Sustaining safety and mobility amongst older adults: The Multilevel Older Person’s Transportation and Road Safety Model

Submitted by

Yu-Ching Ides Wong

Bachelor of Behavioural Science (Hons.)

A thesis submitted for the Doctor of Philosophy

Centre for Accident Research and Road Safety – Queensland

School of Psychology and Counselling

Queensland University of Technology

2014
“Age is never so old as youth would measure it.”

The elderly population represents the fastest growing segment of the population in most developed countries. Unlike earlier cohorts of older adults that included many who were familiar with public transportation, the present cohort of seniors has a greater reliance on the private automobile as their main form of transportation. Increased physical fragility and decreased cognitive, sensory and somatic abilities associated with the aging process makes managing the safety and mobility of older drivers an increasingly critical social and public health issue. Heterogeneity in the nature, extent, and development of functional declines, and in driving behaviours within the older adult population, makes age an unreliable index of driving capacity. Given the counter-productive safety and mobility outcomes of age-based testing strategies, their continued popularity within both the legislative and public domains remains problematic. Self-regulation of driving may provide greater potential for reducing older drivers’ crash risk while maintaining their mobility and independence.

This program of research focused on investigating the driving behaviours and the self-regulatory processes of older adults. Four studies were included in the PhD research program. 1: An initial systematic review of the current older driver self-regulation literature identified the potential Socio-demographic, Driving-specific, and Psychosocial variables associated with older adults’ self-regulatory driving behaviours. 2: These factors were subsequently used to develop the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model. 3: This theoretical framework was then formally tested and respecified in a sample of older drivers (N = 282). 4: The MOTRS model was then quantitatively cross-validated in an independent sample of older drivers (N = 78). Using a two-week prospective naturalistic driving methodology, the driving behaviours of these older drivers were also examined through a combination of both self-report and objective measurements (in-vehicle GPS and accelerometry).

In Study One, existing studies on older adults’ driving related to self-regulatory behaviours were systematically reviewed. Twenty-nine studies were thoroughly examined and rated for quality based on their sample selection, comparability and outcome measures. While Socio-demographic and Driving-specific factors such as age,
gender, health conditions and mileage driven appear to predict older adults’ adoption of driving related self-regulation, research with more refined and rigorous methodology is needed to investigate older adults’ self-regulatory driving behaviours. This study also revealed a paucity of research on the Psychosocial factors involved in older adults’ adoption of self-regulatory driving behaviours.

The Multilevel Older Person’s Transportation and Road Safety (MOTRS) model was developed from information extracted from the systematic review, and from the existing literature on health behaviour change. The MOTRS model is a theoretical model that predicts older adults’ adoption of self-regulatory driving behaviours. The MOTRS model considers the driver, the environment, and the interaction between the two, through incorporating the influence of psychosocial factors such as driving related attitudes and confidence. The MOTRS model represents an advance over existing theoretical models in the older driver literature due to its ability to generate specific and testable pathways about the dynamic interactions of factors within the model.

Study two was a quantitative investigation to formally test the pathways of the proposed MOTRS model, focusing on how Socio-demographic, Driving-specific and Psychosocial factors influence older adults’ adoption of driving self-regulation. A wide range of Socio-demographic, Driving-specific and Psychosocial variables predicted older adults’ (self-report) driving self-regulation. Analyses revealed that the relationship between older adults’ driving self-regulation, socio-demographic and driving specific variables was mediated by Psychosocial factors, such as attitudes towards driving and driving confidence. Structural equation modelling was used to formally test the overall structure of the proposed model. The respecified MOTRS model accounted for 75% of variance in participants’ self-regulation (determined by self-report).

Study Three provided a quantitative re-examination of the MOTRS model and older adults’ driving behaviours using a two-week naturalistic observational study of 78 older drivers. Specific pathways of the MOTRS model were cross-validated using mediation analyses. This study also examined the self-report and objectively measured driving behaviours of older adults using a combination of self-report survey, prospective self-report diary and in-vehicle devices (GPS and recording
accelerometers). Results provided support for the application of the MOTRS model in predicting older adults’ actual driving behaviours. While older adults generally overestimate their overall driving exposure (travel duration and distance), their self-reported self-regulatory practices were in general agreement with their objectively measured driving behaviours. Objectively measured driving behaviours revealed that older drivers who reported higher self-regulation also experienced reduced driving exposure and fewer acceleration-related events. This finding provides preliminary support for the use of self-regulation in maintaining the safety and functional mobility of older adults. This study also provided support for the use of GPS and accelerometer technologies in assessing older adults’ driving behaviours.

Findings from this research program support the application of the MOTRS model in predicting older adults’ driving self-regulation. Results demonstrated that Psychosocial variables provided key contributions to understanding self-regulatory behaviours. Additionally, the results showed that environmental factors, such as availability of accessible alternative transportation options and urban density, significantly influence older adults’ practice of driving-self-regulation. General agreement between self-reported self-regulatory driving practices and objectively measured driving exposure was found. The reduced driving exposure and acceleration-related events among self-regulating older drivers provided preliminary empirical support for the use of self-regulation as a compensatory strategy to maintain older adults’ safety and mobility. A significant proportion of driving trips were for recreational, spiritual, and social purposes, suggesting more flexible alternative transportation options may be required to satisfy these mobility needs. Further work is required to explore the Psychosocial factors that underlie older drivers’ self-regulation in greater detail, and to determine whether the predictions of the MOTRS model can be applied to drivers across other cultures.

There is a need to better manage older adult safety without unnecessarily compromising their mobility and independence. This need is amplified by the rapid expansion of the older adult population internationally. This research program has advanced our current understanding of older adults’ self-regulatory behaviours by developing and testing a theoretical model that predicts older adults’ practices of self-regulation in regards to driving, an everyday activity that holds considerable personal meaning for many older adults.
Author Contribution

The PhD candidate designed the studies, with the guidance and support provided by both the principal supervisor (Associate Professor Simon Smith) and the associate supervisor (Professor Karen Sullivan). The doctorate candidate was the Principal Investigator of the external funding provided by NRMA-ACT Road Safety Trust. The doctorate candidate recruited the participants of the studies, with the infrastructural support provided by the Discipline of Pharmacy, the University of Canberra. The doctorate candidate carried out analyses of all the data. The doctorate candidate prepared the manuscript, with editorial assistance provided by both supervisors.
Acknowledgements

This research was supported by an external grant provided by the NRMA-ACT Road Safety Trust to “Better Understand the Driving Behaviours of Older Australian Drivers”, and infrastructural support provided by the Centre of Accident Research and Road Safety –Queensland and the Discipline of Pharmacy, University of Canberra. I would also like to thank the organisations that have assisted in recruiting participants for this research – University of 3rd Age, Council on the Aging, and Country Women’s Association. I acknowledge Dr. Ronald Schroeter for copy editing and proofreading advice as covered in the *Australian Standards for Editing Practice*, Standards D and E.

Foremost, I would like to express my sincere gratitude to my supervisors, Associate Professor Simon Smith, and Professor Karen Sullivan, for giving so generously of their time and expertise during this program of research. This research would not have been possible without their steadfast encouragement, attention to detail, demand for excellence, as well as their astute professional and personal guidance. They deserve more thanks then words allowed me to express.

I would also like to offer my special thanks to Professor Barry Watson, Professor Elizabeth Beattie and Professor Mark Horswill for their time and expertise in the development and completion of this research. Thanks are also due to my colleagues, whose support, camaraderie, procrastination and paperwork management strategies have been indispensable. My partner, who patiently supported, encouraged, and tolerated me in the final stages of my dissertation. Finally, my special thanks are extended to all the volunteers who provided their invaluable time, effort and goodwill as participants in the studies.
Dedication

This dissertation is dedicated to my mother, and (maternal) grandmother. First, I am deeply indebted to my mother, who taught me to follow my dreams with tenacity, and never let hardships stifle my stride. She is the most graceful, loving; yet formidable woman. I would not have achieved this without the discipline, and rigour that she has exemplified and imparted upon me. Words cannot express my gratitude for her unconditional love, support, and sacrifices.

