expected to be more reliant upon their private vehicles for mobility, particularly once they reach 65 years of age when they are more likely than older men to live alone (Rosenbloom & Herbel, 2009). D'Ambrosio and colleagues (2008) found that older women who lived alone were less likely to self-regulate their driving and more likely than other women to report higher confidence in their driving skills. However, in the current study, neither age nor the number of drivers in the household differed across the typologies. Despite this, the consistent findings of gender differences in attitudes toward driving (e.g., Conlon et al., 2017) suggest that the factors influencing denial/defensiveness for each gender merit further investigation.

Neuropsychologically based awareness deficits describe the loss of awareness that can occur with age- or disease-related changes in the cognitive skills necessary to mediate the experience of awareness (Clare, 2004a; McGlynn & Schacter, 1989; Ownsworth et al., 2006). While the age of participants or their performance on a general cognitive screen did not distinguish between the awareness typologies, executive functions that underlie self-monitoring and self-regulatory skills (e.g., cognitive flexibility) significantly contributed to group membership (Stuss, 1991; Stuss et al., 2001). However, the hypothesis that a group of older drivers with neuropsychologically based unawareness would emerge in the present study was not supported and may be explained by the relatively good executive function skills of the current sample. Indeed, while the executive control index significantly differentiated between the four groups, the group with the poorest skills in this area (Impaired but Not Restricted) demonstrated accurate domain-specific awareness of their hazard

perception skills. However, this group did not report compensatory situational avoidance despite reporting a similar level of discomfort with driving as the Good Self-Awareness, Impaired group. Investigation of awareness and compensatory driving self-regulation using prospective research might reveal early changes in executive function skills to signal drivers who go on to develop neuropsychologically based unawareness. It would also allow for causal interpretations to be made with respect to the relationship between executive function impairment, awareness and the compensatory changes older drivers introduce to their driving behaviour. The present findings suggest that executive control may need to be significantly impaired before awareness is compromised.

The psychosocial characteristics explored in the present study, including barriers to the practice of driving self-regulation such as principal driver status, failed to elucidate what might have contributed to the lower levels of avoidance behaviour reported by the Impaired but Not Restricted group. Future research might include an awareness interview, alongside methods such as prediction-performance discrepancy, to help clarify the phenomenological experience of each awareness typology (Clare, 2004b; Clare et al., 2005; Clare et al., 2011). Ownsworth and colleagues (2000) developed a Self-Regulation Skills Interview (SRSI) to assess metacognitive processes and self-regulation skills such as strategy knowledge. It is possible that the drivers in this group may differ from the Good Self-Awareness, Impaired group in terms of strategy awareness and knowledge, such that their lower levels of situational avoidance was a product of not knowing what compensatory strategy to use rather than a result of unawareness. Alternatively, they may have been practicing a different form of driving self-regulation not assessed in this study (e.g., tactical or life goal self-regulation, Molnar, Eby, Langford et al., 2013).

Crosson and colleagues (1989) argue that the type of awareness that is elicited guides the type of compensation that is to be applied. A driver who has intact online anticipatory and

emergent awareness may be able to apply strategic and tactical compensatory strategies only in the situations they require them (e.g., avoiding driving in congested traffic areas only when it is raining) (Crosson et al., 1989). However, deficits in online awareness may necessitate the consistent practice of compensatory strategies at life-goal and strategic levels (e.g., choosing to move closer to preferred destinations and consistently avoiding driving on busy roads) (Crosson et al., 1989). This has direct implications for educational interventions and will be discussed in further detail in the final chapter. Future research should also examine whether metacognitive knowledge and online awareness are uniquely associated with driving self-regulation at the different levels of driving behaviour (e.g., strategic, tactical and operational) (Michon, 1985).

Several limitations of this study are important to acknowledge. Given the possibility of sampling bias with a convenience sample, future research should aim to recruit a larger sample more representative of the general population of community-based older adults to increase external validity of the current findings. This is particularly true given the small ratio of participants to clustering variables. Sampling bias might also contribute to the lack of a High Symptom Reporting group given that this group would be expected to be less willing to participate. This was discussed in Chapter 5 and was also hypothesised to be a contributing factor to the low number of 'underestimators' in Broberg & Willstrand's (2014) study. As indicated earlier, prospective longitudinal research would also allow for the stability of the cluster solution to be assessed over time to identify the extent to which individuals move between typologies and how changes in awareness might impact driving behaviour.

Nonetheless, this study demonstrated that distinct subgroups of older drivers can be identified based upon awareness phenomena, with some older adults exhibiting intact awareness and others who overestimated their driving-related skills and displayed psychosocially based awareness deficits. These groups demonstrated meaningful differences

in self-reported compensatory situational avoidance, supporting both driving self-regulation and awareness theory (Anstey et al., 2005; Crosson et al., 1989; Hassan et al., 2015a; Rudman et al., 2006; Toglia & Kirk, 2000; Wong et al., 2014). This research further suggests that of the factors that contribute to instances of unawareness in an older driver population, psychosocially based awareness deficits might be considered to be most prevalent in amongst those who are cognitively healthy.

This study extends the literature in this area by confirming the distinction between metacognitive knowledge and online awareness (Toglia & Kirk, 2000), and highlighting the domain specificity of the awareness construct among older drivers. Driving is a complex task involving several skill sets reliant upon visual, cognitive and physical abilities (Anstey et al., 2005). Just as there are considerable individual differences among older drivers across these driving skill sets (Anstey et al., 2005; Hakamies-Blomqvist et al., 2004), variability also exists between and within older drivers in terms of awareness of functioning in these areas. Differences in awareness levels and reasons for unawareness have direct implications for interventions targeted at improving awareness and the use of driving self-regulation as a safe driving strategy (Crosson et al., 1989; Molnar et al., 2015). The present findings highlight the need for further research attention on the measurement of awareness and the identification of factors that contribute to instances of unawareness within the older driver population.

Chapter 8 : General Discussion

This research had four aims: 1) to develop and validate a measure of driving self-regulation that distinguishes compensatory from non-compensatory driving behaviour; 2) to distinguish between older drivers who possess the capacity to effectively evaluate their driving skills and those who do not; 3) to determine the influence of neuropsychological and psychosocial factors in explaining instances of unawareness in older drivers; and 4) to examine whether the degree of compensatory driving behaviour reported differs between older drivers with good awareness and those with neuropsychologically and/or psychosocially based unawareness. To achieve these aims, a questionnaire assessing frequency of situational avoidance, a form of driving self-regulation at the strategic level of driving behaviour, was developed and using Rasch analysis, was found to be a reliable and valid measure within a baby boom and older adult sample ($N = 399$) (see Chapter 4). The situational avoidance construct was found to be unidimensional and hierarchical, where avoidance of driving situations followed a specific pattern with more frequent avoidance of some situations (e.g., night driving) over others (e.g., intersections). A smaller subsample of participants ($n = 79$) completed the Situational Avoidance Questionnaire (SAQ) and were classified as compensatory-restricted or non-restricted based upon their answers to a semi-structured interview that assessed their reasons for the situational avoidance behaviour reported on the SAQ (see Chapter 5). The SAQ was found to have high diagnostic accuracy in classifying the two driver groups, with a SAQ cut-off score of 33 suggesting the practice of compensatory situational avoidance.

In the second phase of the research, awareness of hazard perception skills was assessed within the theoretical framework proposed by Crosson and colleagues (1989) and extended by Toglia and Kirk (2000) (see Chapter 6). Participants ($n = 79$) rated their hazard perception skills prior to any of the tests (metacognitive knowledge), predicted how well they thought

they would perform prior to each test (anticipatory awareness), rated their confidence in accuracy after each trial of a divided attention task (emergent awareness), and rated their overall performance on each task at its completion (self-evaluation). A discrepancy method of awareness assessment was used, comparing subjective estimations to objective test performance. Correlational analysis supported the distinction between metacognitive knowledge and online awareness as proposed by the Toglia and Kirk (2000) model. Online awareness indices were also more strongly associated with objective test scores confirming these indices as task- and time-specific (Toglia & Kirk, 2000). Domain-specific awareness was observed, with awareness levels varying between and within objects of awareness (hazard perception versus memory domains). While a positive self-bias was found for the metacognitive knowledge indices across the driving tasks, online awareness indices differed across tasks and suggested inherent differences in the rating of tasks involving reaction time.