This dissertation is also dedicated to my grandmother, or Poh Poh, as I called her in her language. She cared for my mother, and her siblings as a single mother, at a time when life was much harder for women. She is barely literate, yet she is the strongest, most compassionate, person I have ever known, and the inspiration behind this research program. She instilled in me an unshakable (at times, no doubt irritating) thirst for knowledge and its ability to transform lives since I was a little girl. She always told me “They can take everything away from you but they cannot take your education.” Her unwavering faith in me helped me through my darkest days.

It is to these extraordinary (yet, very ordinary) women in my life that I dedicate this dissertation.
## List of Abbreviations

The following abbreviations and acronyms are used within this document:

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABT</td>
<td>Age-based testing</td>
</tr>
<tr>
<td>ACT</td>
<td>Australian Capital Territory</td>
</tr>
<tr>
<td>AMD</td>
<td>Age-related Macular Degeneration</td>
</tr>
<tr>
<td>CDT</td>
<td>Clock Drawing Test</td>
</tr>
<tr>
<td>DEC model</td>
<td>Driving as Everyday Competence model</td>
</tr>
<tr>
<td>HBM</td>
<td>Health Belief Model</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>GSA</td>
<td>The Gerontological Society of America</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
</tr>
<tr>
<td>ISS</td>
<td>Injury Severity Score</td>
</tr>
<tr>
<td>MOTRS model</td>
<td>Multilevel Older Person’s Transportation and Road Safety Model</td>
</tr>
<tr>
<td>NSW</td>
<td>New South Wales</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic and Cooperation Development</td>
</tr>
<tr>
<td>PDP</td>
<td>Parallel Distributed Processing</td>
</tr>
<tr>
<td>TPB</td>
<td>Theory of Planned Behavior</td>
</tr>
<tr>
<td>TTM</td>
<td>Transtheoretical Model of Behaviour Change</td>
</tr>
<tr>
<td>UFOV</td>
<td>Useful Field of View</td>
</tr>
</tbody>
</table>
# Table of Contents

Abstract................................................................................................................................. 2

Author Contribution................................................................................................................. 5

Acknowledgements.................................................................................................................. 6

Dedication................................................................................................................................. 7

List of Abbreviations............................................................................................................... 8

Table of Contents..................................................................................................................... 9

Lit of Figures............................................................................................................................. 13

List of Tables........................................................................................................................... 15

Statement of original authorship............................................................................................. 17

Oral Presentations arising from the research program........................................................ 18

Publications arising from the research program................................................................. 19

Chapter 1: Introduction............................................................................................................. 21

  Introductory comments......................................................................................................... 21
  1.2. Study Background and Rationale .................................................................................. 21
  1.3. Purpose of the Study ..................................................................................................... 23
  1.4. Research aims and objectives....................................................................................... 24
  1.5. Demarcation of scope ................................................................................................... 24
  1.6. Structure of thesis ......................................................................................................... 25

Chapter 2: Literature Review................................................................................................. 27

  2.1. Introductory Comments............................................................................................... 27
    2.2.1. Growing Cohort of Older Drivers ........................................................................ 27
    2.2.2. Crash Risk of older adults .................................................................................... 30
    2.2.3. Types of crashes ..................................................................................................... 31
    2.2.4. Increased fragility .................................................................................................... 31
    2.2.5. Capacity to Drive .................................................................................................... 33
    2.2.6. Age-related diseases and driving capacity .......................................................... 35
    2.2.7. The heterogeneity of the older driver cohort ......................................................... 36
    2.2.8. The Gap between driving capacity and driving behaviours .................................. 37
    2.2.9. Driver Style: The other component of driving ...................................................... 38
    2.3. Current Older Driver Safety Strategies...................................................................... 40
      2.3.1. Mandatory restrictions ....................................................................................... 41
      2.3.2. License restrictions .............................................................................................. 51
    2.4. Self-regulation as Alternative Older Driver Safety Strategy ..................................... 54
      2.4.1. Proportion of older drivers who self-regulate ...................................................... 55
      2.4.2. Self-regulation to Extending Mobility .................................................................. 56
      2.4.3. Application of Self-regulation in Health Promotional Context ............................ 57
      2.4.4. Effectiveness of Self-regulation .......................................................................... 58
      2.4.5. Problems with current self-regulatory usage ...................................................... 59
      2.4.6. Summary of self-regulation ................................................................................. 60
    2.5. Research Questions ...................................................................................................... 61
    2.6. Chapter summary ......................................................................................................... 63

Chapter 3: Study 1A – Systematic Review of Self-regulation of Older Drivers.................. 65

  3.1. Introductory comments ............................................................................................... 65
9.2.4. Research Question 4: How can we improve older adults’ practice of driving-related self-regulation? ................................................................. 235

9.3. Contributions to research ........................................................................ 238
9.4. Practical implications of the research program ........................................ 240
9.5. Strengths of the research program .............................................................. 242
9.6. Limitations of the current research program ............................................. 244
9.7. Suggestions for future research ................................................................. 246
9.8. Concluding comments ............................................................................. 248

10. References ................................................................................................. 251

Appendix A: Questionnaire for Study Two and Three ................................. 273
Appendix B: Participant Information Sheet for Study Three ....................... 283
Appendix C: Recruitment Flyer for Study Three .......................................... 287
Appendix D: Driving Diary for Study Three .................................................. 288
Appendix E: Checklist for Equipment Fitting Sessions (Study Three) .......... 297
Appendix F: Sub-study on the Relationship between Cognitive Impairment and Self-regulation .................................................................. 300
List of Figures

Figure 1: Percentage of the population aged 65 and over, 2000-50...............................28
Figure 2: Number and percentage of drivers aged 65 or more in Queensland, 2004-12.................................................................29
Figure 3: Framework for older adults’ transportation and safe mobility (Dickerson et al., 2007)........................................................................................................................................40
Figure 4: Michon’s Hierarchical Driver Behavior Model (Michon, 1985).................86
Figure 5: The Multifactorial model of Older Driver Safety (Anstey et al., 2005).............................................................................87
Figure 6: The Driving as Everyday Competence (DEC) model (Lindstrom-Forneri et al., 2007) .................................................................88
Figure 7: The Simplified version of the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model........................90
Figure 8: Example of the excitatory and inhibitory activation network of MOTRS. Red arrows represent excitatory (i.e. positive) activation; blue arrows represent inhibitory (i.e. negative) activation........................................93
Figure 9: The Multilevel Older Person’s Transportation and Road Safety (MOTRS) model..................................................................................................................................104
Figure 10: Hypothesized overall structure of the MOTRS model..............................108
Figure 11: A fully mediated model of self-regulation .................................................155
Figure 12: Model 2 - a partial mediated model of self-regulation..............................156
Figure 13: Structural model of Model 1 - fully mediating model of self-regulation................................................................................161
Figure 14: Re-specified partially mediating model of self-regulation (Model 2)......................................................................................163
Figure 15: Recording accelerometry devices in the trunk of the instrumented vehicle in Classen et al. (2006)........................................174
Figure 16: Hypothesis 1 - partial mediation between driving space and self-regulation.............................................................................175
Figure 17: Hypothesis 2 - partial mediation between health and self-regulation..............................................................................176
Figure 18: Hypothesis 3 - complete mediation between driving performance and self-regulation........................................................................176
Figure 19: Hypothesis 4 - complete mediation between dependency on other driver and attitudes towards driving.................................177
Figure 20: Hypothesis 5 - partial mediation between attitude towards driving and driving confidence................................................................................177
Figure 21: Hypothesis 6 - partial mediation between gender and self-regulation.................................................................................178
Figure 22: Hypothesis 7 - complete mediation between alternative transportation usage and self-regulation........................................178
Figure 23: GPS Trackstick used in the current study...................................................183
Figure 24: Braking time under various speeds at 0.45g and 0.35g...........................184
Figure 25: Hypothesis 1 - partial mediation between driving space and self-regulation...........................................................................194
Figure 26: Hypothesis 2 - partial mediation between health and self-regulation......................................................................................195
Figure 27: Hypothesis 3 - complete mediation between driving performance and self-regulation ................................................................. 195
Figure 28: Hypothesis 4 - complete mediation between dependency on other driver and attitudes towards driving ................................................. 196
Figure 29: Hypothesis 5 - partial mediation between driving confidence and self-regulation ........................................................................ 197
Figure 30: Hypothesis 6 - mediation of gender and self-regulation ................. 197
Figure 31: Hypothesis 7 - complete mediation between alternative transportation usage and self-regulation .................................................. 198
Figure 32: Bland-Altman plot of self-reported and GPS duration (hr) ......... 213
Figure 33: Bland-Altman plot of GPS and diary recorded duration (hr) ......... 214
Figure 34: Bland-Altman plot of GPS and diary recorded number of trips ....... 215
List of Tables

Table 1: Age-based testing (ABT) requirements within the United States of America as at April, 2013 ................................................................. 43
Table 2: The licensing requirements for older drivers adopted by different Australian jurisdictions ............................................................. 48
Table 3: Frequency distribution of NOS scores of studies (N = 29) ...................... 69
Table 4: Summary of Studies Using Self-Report Self-regulation as Outcome Measure ........................................................................................................ 71
Table 5: Summary of Studies Using Objective Self-regulation as Outcome Measure ........................................................................................................ 74
Table 6: Summary of Self-regulation Studies Using Qualitative Methodologies ........................................................................................................... 75
Table 7: Equivalence tests and mean differences statistics for the Postal and Internet sample ........................................................................................ 121
Table 8: Sample characteristics (N = 273), and separate descriptives for female (n = 171) and male (n = 102) older drivers ........................................ 123
Table 9: Participants’ driving characteristics (N= 273), and separate descriptive statistics for female (n = 171) and male (n = 102) older drivers ........................................................................................................ 125
Table 10: Participants’ driving confidence (5 = most confident), and separate descriptive statistics for female (n = 171) and male (n = 102) older drivers ........................................................................................................ 128
Table 11: Participants’ driving avoidance (1 = least avoid), and separate descriptives for female (n = 171) and male (n = 102) older drivers .......... 130
Table 12: Descriptives and standard multiple regression of subscale scores of participants Attitudes and Beliefs towards driving (5 = strongly agree) in predicting intention to drive ................................................................. 132
Table 13: Scale characteristics (N = 273), and separate descriptive statistics for female (n = 171) and male (n = 102) older drivers ......................... 133
Table 14: Bivariate correlations for demographic and driving exposure variables and self-reported self-regulation .................................................. 135
Table 15: Bivariate correlations between psychosocial variables and mean driving avoidance .................................................................................. 136
Table 16: Bivariate correlations (Pearson’s r) between all key variables .......... 137
Table 17: Hierarchical Multiple Regression results of socio-demographic, driving exposure and psychosocial variables on self-regulation .............. 140
Table 18: Comparative fit measures for both MOTRS models ................................ 164
Table 19: Reasons for withdrawal from study ................................................... 179
Table 20: Comparison of age and gender between sampled participants and active license holders of the Australian Capital Territory of the year 2012 ................................................................. 180
Table 21: Equivalence tests and mean differences statistics for the Study Two and Study Three sample ........................................................................ 189
Table 22: Participants’ sample characteristics .................................................................................................................................................. 190
Table 23: Participants’ driving-related characteristics ........................................ 192
Table 24: Time of day of driving trips .................................................................. 208
Table 25: Percentages of driving duration by driving purpose .......................... 209
Table 26: Bivariate correlations between GPS measured driving parameters and key variables of the MOTRS model

Table 27: Correlations of travel time obtained from questionnaires, diaries and GPS units

Table 28: Time of day of driving: self-report versus objective record

Table 29: Bivariate correlations (Pearson’s r) between longitudinal and lateral accelerations

Table 30: Bivariate correlations (Pearson’s r) between accelerations and driving exposure variables

Table 31: Bivariate correlations (Pearson’s r) between accelerations and self-reported socio-demographic and driving exposure variables (n = 30)
Statement of original authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge, this thesis contains no material previously published or written by another person except where due reference is made.

Name: Yu- Ching Ides Wong

Signature: QUT Verified Signature

Date: April 2014
Oral Presentations arising from the research program


Publications arising from the research program


Chapter 1: Introduction

Introductory comments

This chapter presents the background, rationale and structure of the current research program. In an effort to better manage older driver safety without significantly limiting their functional mobility, this program of research investigated the self-regulatory behaviours of older Australian adults. Following the ineffectiveness of current strategies such as mandatory Age-Based Testing (Langford et al., 2008), increased attention has been directed towards identifying more flexible and multifaceted strategies to manage older driver safety. One such strategy that has received emerging public, legislative and empirical support is that of self-regulation. Self-regulation is a type of compensatory strategy often employed by older drivers\(^1\) in response to progressive functional declines. It is defined in the current research program as deliberate, a-priori self-restriction strategies intended to reduce exposure to potentially harmful driving conditions. This research program examined the factors that contribute to older drivers’ adoption of self-regulation. The background, and rationale, aims, scope and overall structure of this research program is outlined in the remainder of this chapter.

1.2. Study Background and Rationale

With increased medical care and sustained low birth rates, the elderly population represents the fastest growing segment of the population in most developed countries. According to Cosgrove (2011), private vehicle transportation is responsible for close to 90 per cent of current urban travel across Australian capital cities. With the aging of the babyboomers, a generation that has historically relied heavily upon private vehicles as major mode of transportation, managing the travel needs of the rapidly expanding older driver cohort has become an increasingly critical social and public health issue.

Crash statistics typically demonstrate that, when compared to road users of other age groups (with the exception of novice drivers), the crash risk and fatality

\(^1\) For the purpose of this research program, “older drivers” is defined as older adults (above 65 years of age) who operate private vehicles, mainly for personal automobile.
rates of older drivers tend to be higher per licence, population or distance driven. While debate exists regarding the role of low mileage bias in the overrepresentation of older drivers in crash statistics, the increased physical fragility of older adults places them at disproportionate risk of sustaining more serious crash-related injuries. For instance, compared to younger drivers, hospital records report older drivers to be more likely to have longer hospital stays, more likely to be admitted to the Intensive Care Unit and more likely to be discharged to facilities other than their home (e.g. skilled nursing facilities and extended care facilities).

Normal aging is associated with increased functional and sensory declines. These declines in functional abilities have been correlated with increased deficits in driving performance. Specifically, decreases in visual and cognitive performance have been consistently identified as important predictors of performance on a range of driving-related tasks, with generally moderate effect sizes. The relationships between these functional abilities and driving performance, however, typically decrease significantly when other outcome measures are used, such as on-road driving performances and crash statistics. The difficulty in accurately and reliably predicting older adults’ driving performances on more ecologically valid measures resulted in the lack of consensus in regards to the appropriate fitness-to-drive assessments.

Currently the most commonly used older driver safety strategy, Age-Based-testing (ABT), typically requires older drivers of a certain age to undergo mandatory testing, in the form of general medical certificate, visual, cognitive or on-road test (or a combination of these assessments). Empirical evidence has consistently demonstrated ABT strategies to be ineffective in reducing the crash risks of older drivers and other road users. Further, emerging evidence suggests that ABT may contribute to counterproductive safety and mobility outcomes by 1) deterring more safety-conscious older drivers from renewing their licenses, and 2) discouraging self-monitoring through the provision of tests that are promoted as predictive of older drivers’ driving performance.

In response to the ineffectiveness of ABT, increased attention has been directed towards identifying alternative, more flexible, strategies that address the homogeneity of abilities and transportation needs of older drivers. Self-regulation is a compensatory strategy that holds the potential to improve older driver safety while
maintaining their functional mobility. Self-regulation typically refers to the practices that some older drivers adopt to adjust, or restrict, their driving to certain times and conditions to which they feel more confident.

Self-regulation of driving is a compensatory strategy that has been recommended by road authorities to maintain older driver safety; however, the use of this strategy has not been rigorously investigated. Despite its promotion by road authorities as a strategy that may enhance the safety of older adults, previous studies demonstrate that older adults’ adoption of self-regulatory driving practices is not related to their driving abilities. In order to maximise the safety benefits of self-regulation, it is important to determine the factors that influence older adults’ decisions to self-regulate, and the potential barriers that might prevent its use. Such research would identify underlying factors and barriers behind older adults’ decisions to self-regulate, and possible approaches to consider when promoting the use of self-regulation among this population.