Lastly, distinct typologies of older drivers were identified using cluster analysis according to their awareness of hazard perception and simple reaction time skills, and their responses on measures of executive function, denial/defensiveness (Marlowe-Crown Social Desirability Scale) and driving discomfort (see Chapter 7). As was predicted, these groups demonstrated meaningful differences on the SAQ. Specifically, the psychosocially based unaware / High Defensiveness group reported the lowest level of situational avoidance and did not differ from the unimpaired group ("good self-awareness, unimpaired"). By comparison, the Good Self-Awareness, Impaired group demonstrated accurate domain-specific awareness of their simple reaction time skills and obtained a mean SAQ score above 33 indicating compensatory situational avoidance. A neuropsychologically based unawareness group was not found in the present study, with the group with the poorest executive function skills demonstrating awareness of their hazard perception skills. However,

this group did not report compensatory situational avoidance and the measures included in this study failed to explain these findings.

These results will be discussed in terms of: 1) the construct of driving self-regulation and its measurement; 2) measurement of awareness in an older driver population; and 3) the implications of these findings for educational programs targeted at increasing the self-regulatory behaviour of older adults. The limitations of this thesis and relevant future research directions are addressed within each of these sections.

The Construct of Driving Self-Regulation and its Measurement

Driving self-regulation represents a multidimensional construct comprised of different self-regulatory strategies at life-goal, strategic, tactical and operational levels of driving behaviour (Molnar et al., 2014; Molnar, Eby, Charlton, et al., 2013; Molnar, Eby, Langford et al., 2013). The current study found situational avoidance, one component of driving self-regulation at the strategic level, to be unidimensional and hierarchical or cumulative (Davis et al., 2016). It follows that changes in driving-related skills might prompt avoidance of certain situations reliant on those skills (e.g., perceived changes in vision for night driving may prompt avoidance of driving at night). It is also just as likely that, for some older adults, changes in lifestyle and/or the greater flexibility afforded by retirement may have motivated avoidance of some of the more frequently avoided driving situations (e.g., night, in wet weather or in busy traffic) (Molnar, Eby, Charlton et al., 2013). However, cumulative avoidance of five or more driving situations (a SAQ score of 33 or higher) was found to significantly differentiate between compensatory-restricted and non-restricted drivers in the present thesis. Replication of this hierarchical structure and cut-off score using a sample of older drivers that is more representative of the general older driver population (i.e., a study not reliant on a convenience sample) would assist in validating the current study findings. Inclusion of other forms of strategic behaviour (e.g., trip planning strategies or the use of

passengers to assist with navigation or monitoring of driving) (Molnar, Eby, Langford et al., 2013) would also further clarify the construct of strategic driving self-regulation.

This research highlights the importance of considering the motivations for avoiding various situations given the meaningful differences observed in subjective and objective performance between compensatory-restricted and non-restricted drivers in Chapter 5, and in the degree of compensatory situational avoidance reported among the awareness typologies identified in Chapter 7. Driving behaviour should only be characterised as a form of driving self-regulation based upon whether this behaviour was initiated in response to specific declines in driving-related abilities or a general sense of discomfort or loss of confidence on the road (Molnar et al., 2015). Differences in prevalence rates of compensatory behaviour across the different types of driving self-regulation (e.g., life-goal, strategic, tactical and operational), and the frequency of compensatory behaviours within each type of driving self-regulation need to be determined with this assertion in mind.

The value of questionnaire research lies in its ability to capture the subjective experience of driving among older adults, the symbolic and practical importance of driving to one's lifestyle and factors self-perceived as influential in determining one's driving decisions (Molnar et al., 2015; Sullivan et al., 2011). The emergence of a group with psychosocially based unawareness (high defensiveness) attests to the importance of ongoing questionnaire research in this area. However, research on the objective driving practices of older adults has found discrepancies between older drivers' self-report and their actual driving behaviour (e.g., Blanchard & Myers, 2010; Marshall et al., 2007; Thompson et al., 2016). Future research should continue to obtain self-report data alongside objective driving exposure data. In the present study, the Impaired but Not Restricted group demonstrated awareness of their hazard perception skills and reported a high degree of subjective cognitive change. This group also reported intentions to restrict their driving behaviour (readiness to change) but did

not report the use of compensatory behaviour. Comparison between self-reported and objective driving data might help identify factors that serve as a barrier to the translation of intentions into actions (Molnar et al., 2015). It would also be of interest to determine whether some drivers within the High Defensiveness group practice compensatory situational avoidance but choose not to report this behaviour on a self-report questionnaire. These individuals would differ from those using denial as an active coping strategy, suggesting socially desirable responding rather than a form of unawareness as such.

Investigation of the practice of driving self-regulation using prospective research would further our understanding of these behaviours and their implications for the on-road safety of older road users. Exploration of the impact of changes in health status and functional ability on the practice of different forms of driving self-regulation would allow for the determination of causal links between changes in function and the initiation of driving self-regulation. The hypothesis of a mediating role of awareness and attitudes toward driving in determining the appropriateness of the self-regulatory strategies practiced should also be explored. Use of prospective research might help confirm, that in the absence of acute onset of disease or disability, the practice of driving self-regulation exists of a continuum that ultimately culminates in cessation of driving (Dellinger et al., 2001). Finally, it is essential to determine the extent to which driving self-regulation (in its many different forms) can maintain the safe mobility of older drivers through a reduction in crash risk.

Research has demonstrated that natural groups appear to exist within the older driver population based upon their practice of driving self-regulation. For example, non-restricted, compensatory-restricted and 'others' (i.e., those who report driving behaviour change for reasons unrelated to self-regulation) (Molnar et al., 2014); and low, medium and high 'self-regulators' (Bergen et al., 2017). Ongoing investigation of characteristics that distinguish between these driver groups is important, as it is likely that factors contributing to the

practice of driving self-regulation will differ according to the reasons for self-regulation and the types of self-regulatory behaviour exhibited (Dellinger et al., 2001; Molnar et al., 2014). It is also likely that driving self-regulation as a safe driving strategy is appropriate only for certain subgroups of older drivers, for example, those with largely intact cognitive skills. The latter has been proposed due to the impact of cognitive impairment on the experience of self-awareness and the relationship of self-awareness to the practice of driving self-regulation (Daigneault et al., 2002; Hakamies-Blomqvist et al., 2004; Meng et al., 2013).

Measurement of Awareness in an Older Driver Population

This thesis sought to advance our understanding of the awareness construct within a cognitively healthy older driver population through the application of a comprehensive model of awareness derived from theories of metacognition, self-efficacy and neuropsychology (Toglia & Kirk, 2000). The distinction between self-knowledge and beliefs that exist prior to a task (metacognitive knowledge) and one's capacity for self-monitoring and self-evaluation in the setting of a specific task (online awareness) was supported in this population (Toglia & Kirk, 2000). This thesis also demonstrated the complexity of the awareness construct through the multi-domain assessment of awareness and differences observed in the self-ratings across different driving-related skills and memory tasks (Clare, 2004a; Clare et al., 2011). These results suggest that it is not enough to measure a single form of awareness in relation to a single object of awareness and deem an older adult as 'aware' or 'unaware'. Future research should incorporate multiple methods of awareness assessment (e.g., clinician ratings, prediction-performance discrepancy, and phenomenological methods) to obtain richer information that can advance our theoretical understanding in this area, and improve the clinical utility of the methods of assessment (Clare, 2004b; Clare et al., 2005).

Awareness of driving limitations is necessary (but not sufficient) for the practice of appropriate driving self-regulation, or driving behaviour that corresponds to but does not

exceed one's skill level (Ackerman et al., 2011; Anstey et al., 2005). This thesis found that the degree of self-reported situational avoidance differed significantly among groups with varying levels of awareness and unawareness. Future research should explore whether different forms of awareness correspond to different forms of driving self-regulation. One might expect stronger associations between metacognitive knowledge and life-goal or strategic decisions, whereas online awareness may correspond more strongly to tactical or operational driving decisions (Crosson et al., 1989; Michon, 1985; Toglia & Kirk, 2000). For example, investigation of the impact of one's appraisal of task demands (online anticipatory awareness) and their awareness of naturalistic action errors (online emergent awareness) on driving performance during an on-road or simulated driving task would help determine the role of online awareness in contributing to an older adult's safety on the road.