1.3. Purpose of the Study

This program of research fills a significant knowledge gap in the current transportation and aging literature regarding the self-regulatory driving practices of older adults. Due to the lack of rigorous investigations and theoretically based developments in this area, this research program had two primary purposes. The first of these purposes was to better understand the self-regulatory driving practices of older drivers, and the factors that motivate (and inhibit) their decisions to self-regulate, with a focus on the Psychosocial variables that underlie these decisions. The second purpose was to develop, and evaluate, a theoretical model that accounts for their self-regulatory driving practices.

The ultimate aim of the current research program was to maximise the safety of self-regulatory driving through formally testing its use among a cohort of older Australian drivers. This knowledge is important to discover new ways of improving older driver safety so that functional mobility can be sustained to achieve active and healthy aging.
1.4. Research aims and objectives

Considering the two interrelated purposes of this program of research, there were four primary aims:

1) Identify the factors, the relative saliency of these factors, and the underlying processes, that influence older drivers’ adoption of self-regulation;

2) Develop a comprehensive, formally testable theoretical framework that predicts older drivers’ adoption of self-regulation;

3) Examine the potential differences between self-report and objectively measured driving behaviours, and examine the developed framework against objectively measured behaviours;

4) Contribute to existing knowledge regarding development of interventions that facilitate safe driving practices among older drivers

These aims and objectives were addressed through four research questions, detailed following the literature review in the next chapter. These research questions were based on gaps in the existing literature and formed the foundation of this program of research.

1.5. Demarcation of scope

The current research program adopted an overarching psychological approach to better understanding older adults’ driving behaviours. While other emerging domains, such as smart car technologies, may also contribute to older adult safety and mobility (see Molnar, Eby & Miller, 2003, for an overview), the acceptance and adoption of such technologies remains dependent upon individual decisions. Knowledge on the processes that underlie older adults’ adoption of driving-related self-regulation may also assist in better understanding their decisions to adopt future driving-related compensatory strategies, such as using smart car technologies.

Physical and sensory abilities were measured using the proxy measure of self-reported measures. While it is acknowledged that these are crude measures of actual
physical and sensory abilities, financial and regulatory constraints prevented the use of objective tests. Measures of self-reported physical and sensory abilities have been commonly used within the older driver literature, and have consistently demonstrated to be significant predictors of objectively measured abilities (e.g. Sims et al., 2007; Tuokko et al., 2007).

Due to financial and other practical constraints, the data collection sites established in this program of research were within Australia. Specifically, the survey data was collected as a nation-wide survey, with participants from all jurisdictions within Australia. The ambulatory assessment study was collected within the state of Australia Capital Territory (ACT), Australia. ACT was selected as the data collection site for this part of the program of research for a number of reasons, primarily funding agreement and for improved control of confounds. In terms of funding agreement, the funding that was provided for the necessary equipment for this study stipulated data collection sites to be within the ACT regions of Australia. In terms of control of confounds, testing within one jurisdiction would allow greater control over environmental confounds such as driving conditions (e.g. road conditions, ABT requirements, enforcement levels and traffic density).

1.6. Structure of thesis

The current dissertation contains nine chapters. Chapter 1 presents the background, rationale, aims and objectives, and the brief outlines of this thesis. Chapter 2 contains a comprehensive review of the older driver safety literature, including current strategies that are used to manage older driver safety and identify gaps in the existing literature and relevant research questions. Chapters 3 to 8 provide the four studies of this program of research, developed to address the above identified aims and objectives. Each of these chapters outlines the background, aims and objectives, methods, results and a brief discussion for the four studies. How each study address the research questions will also be addressed within these chapters.

The first study of this program of research, contained in Chapter 3, is a systematic review of the current literature on older drivers’ self-regulation, investigating the proportion of older drivers’ who self-regulation and the factors that contribute to their use of self regulation. The second study, Chapter 4, documents the
development of a theoretical model that accounts for older drivers’ adoption of self-regulation based on information generated from the systematic review. Chapter 5 and 6 present the third study, a large quantitative examination and refinement of the developed model of self-regulation. Chapter 7 presents the fourth study of this program, an investigation of the objectively measured driving behaviours of a group of older drivers within the Australian Capital Territory and the congruency between self-reported self-regulation and objectively measured driving behaviours. The results of this study are presented over two chapters. Chapter 7 presents the cross validation of the proposed theoretical older driver self-regulation model. Chapter 8 focuses on the objectively measured behaviours of these drivers and whether the developed theoretical model accounts for their objectively measured driving behaviours as well as their self-reported self-regulation. Finally, Chapter 9 documents the integration of findings from each studies, strengths and limitations of the research, as well as theoretical and practical implications of these findings.
Chapter 2: Literature Review

2.1. Introductory Comments

This chapter provides a more detailed explanation of the background of the research topic. The literature review contained in this chapter addresses the importance of, and provides an explanation of, the key issues of older driver safety, with a specific focus on the current strategies used to manage older driver safety and the potential use of self-regulation in managing older driver safety.

The second section of the literature review provides an overview of the current strategies applied to improve older driver safety, and evaluates the effectiveness of these strategies. The third and final section of the literature review presents the effectiveness and mobility impacts of self-regulation strategies. This section concludes with a review of existing models of driving among older adults.

2.2.1. Growing Cohort of Older Drivers.

The older driver population (65 years and over) represents a rapid growing segment of the population in many developed countries (Organisation for Economic Co-operation and Development, OECD, 2001; 2009). This demographic change has been associated with sustained low birth rates and increased life expectancy. Globally, the population aged 65 years and over is predicted to double to 16.2% of the world population by 2050 (see Figure 1; OECD, 2001). The growth of the older driver population in Australia, already evident in the current population structure, is expected to continue on its current trajectory (OECD, 2009, 2012; ABS, 2008). In 2007, 13% of Australia’s population were people aged 65 years and over (ABS, 2008). This proportion is predicted to increase to approximately 25% of the overall Australian population in 2056 (ABS, 2008). See Figure 1 for the projected proportion of the population aged 65 years and over.
The growth in the older adult population is predicted to be most pronounced in the 85-years and above age group, with the proportion of people in the ‘old-old’ generation expected to become a more prominent sector of the overall population. According to the Australian Bureau of Statistics (2008), the number of people aged 85 years or more is estimated to increase from 1.6% of the population (in 2007) to 7.3% by 2056. Many European countries are expected to experience rapid increase in this segment of the population. The marked increase in the elderly population makes the old-old (i.e. 85 years and over) an increasingly prominent segment of the overall population.

With improved medical care and increased emphasis on personal mobility, older adults are also keeping their licences longer than had previous generations (Lyman, Ferguson, Braver, & Williams, 2002). As a result, many developed countries are expected to experience a dramatic increase in both the absolute number and the relative proportion of older drivers. In Queensland, licensed drivers aged 60 years or over increased from 16.6% (n = 400 055) in 2001 to 20.9% (n = 689 647) in 2011 (Department of Transport and Main Roads, 2011). See Figure 2 for numbers and
percentages of older drivers in 2004 to 2012.

![Figure 2: Number and percentage of drivers aged 65 or more in Queensland, 2004-12](image.png)

Unlike earlier cohorts of older drivers that included many who were familiar with public transportation, the present cohort of older drivers has a greater reliance on automobile as their main form of transportation. Not surprisingly, private automobile is by far the most preferred and used mode of transportation for current older drivers (Buys, Snow, van Megen & Miller, 2012; Glasgow, 2000; Kostyniuk & Shope, 2003; Vine & Buys, 2010). For example, a recent study of older Australians’ travel patterns reported automobile being responsible for 87.6% of the total number of hours spent on all trips over the one-week tracking period (Buys et al., 2012).

Based on licensing statistics provided in response to an Organisation for Economic Cooperation and Development (OECD) survey in 2000, the proportion of licensed drivers aged 65 and over is expected to increase across all 11 OECD member countries. Over the next two decades, the maturation of the “babyboomers” (those born between 1946 and 1964), combined with increased life expectancy and decreased birth rates, is expected to markedly increase the number and proportion of older drivers on the road. These trends indicate an impending demographic change,
particularly among developed countries such as Australia and United States of America, and a rapid increase in travel needs by older adults in the future.