This research confirmed the frequent finding of a positive self-bias among older drivers in the rating of metacognitive knowledge of driving-related skills (Amado et al., 2014; Carberry et al., 2006; Holland & Rabbitt, 1992; Horswill et al., 2004; Horswill et al., 2013; Horswill et al., 2017; Ross et al., 2012; Tuokko et al., 2007; Wood et al., 2013). However, in the present study, this self-bias was not found across all forms of awareness (e.g., the dissociation observed between metacognitive knowledge and online awareness for the divided attention task), and was not found when the sample was broken down into awareness typologies. Overestimation errors were associated with a tendency toward defensiveness whereas underestimation errors were more common among high performing individuals. Further investigation of differences in awareness across subgroups of older drivers, their practice of compensatory situational avoidance and differences on other safety measures (e.g., on-road performance or crash rates) is needed to determine the characteristics of drivers for whom driving self-regulation represents a safe driving strategy and those who may not possess the skills needed for self-regulation to be effective. Future research should also

establish whether the awareness typologies found in this thesis are consistent across different (and more generalizable) samples of current older drivers. This is important as these typologies are expected to differ in the way in which they respond to feedback about driving ability and thus, educational interventions may obtain better outcomes should they employ individually tailored, awareness-based interventions.

Implications for Educational Interventions

Two of the four awareness typologies that emerged in this study reported a degree of situational avoidance consistent with their objectively measured skills (i.e., the Good Self-Awareness, Impaired group reported a high degree of compensatory situational avoidance, whereas the Good Self-Awareness, Unimpaired group reported little to no situational avoidance). The remaining two typologies also reported little to no situational avoidance, yet demonstrated difficulties on the objective driving and cognitive tasks. The lack of compensatory situational avoidance reported by the Impaired but Not restricted group is unexplained by the current study findings. For the High Defensiveness group, the mismatch between objective skill and driving behaviour may be explained by an unwillingness to disclose driving difficulty and/or compensatory situational avoidance. The tendency toward defensiveness may represent an active coping strategy to avoid the distress experienced if an individual were to acknowledge declines in driving skill, a broader personality style of downplaying personal shortcomings, or a socially desirable response pattern that is not reflected in the group's actual driving behaviour (Clare, 2003; Ownsworth et al., 2006; Weinstein et al., 1994). As noted earlier, incorporation of an awareness interview and objective driving data in future research would allow for the motivations behind defensiveness to be determined.

Research into the effectiveness of older driver education programs has gained traction following the observation that feedback regarding functional ability has been associated with

increased self-awareness and self-reported driving self-regulation (Ackerman et al., 2011; Ackerman et al., 2014; Ackerman et al., 2016; Holland & Rabbitt, 1992; Horswill et al., 2017). However, the effectiveness of these programs has been mixed. While awareness and self-reported driving behaviour of older drivers has been shown to change following participation in an educational program (Eby et al., 2003; Kua et al., 2007; Molnar et al., 2010; Nasvadi, 2007; Owsley et al., 2003; Owsley et al., 2004; Porter & Tuokko, 2011), some studies have shown that driving safety is not enhanced, with a subgroup of older adults continuing to be involved in crashes (Janke, 1994b; Nasvadi & Vavrik, 2007; Owsley et al., 2004). These subgroups of drivers were more likely to be older men and principal drivers of their household (Nasvadi & Vavrik, 2007; Owsley et al., 2004). They were also more likely to express stronger emotional investment in driving at program outset, and reported greater comfort with and higher perceived improvements in their driving skills at the completion of the program (Nasvadi, 2007; Nasvadi & Vavrik, 2007).

While older women and drivers who share driving with others in their household were just as likely to report a high level of defensiveness in the present research, these findings suggest that the presence of defensiveness could impact on a driver's openness to and willingness to implement compensatory changes to their driving. This is consistent with research on the impact of denial on initiation of compensation following traumatic brain injury (Crosson et al., 1989; De Craen et al., 2007; Lam et al., 1988; Ownsworth, 2005; Ownsworth et al., 2006). Possible reasons underlying denial and defensive reactions to age-related declines in driving ability need to be sensitively explored in order to understand the meaning of driving from the older adult's perspective and to identify factors likely to motivate the initiation of changes to their driving behaviour (Barber, 2017; Fleming & Ownsworth, 2006; Toglia & Kirk, 2000; Tuokko et al., 2007).

The content of educational programs designed to promote driving self-regulation has typically involved information on possible age-related declines (e.g., in vision function), the impact of these changes on driver safety, and ways in which older drivers can compensate for these changes through, for example, avoidance of challenging driving situations (e.g., Eby et al., 2003; Nasvadi, 2007; Owsley et al., 2003; Porter & Tuokko, 2011; Stalvey & Owsley, 2003). Recent studies suggest that exposure to this information may elicit a negative stereotype ("older drivers as 'bad' drivers") (Brelet et al., 2016; Ferring et al., 2015), and that when a stereotype threat is activated, older drivers demonstrate an increase in driving error and self-regulate their driving less effectively (Brelet et al., 2016; Joanisse et al., 2012; Joanisse et al., 2013). The negative effects of stereotype threat are argued to be particularly salient for older drivers who ascribe greater value to driving (Joanisse et al., 2013). Future research should explore whether the effects of stereotype threat are stronger for drivers who fall into the High Defensiveness awareness typology (particularly those who are using denial as an active coping strategy), and whether this impacts on how they receive and interpret information provided in driver education programs.

Programs for highly defensive older drivers that include components exploring older driver values and that emphasise consideration of alternatives to driving have been theorised to have a greater impact on the driving decisions of this subgroup (Barber, 2017; Nasvadi & Vavrik, 2007; Tuokko et al., 2007). Providing the opportunity to affirm one's self-worth in domains other than driving can alleviate threats to self-identity in the driving domain through demonstrating that self-worth is a global rather than singular construct (Barber, 2017). Allowing individuals to identify with groups with a more positive connotation can also counteract stereotype threat, for example, when negative information is provided alongside information about older drivers who remain active and socially involved despite a reduction in or cessation of driving (Brelet et al., 2016). Informing older drivers of the underlying

negative stereotype threat can also work to reduce its effects on driving behaviour (Brelet et al., 2016; Johns, Inzlicht, & Schmader, 2008).

In a novel approach, Tuokko and colleagues (2015) used theatre to help conceptualise the broader psychological and social barriers to safe driving among older drivers. Three actors acted out the dilemmas faced by older drivers as they consider their safety on the road. Relative to a 'just the facts' intervention, participants demonstrated a greater willingness to consider changing their driving behaviour after viewing the play. In a different approach, Horswill and colleagues (2017) demonstrated that older drivers' positive self-bias on a hazard perception test could be reduced dramatically with the provision of direct feedback in which the driver's hazard perception latencies were compared to an average driver their age and to a hypothetical 'expert'. Taken together, these findings suggest that the use of direct feedback, informing participants of the effects of stereotype threat, exploration of values related and unrelated to driving, and discussing ways in which drivers have remained active and healthy with driving reduction/cessation might be important factors to consider in the development of educational interventions for those presenting with high levels of defensiveness.

These interventions may be further specified to allow for the greatest level of mobility. For example, an older driver who possesses intact online awareness skills should have the prerequisite ability to implement compensatory strategies only in the situations that require them (e.g., tactical compensation) (Crosson et al., 1989). However, for those drivers who have poor online awareness, consistent use of self-regulatory strategies at life-goal and strategic levels of driving behaviour may be required (Crosson et al., 1989). For drivers who demonstrate the greatest awareness deficits, life-goal self-regulation, for example the use of vehicles with advanced technologies and relocation to an area with multiple non-driving options (Molnar, Eby, Langford et al., 2013; Molnar et al., 2007), may be the only appropriate approach prior to driving cessation.

Conclusions

With age- or disease-related declines in driving ability, older adults are faced with the difficult decision of whether or not they should continue to drive, and how they might modify their driving to improve their safety when on the road. Theories of driving self-regulation propose that awareness of one's driving ability is necessary but not sufficient for the appropriate use of driving self-regulatory strategies (Anstey et al., 2005; Hassan et al., 2015; Kowalski et al., 2014; Rudman et al., 2006; Wong et al., 2014). Additional factors, both internal and external to the older adult, interact with their self-knowledge to determine their actual behaviour on the road (Hassan et al., 2015a; Kowalski et al., 2014; Rudman et al., 2006; Wong et al., 2014). The complexity of the decision to self-regulate driving was highlighted in the present thesis through the identification of four distinct awareness typologies that demonstrated meaningful differences in compensatory situational avoidance, measured using the Situational Avoidance Questionnaire (SAQ, Davis et al., 2016).