2.2.2. Crash Risk of older adults

Crash statistics historically show that, when compared to road users of other age groups (with the exception of novice drivers), the crash risk and fatality rates of older drivers tend to be higher per licence, population or distance driven (Cerelli, 1995; Fildes, 2005; Holland, 2002; McGwin & Brown, 1999; McKnight & McKnight, 1999; Retchin & Anapolle, 1993; Stutts & Martell, 1992). However, more recent research argues that the increased crash rate per distance driven may have been exaggerated due to the “low mileage bias”\(^2\), that is, the increased crash risk is dominated by the subset of low mileage older drivers (<3000km per year), and that older adults who drive more than this have crash rates that are similar to other aged drivers (Hakamies-Blomqvist, Siren & Davidse, 2004; Langford, Fitzharries, Newstead, & Koppel, 2004; Langford, Methorst, & Hakamies-Blomqvist, 2006). Thus, the increased crash rate experienced by older drivers could be inflated due to the lower annual mileage driven, and older drivers as a population, may not have a higher crash rate (Langford, Methorst & Hakamies-Blomqvist, 2006).

In a study of low mileage bias of older drivers, Langford et al. (2006) reported that the crash rates were elevated only for those older drivers who drove less than 3000km per year. These low mileage drivers (< 3000km per year) represented just over 10% of the older drivers within their sample (\(n = 800\); Langford et al., 2006), suggesting that the majority of the older driver cohort may be just as safe as the general driving population. While the low mileage bias on crash risk has been replicated using data from several countries (e.g. Hakamies-Blomqvist et al., 2002 using Finnish data; Langford et al., 2006 using Dutch data; Fierro, 2008, using Spanish data), mileage data (and most crash data) were based solely on self-reported information. It is widely recognised that self-reported information is prone to problems associated with memory recall and other participant biases such as self-desirability and optimism bias (e.g. Lajunen & Summala, 2003; Paulus & Reid, 1991).

\(^2\) While the majority of distance-travelled studies assess driving distance under the metric system (i.e. km or hr per year), the term of low mileage bias remained in use to describe this phenomenon.
Indeed, annual self-report mileage estimates yield poor test-retest reliability and inter-method reliability when comparing weekly versus annual mileage estimates, and when comparing self-report versus objective measures of driving distances (Blanchard & Myers, 2010; Staplin, Gish, & Joyce, 2008). Staplin et al. (2008) found low mileage older drivers (as measured by odometer readings) tend to yield large underestimation of annual mileage drive, while high (objectively measured) mileage drivers tend to overestimate their annual mileage. In light of these findings, Langford Bohensky, Kpppel and Newstead (2008) reanalysed their data (from Langford et al. 2006) based on Staplin’s findings, rather than self-reported mileage. Reference to odometer readings yielded a reduced magnitude in low mileage bias, however, Langford et al. (2008) found that the mileage/crash associations remained evident. In other words, low-mileage older drivers are still at greater crash risk than their higher-mileage counterparts. Staplin et al.’s study has underscored a problem with drawing conclusions based on self-reported data, and identifies a critical need to use objective travel data in to establish older drivers’ driving behaviours.

2.2.3. Types of crashes

The types of crashes that older drivers are involved in are typically qualitatively different to that of drivers from younger age groups. Compared to younger drivers, older drivers are less likely to be involved in single vehicle crashes, especially crashes due to speeding, risky overtaking or driving under the influence of alcohol. In contrast, older drivers are more likely to report vehicle-to-vehicle collisions, especially at intersections and in circumstances where the older driver is attempting to turn across oncoming traffic (e.g. Dulisse, 1997; Hakamies-Blomqvist, 1998, 2004; Hauer, 1988; Kostyniuk, Eby & Miller, 2003). Successfully negotiating through an intersection requires the simultaneous combination of a range of sensory and cognitive skills and abilities. Thus, negotiating an intersection represents a ‘testing of the limits’ type task for older drivers (European Road Safety Observatory, 2006).

2.2.4. Increased fragility

While debate continues as to whether the increased crash risk reported can be completely accounted for by the low mileage bias, the increased physical fragility of
older adults places them at a disproportionate risk of serious injury. Due to reductions in bone strength and fracture tolerance, older adults are significantly more likely to sustain serious injuries or death as a result of crash (e.g. Dejeammes & Ramet, 1996; Evans, 2001; Mackay, 1998; McGwin, Sims, Pulley, & Roseman, 2000; McKnight & McKnight, 1999; Padmanaban, 2001; Evans, 1991; Ulfarsson & Mannering, 2004; Viano et al., 1990). Using multiple data sources from the United States of America, Li, Braver and Chen (2003) reported that, when compared to drivers aged 30-59, those who are 70-74 years of age were twice as likely to die as a result of crash. Drivers aged 80 years and over were about five times more likely than their 30-59 year old counterparts to die from crashes. Using Australian fatal crash data, a more recent study by Langford and Koppel (2006) demonstrated similar mortality patterns. Older drivers are also more likely to die from injuries incurred as a result of the crash at a later time-point; hospital records obtained from the Boston Medical Center Trauma Registry revealed that once admitted, older drivers had a mortality rate of 17.1%, compared to 2.6% among all younger drivers in the registry (Bauzer et al., 2008). This finding implies the current mortality data underestimates the number of older drivers who die from motor vehicle crashes.

Besides higher mortality rates, hospital records in both Australia and the U.S.A. show that older drivers are more likely to record longer hospital stays, higher Injury Severity Score (ISS)\(^3\), increased likelihood of being admitted to the Intensive Care Unit (ICU) and longer length of stay within the ICU, less likelihood of being discharged directly home when compared to drivers of other age groups (Bauza Lamorte, Burke & Hirsch, 2008; Meuleners et al., 2006; Salen, Kellmell, Baumgratz et al., 2003). Given the lowered bone strength due to increased prevalence in osteoporosis, older drivers recorded significant increases in fractures of the extremities from crashing (Bauza et al., 2008). Older drivers also demonstrated much higher likelihood in sustaining a range of more serious injuries including intracranial haemorrhage, spinal cord injuries and serious injuries to the thorax, contributing to their high mortality rate discussed above (Bauza et al., 2008).

\(^3\) ISS is an anatomical score to assess trauma severity, and ranges from 0 to 75, with 75 equates to “unsurvivable”. An ISS score greater than 15 is indicated as a major trauma (or polytrauma). Scores above 25 indicate severe injury.
Road trauma involving older adult has been estimated to cost the community over AUD $300 million per year in one Australian state alone (Victorian Parliament, 2003). Given the projected increase in both number and proportion of older drivers, their increased reliance upon driving as their main mode of transportation, and their increased likelihood of sustaining serious crash-related injury, managing older driver safety has become an increasingly prevalent social and public health issue.

### 2.2.5. Capacity to Drive

Accurately identifying predictors of older adults’ capacity to drive safely has long been seen as a route to reducing their crash risk. To date, much of the existing older driver literature has been directed towards identifying factors that contribute to older adults’ driving capacity. Driving capacity is defined as the ability of older drivers to drive safely (Anstey et al., 2005). While identifying predictors of driving capacity is outside the scope of the current program of research, capacity to drive is an integral part of older driver safety, and understanding the issues in identifying predictors of driving capacity informs the rationale of the current research. Thus, the following section briefly outlines the state of the current literature on factors that predict older adults’ capacity to drive.

It is generally accepted that due to the process of normal ageing, older adults can experience increased sensory and cognitive declines. For example, normal ageing is frequently associated with changes in visual functions that lead to increase in glare sensitivity, reductions in visual acuity and contrast sensitivity (Haegerstrom-Portnoy, Schneck & Brabyn, 1999). Given the commonly held belief that vision is the major sensory input for driving, the effects of visual impairments on older adults’ driving performance have been widely investigated (see Anstey et al., 2005; and Owsley & McGwin, 1999, for reviews). These studies generally demonstrate that while static visual acuity is a poor predictor of older adults’ driving performance, other visual abilities such as visual field loss, in particular visual attention, have shown more promise to be important predictors of older drivers’ performance (Cross, McGwin et al., 2009; Johnson & Wilkinson, 2010; Roge, Otmani, Pebayle & Muzet., 2008).

In terms of cognitive abilities, cognitive-ageing studies consistently report that older adults demonstrate general decline in performance in cognitive tasks,
particularly in tasks that exert high demand upon executive functions or require fast processing speed (Bryan & Luszcz; 2000; Salthouse; 2010). Driving in traffic is a complex task that requires efficient and simultaneous processing of relevant information, rejection of irrelevant information, timely decision making and adequate response times to avoid collisions. Thus, speed of information processing, adequate reaction times, and executive function performance have each been hypothesized as necessary for competent driving. Indeed, declines in these cognitive abilities have been associated with deficits in a range of driving-related tasks, including simulated and on-road driving performance (Daigneault, Joly & Frigon, 2002; De Raedt & Ponjaert-Kristoffersen, 2000; Hu et al., 1998; Maratolli & Richardson, 2005; McKnight & McKnight, 1999; Odenheimer et al., 1994; Stutts, Stewart & Martell, 1998). Overall, low to moderate correlations have been reported between different measures of cognitive performance and driving outcomes measures, with Useful Field Of View (UFOV, a measure of visual attention) reporting moderate associations with older drivers’ crash risk (Owsley, Ball et al., 1998; Owsley, McGwin, Chapman & Owsley, 1998; Sims et al., 2000).

Besides cognitive and visual abilities, other physical and sensory factors such as hearing impairments, heart disease, neck and trunk rotation, arthritis and medication usage have each been investigated as a potential contributor to older adults’ capacity to drive (Hickson, Wood, Chaparro, Lacherez, & Marszalek, 2010; Ivers, Mitchell & Cumming, 1999; Leveille et al., 1994; McGwin, Sims, Pulley, & Roseman, 2000; Ray, Thapa, & Shorr, 1993). However, associations between these presumed risk factors and driving outcome measures remain inconsistent, with many studies failing to replicate the association between physical conditions and driving performance (e.g. Margolis et al., 2002; Marotolli et al., 1998; Owsley et al., 2001; Sims et al., 1998, 2000).

The direction of causality between these factors, reduced driving exposure, increased fragility, driving performance and crash risk has been difficult to establish. An example of how apparent risk factors might interact follows. Older drivers with health impairments may report subsequent reduced driving exposure. As highlighted above, those who drive less distance per year have been demonstrated to have significantly higher crash rate due to the “low mileage bias”. Further, drivers, particularly older drivers, are less likely to report a crash if no serious injuries was
caused (Anstey et al., 2009; Marratoli et al., 1997). Presumably, drivers with existing health and medical conditions would be more likely to incur injury following crashes. Thus, the resulting increased in crash risk among older adults with medical conditions might be due to their increased fragility, rather than reduced driving performance. It remains unclear whether the elevated crash risk of drivers with health conditions is due to their reduced functional abilities, increased fragility or to their reduced driving exposure. This example illustrates how apparently simple risk factors interact with each other to influence older drivers’ crash risk. Given the difficulties in identifying the underlying factors, and quantifying the degree to which these factors contribute to older drivers’ driving skills, researchers have yet to develop screening assessments that can feasibly and reliably identify at-risk older drivers with high sensitivity and specificity (Antin et al., 2012).

2.2.6. Age-related diseases and driving capacity

Normal age-related changes aside, older populations also exhibit increased prevalence in degenerative neurological disorders (e.g. Alzheimer’s disease or Parkinson’s disease), ocular diseases (e.g. cataract, glaucoma and other age-related maculopathy), and other pathologies that may influence sensory, somatic and cognitive functions. Cognitive pathologies such as dementia are associated with deficits in driving performance (e.g. Gorrie et al., 2007; Ott et al., 2010). For instance, Tuokko, Tallman, Beattie, Cooper, and Weir (1995) found that older drivers with dementia had about 2.5 times more traffic crashes than a matched non-demented control group. Using caregiver-reported crashes, individuals with dementia had 2.5-8 times greater risk of crash compared to healthy controls (Man-Son-Hing, Marshall, Molnar, & Wilson, 2007).

Similarly, many questionnaire-based studies have shown that older adults with age-related macular degeneration (AMD) often report greater driving-related difficulty than do visually unimpaired older drivers (see Owsley & McGwin, 2008, for a review). Simulated driving or controlled driving studies have demonstrated that AMD can be associated with deficits in driving performance, in terms of longer braking latencies, slower speed, lane deviation and response to simulated accidents (Szlek et al., 1995), and worse closed-road driving performance (Wood, Mallon & Kerry, 2001). Other common age-related visual impairments (e.g. cataracts) have also
been found to be associated with degraded driving performance, especially night-time driving performance (Owsley & McGwin, 2008; Rubin et al., 2007; Wood et al., 2001; 2010).

It is important to acknowledge that rather than having sudden, acute and noticeable onset of symptoms, the course of functional impairment in both age-related ocular diseases and neurological disorders are typically gradual (Man-Son-Hing et al., 2007; Owsley & McGwin, 2008). Consequently, the early stages of these pathologies are often undetected (Sims et al., 2000). Thus, a significant number of senior drivers with incipient visual or cognitive pathologies may continue to drive (e.g. Adler & Kuskowski, 2003; Ross et al., 2009). Hopkins et al. (2004) estimated that in the U.S., approximately 34,000 older adults with dementia continued to drive in 2000, with a projected increase to 100,000 in 2028.

2.2.7. The heterogeneity of the older driver cohort

It is vital to consider the heterogeneity of the older driver cohort, with considerable inter-individual variability in performance and health measures, even at older ages (Anstey, Horswill et al., 2012; Hayden et al., 2011; Janke, 1994; Waller, 1992). While there is general consensus within the research literature that chronological age is not predictive of crash rates per exposure (Fontaine, 2003; Hakamies-Blomqvist et al., 2002; Keall & Frith, 2006; Langford et al., 2006), the prevalence of health and medical conditions, and the medications used to treat these conditions increases with age. The effects of aging often manifest differently between individuals. Not all older adults experience the medical conditions and functional declines discussed above. Further, the processes of diagnosis and treatment of these conditions are generally different. The functional consequences of health and medical conditions experienced within this cohort are also heterogeneous (Owsley & McGwin, 2008).

Besides variation in functional abilities, older adults also present with a diverse range in driving behaviours and transport needs. Both self-reported and objectively measured driving exposure data reveal that they differ greatly in driving behaviours and practices (e.g. Langford et al., 2006; Blanchard & Myers, 2010). The evident variability between individuals in the manifestations and the development of
functional declines, and in driving behaviours and practices, make age an unreliable index of driving capacity.

2.2.8. The Gap between driving capacity and driving behaviours

Given that cognitive and visual functions have been consistently reported to be significant contributors to driving performance (e.g. Bedard et al., 2006; Hoffman, McDowd, Atchley & Dubinsky, 2005; McGwin, Chapman & Owsley, 2000; Owsley et al., 1998; Owsley & McGwin, 1999; Richardson and Marottoli, 2003; Wood et al., 2001), age-related declines in these functions have been perceived by many to have serious implications for older driver safety. While the correlation between various measures of cognition and driving outcome measures (crashes or on-road test) are low to moderate in effect sizes, associations between visual functions and driving outcome measures (e.g. simulated driving) are generally inconsistent (e.g. Ivers et al., 1999; Margolis, 2002; Maratolli et al., 1998; Owsley et al., 2001; Sims et al., 2000).

The diversity of measures used in assessing functional abilities (e.g. Blessed, UFOV, Trail Making Test; MOMSSE) and the shared variance of these measures make it difficult to isolate and identify which factors, and to what extent these factors, contribute to older drivers’ driving performance. Similarly, the wide range of driving outcome measures used (e.g. response time tasks, Hazard Perception Test, simulated driving, on-road driving, self-reported retrospective and prospective crashes, self-reported accidents and state crash records) make it difficult to accurately estimate the extent to which these functional abilities contribute to older driver safety.