The present research demonstrated that awareness within the driving domain could be characterised by two distinct forms, metacognitive knowledge and online awareness (Toglia & Kirk, 2000), and that awareness levels vary across different hazard perception and memory tasks. For some participants, awareness of their skills in specific areas was associated with appropriate self-reported situational avoidance; while for others, defensiveness was associated with the overestimation of driving-related skills and the absence of compensatory situational avoidance. This research also found a group who demonstrated awareness of their hazard perception skills and yet did not report using compensatory situational avoidance for the difficulties they exhibited on objective tests. For these latter groups, educational programs may need to be tailored to reflect the different problem areas (e.g., awareness deficits versus the implementation of compensatory behaviour). Future prospective research is needed to establish the safety benefits of voluntary driving self-regulation using measures that

distinguish compensatory from non-compensatory behaviour, such as the SAQ. The results of this thesis also suggest that natural groupings of older adults exist comprising those for whom driving self-regulation may be appropriate, and those who may require further monitoring and intervention to address individual barriers to the effective use of self-regulation, such as defensiveness.

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Appendix A – Copyright License

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Appendix B – Situational Avoidance Questionnaire (SAQ) Items

Situational Avoidance Questionnaire Items (Davis et al., 2016)

Item	Converted Response Scale – *"Do you avoid it?"*
1. Merging	0 = *No*, 1 = *Yes*
2. Rain	0 = *No*, 1 = *Yes*
3. Busy traffic	0 = *No*, 1 = *Yes*
4. Small 1-lane roundabouts	0 = *No*, 1 = *Yes*
5. Busy 2-lane roundabouts	0 = *No*, 1 = *Yes*
6. Driving through intersections without lights	0 = *No*, 1 = *Yes*
7. Right turns with lights but without a right arrow	0 = *No*, 1 = *Yes*
8. Right turns without lights or stop/give way signs	0 = *No*, 1 = *Yes*
9. Night	0 = *Never*, 1 = *Sometimes*, 2 = *Always*
10. Night when wet	0 = *Never*, 1 = *Sometimes*, 2 = *Always*
11. Night in busy areas with glare	0 = *Never*, 1 = *Sometimes*, 2 = *Always*
12. Changing lanes	0 = *No*, 1 = *Yes*
13. Highways/motorways	0 = *No*, 1 = *Yes*
14. Unfamiliar routes, detours, or sign changes	0 = *No*, 1 = *Yes*
15. Congested traffic areas with many signs, cars, pedestrians, cyclists and buses	0 = *No*, 1 = *Yes*
16. Long distances	0 = *Never*, 1 = *Sometimes*, 2 = *Always*

Appendix C – SAQ Conversion Table

Conversion Table for the Situational Avoidance Questionnaire (Davis et al., 2016).

SAQ Avoidance Subscale Raw Score	Rasch Location Value	Rescaled Score
0	-4.342	0
1	-3.44	11
2	-2.771	18
3	-2.275	24
4	-1.862	29
5	-1.495	33
6	-1.158	37
7	-0.842	41
8	-0.54	45
9	-0.249	48
10	0.035	51
11	0.315	55
12	0.595	58
13	0.88	61
14	1.175	65
15	1.487	69
16	1.826	73
17	2.209	77
18	2.672	82
19	3.303	90
20	4.165	100

Appendix D – Comparison Data for Awareness Measures

List of Comparison Data used to define the Age-Based Performance Criterions on the

Prediction and Self-Evaluation Visual Analogue Scales for each Functional Task.

Task	Comparison Data
Logical Memory	Normative data (Wechsler, 2009).
Contrast Sensitivity	Data for persons aged 55 to 75 ($n = 25$) was obtained from normative data reported in Mantyjarvi and Laitinen (2000). Data for persons over the age of 75 was obtained from a comparative sample of 34 Queensland drivers (Brown, 2009; Davis, 2010).
Divided Attention	A sample comprised of Queensland drivers, 55-64: $n = 26$; 65-74: $n = 25$; 75+: $n = 20$.
Simple Reaction Time and Hazard Perception	Data published in Horswill et al. (2009), comprised of Queensland drivers, 35-55: $n = 22$; 65-74: $n = 34$; 75-84: $n = 23$.