Studies using other outcome measures such as state crash records have reported inconsistent outcomes (e.g. Margolis et al., 2002; Sims et al., 2000). The infrequent occurrence of crashes makes it difficult to identify any meaningful associations between presumed risk factors and on-road outcomes. Further, official crash records typically do not take into consideration ‘near misses’ and less serious motor vehicle crashes – crashes that result in less serious injuries or involve costs below a certain threshold may not even be recorded by police (Anstey, Wood et al., 2007). While assessment of on-road driving performances appears to increase the external validity of studies that use those methods, these approaches also differ in their reliability and validity, depending on experimental and extraneous factors such
as the road conditions, instructor/experimenter, vehicles used and length of driving times. Thus, there is currently no consistent methodology used in either on-road or simulator studies.

A major limitation of the body of older adults’ capacity to drive literature is that few studies consider the importance of driving exposure on older adults’ driving behaviours and overall safety. While driving exposure has been traditionally quantitatively defined as overall distance per year (see low mileage bias), qualitative characteristics such as the timing and nature of driving has been shown to alter crash risk, especially amongst older drivers. Thus, the current program of study defines driving exposure in both quantitative (distance per year) and qualitative (driving times and nature of driving) terms.

Consideration of driving exposure is important as older drivers typically alter their driving behaviours and reduce their driving exposure due to lifestyle changes, and in recognition of changes to functional and sensory abilities (e.g. Charlton et al., 2006). Ignoring the influence of exposure may lead to inaccurate estimates of the impacts these functional impairments have on older drivers’ crash risk. Additionally, it is possible that some risk factors (e.g. decreased glare sensitivity) are only accurate predictors of those who continue to drive under certain road conditions (i.e. conditions of high glare), contributing to the inconsistent findings observed in the literature. Thus, ignoring driving exposure and driving behaviours may have reduced the sensitivity of the studies in identifying important predictors for those who continue to drive under potentially hazardous driving situations.

2.2.9. Driver Style: The other component of driving

Driving can be viewed as comprising of two main components: driving skills and driving style (Elander, West & French, 1993). Driving skills refers to performance on elements of the driving tasks. In the context of older driver safety, this includes the cognitive-visual and other sensorimotor abilities required to maintain speed and lane positioning, as well as the response time taken to detect and respond to potential road hazards. Driving style refers to the way individuals decide to drive, the driving patterns and behaviours they have established over time. In the older driver context, driving style includes driving exposure (qualitative and quantitative), choice
of driving speed, and tendency to commit traffic violations (Elander et al., 1993; Taubman-ben-Ari, Mikulincer & Iram, 2004). Older drivers’ driving style would be expected to be influenced by their general driving needs and values as well as by their driving related beliefs and attitudes, and other personality factors, such as impulsivity and sensation seeking. However, the factors that influence older drivers’ driving style, and the interaction between these factors, have not been thoroughly studied. Consequently, more recent studies have directed their efforts towards understanding factors that contribute to older drivers’ driving behaviours. In particular, the area of driving exposure and the potential to improve older driver safety by modifying older drivers’ driving exposure in the form of self-imposed driving restrictions.
2.3. Current Older Driver Safety Strategies

Following the evident demographic change in driving population and apparent increases in both severity and prevalence in crash risk among older drivers, older driver safety has become a public health concern. A recent review of the current literature on older driver safety and mobility by the Transportation and Aging Interest Group of the Gerontological Society of America (GSA) has led to the development of the following framework to conceptualise current research within the area of transportation and safe mobility (Dickerson et al., 2007). The current study has expanded upon the framework put forward by the GSA, by also including the use of licence restriction, a more recently developed strategy to manage older driver safety (see Figure 3). Further, the term “Transitioning to Nondriving” has been replaced by “Self-regulation”, as it remains the only commonly adopted and researched strategy for crash prevention and maintenance of mobility.

Figure 3: Modified framework for older adults' transportation and safe mobility (adapted from Dickerson et al., 2007)
As can be seen in Figure 3, driving activities may be considered along a continuum. The spectrum runs from complete driving independence, with crash prevention being the primary goal, through voluntary self-regulation of driving exposure, balancing both safety and mobility aspects, to complete driving cessation, where maintenance of older adults’ mobility becomes the primary focus (Dickerson et al., 2007). This framework is consistent with the interpretation of many older driver studies (e.g. Antin et al., 2012; Charlton et al., 2006; Gwyther & Holland, 2012; Lyman et al., 2001; Marottoli and Richardson, 1998). While the framework for transportation and safe mobility shows that advancement at the vehicle and environment levels (e.g. vehicle modification and roadway design) can also improve older driver safety and mobility, the current program of research focuses on strategies at the driver level. In particular, the following sections will focus on commonly used strategies that have been adopted for both crash prevention and mobility maintenance. These strategies can be mainly categorised into two broad approaches: mandatory restrictions (i.e. age-based testing [ABT] and licensing restrictions) and voluntary regulation (i.e. self-regulation). The following section presents an overview of the use and empirical evidence of mandatory restrictions.

2.3.1. Mandatory restrictions

Mandatory restrictions on driving are commonly adopted by licensing authorities both within Australia and internationally. As older drivers have come under increased scrutiny (often in the context of emotive but specific crash incidents involving older drivers), managing older driver safety has become an issue of legislative concern. The most commonly used strategy by licensing authorities internationally is that of age-based testing (ABT). However, there is considerable variation between countries, and jurisdictions within countries, regarding the age, testing requirements and conditions associated with ABT.

2.3.1.2 Age-based testing (ABT) in an international context

In an attempt to manage the safety of older motorists, many licensing authorities have adopted mandatory age-based testing (ABT) as a condition for relicensing older drivers. The ages at which assessment procedures are required for relicensing begin vary among jurisdictions, but typically begin somewhere between
65 years old to as late as 80 years old. Most jurisdictions generally offer accelerated renewal periods/cycles for older drivers (e.g. requiring them to renew their licence every two years instead of every five years for general motorists). The assessment procedures used for relicensing varies from in-person renewal only, submission of medical certificate from general practitioners, periodic check-ups, visual acuity tests, road knowledge test to on-road driving test, or a combination of these procedures (See Table 1 for relicensing procedures in U.S. and Europe, and Table 2 or relicensing procedures in Australia). Forty-two U.S. states (out of 51, including Washington, D.C.) require a vision test at in-person renewal. While some states specify that drivers over certain age need to undergo visual examination, most states applied this requirement to all general vehicle licence holders. Thirty-two states have special provisions for older drivers. Of those 32 states, 19 states offer accelerated renewal cycles for older drivers; three states require submission of medical certificate, or physical examination, from general practitioners; and one state requires older licence holders to undergo written road knowledge test.
Table 1: Age-based testing (ABT) requirements within the United States of America as at April, 2013\(^4\)

<table>
<thead>
<tr>
<th>State</th>
<th>Age</th>
<th>Accelerated renewal cycle/regular renewal cycle</th>
<th>Vision test at in-person renewal</th>
<th>Special provisions for older drivers</th>
<th>Medical examination</th>
<th>On-road tests</th>
<th>Other provisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alabama</td>
<td>65</td>
<td>4/ 4yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Alaska</td>
<td>69</td>
<td>5/ 5 yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>In-person renewal after the age of 70</td>
</tr>
<tr>
<td>Arizona</td>
<td>65</td>
<td>5/Until age 65</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>In-person renewal after the age of 70</td>
</tr>
<tr>
<td>Arkansas</td>
<td>Nil</td>
<td>4/ 4 yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>California</td>
<td>70</td>
<td>5/ 5 yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>In-person renewal after the age of 61</td>
</tr>
<tr>
<td>Colorado</td>
<td>61</td>
<td>5/10 yr.</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>In-person renewal only</td>
</tr>
<tr>
<td>Connecticut</td>
<td>Nil</td>
<td>6/6yrs</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Delaware</td>
<td>Nil</td>
<td>8/8yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>District of Columbia</td>
<td>70</td>
<td>8 yr.</td>
<td>Yes</td>
<td>Medical certificate</td>
<td>Nil</td>
<td>In-person renewal only</td>
<td></td>
</tr>
<tr>
<td>Florida</td>
<td>80</td>
<td>6/ 8 yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Eye exam every renewal</td>
</tr>
<tr>
<td>Georgia</td>
<td>59</td>
<td>5/8 yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Eye exam every renewal</td>
</tr>
<tr>
<td>Hawaii</td>
<td>72</td>
<td>2/6 years</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Idaho</td>
<td>64</td>
<td>4/8 yr.</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>In-person renewal, and eye exam after age 69</td>
</tr>
<tr>
<td>Illinois</td>
<td>75</td>
<td>Age 81-86 = 2 yr Age &gt;87 = 1 yr General = 4yr.</td>
<td>Yes</td>
<td>Nil</td>
<td>Yes</td>
<td>Nil</td>
<td>In-person renewal after aged 75</td>
</tr>
<tr>
<td>Indiana</td>
<td>75</td>
<td>Age 75-84 = 3 yr</td>
<td>Yes</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>

\(^4\) Adapted from information provided by Insurance Institute for Highway Safety (April, 2013)
<table>
<thead>
<tr>
<th>State</th>
<th>Age</th>
<th>Accelerated</th>
<th>Vision test at in-</th>
<th>Special provisions for older drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Aged &gt;84 = 2 yr General = 6 yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Iowa</td>
<td>70</td>
<td>2/5yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Kansas</td>
<td>65</td>
<td>4/ 6 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Kentucky</td>
<td>Nil</td>
<td>4yr.</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Louisiana</td>
<td>70</td>
<td>4 yr.</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Maine</td>
<td>65</td>
<td>4/6 yr.</td>
<td>At 40, 52, 65 and over</td>
<td>Nil</td>
</tr>
<tr>
<td>Maryland</td>
<td>40</td>
<td>8 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Massachusetts</td>
<td>75</td>
<td>5 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Michigan</td>
<td>Nil</td>
<td>4 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Minnesota</td>
<td>Nil</td>
<td>4 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Mississippi</td>
<td>71</td>
<td>4 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Missouri</td>
<td>70</td>
<td>Age &gt; 70 = 3 yr General = 6 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Montana</td>
<td>75</td>
<td>4 / 8 yr General = 8 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Nebraska</td>
<td>72</td>
<td>5/5 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Nevada</td>
<td>70</td>
<td>4/4 yr.</td>
<td>Yes</td>
<td>Medical Certificate Nil</td>
</tr>
<tr>
<td>New Hampshire</td>
<td>Nil</td>
<td>5/5 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>New Jersey</td>
<td>Nil</td>
<td>4/4 yr</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>New Mexico</td>
<td>67</td>
<td>Age 67-75 = 4 yr Age&gt; 75 = 1 yr General =8 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>New York</td>
<td>Nil</td>
<td>8 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>State</td>
<td>Age</td>
<td>Accelerated</td>
<td>Vision test at in-</td>
<td>Special provisions for older drivers</td>
</tr>
<tr>
<td>---------------------</td>
<td>------</td>
<td>-------------</td>
<td>--------------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td>North Carolina</td>
<td>66</td>
<td>5/8 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>North Dakota</td>
<td>78</td>
<td>4/6 yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Ohio</td>
<td>Nil</td>
<td>4/4yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>Nil</td>
<td>4/4yr</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Oregon</td>
<td>50</td>
<td>8/8 yr</td>
<td>After age 50 only</td>
<td>Nil</td>
</tr>
<tr>
<td>Pennsylvania</td>
<td>45</td>
<td>Aged 65 = 2 yr General = 4 yr.</td>
<td>Nil</td>
<td>Physical and vision exam for drivers 45+</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>75</td>
<td>2/5yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>South Carolina</td>
<td>65</td>
<td>5/10yr</td>
<td>Yes for aged &gt; 65</td>
<td>Nil</td>
</tr>
<tr>
<td>South Dakota</td>
<td>Nil</td>
<td>5/5 yr</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Tennessee</td>
<td>Nil</td>
<td>5/5 yr</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Texas</td>
<td>79</td>
<td>Aged &gt; 85 = 2 yr General = 6 yr.</td>
<td>Nil</td>
<td>Nil In person renewal for aged 79 and over</td>
</tr>
<tr>
<td>Utah</td>
<td>Nil</td>
<td>5/5 yr</td>
<td>Yes, for age 65 +</td>
<td>Nil</td>
</tr>
<tr>
<td>Vermont</td>
<td>Nil</td>
<td>4/4 yr.</td>
<td>Nil</td>
<td>Nil</td>
</tr>
<tr>
<td>Virginia</td>
<td>80</td>
<td>5/5 yr.</td>
<td>Yes for aged 80+</td>
<td>Nil</td>
</tr>
<tr>
<td>Washington</td>
<td>65</td>
<td>5/5yr.</td>
<td>Yes</td>
<td>Nil In-person renewal after aged 65</td>
</tr>
<tr>
<td>West Virginia</td>
<td>Nil</td>
<td>5/5yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Wisconsin</td>
<td>Nil</td>
<td>8/8yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
<tr>
<td>Wyoming</td>
<td>Nil</td>
<td>4/4yr.</td>
<td>Yes</td>
<td>Nil</td>
</tr>
</tbody>
</table>
2.3.1.2. Age-based testing (ABT) in an Australian context.

Currently, all jurisdictions within Australia have some form of mandatory age-based assessment, except for the state of Victoria, where older drivers are assessed only if they are referred to the licensing authority, usually following a crash or traffic misdemeanour. While different jurisdictions have adopted different licensing requirements for older drivers, they generally require drivers over the age of 75 years old (in the case of South Australia, 70 years or over) to undertake an annual medical examination (see Table 2 for licensing requirements for older drivers within Australia). New South Wales (NSW) is the only state within Australia that offers older motorists the option of a restricted license without undergoing age-based testing.

As in the U.S. and Europe, in Australia a vision test and/or general medical certificate remains the most common form of relicensing assessment procedures for older drivers. In other words, the current ABT requirements within Australia (as well as most jurisdictions internationally) do not take into account other driving-related functional abilities (e.g. cognitive abilities), driving behaviours or the transport needs of the older driver involve. Substantial changes in the relicensing systems for older drivers have been proposed in a number of jurisdictions (see Table 2 for details). Briefly, the ABT requirements for older drivers have relaxed in terms of initial age required to undergo ABT (i.e. older age of initial ABT), as well as providing older drivers the option of longer renewal cycles.
Table 2: The licensing requirements for older drivers adopted by different Australian jurisdictions

<table>
<thead>
<tr>
<th>State/Territory</th>
<th>Medical Examination</th>
<th>Practical Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACT</td>
<td>Annual medical certificate from the age of 75</td>
<td>When reported by medical practitioner, police, or members of the public</td>
</tr>
<tr>
<td>New South Wales</td>
<td>Annual medical certificate from the age of 75</td>
<td>Biannual on-road test from the age of 85 (may complete test near home rather than at registry for a service fee) Not required for conditional licences</td>
</tr>
<tr>
<td>Northern Territory</td>
<td>When reported by medical practitioner, police, or members of the public</td>
<td>When reported by medical practitioner, police, or members of the public</td>
</tr>
<tr>
<td>Queensland</td>
<td>Required from the age of 75 (renewal cycle determined by the medical practitioner)</td>
<td>When reported by medical practitioner</td>
</tr>
<tr>
<td>South Australia</td>
<td>Annual medical certificate (and eyesight examination) required from the age of 70</td>
<td>From the age of 85, on-road test required for licence class higher than a car or motorcycle</td>
</tr>
<tr>
<td>Tasmania</td>
<td>Annual medical certificate required from the age of 75</td>
<td>When reported by medical practitioner</td>
</tr>
<tr>
<td>Victoria</td>
<td>From the age of 75, licence renewal cycle available for only 3 years (instead of 10 years for general motorists)</td>
<td>When reported by medical practitioner, police, or members of the public</td>
</tr>
<tr>
<td>Western Australia</td>
<td>Medical examination required from the age of 80 to assess fitness to drive</td>
<td>Annual on-road test from age 85</td>
</tr>
</tbody>
</table>

5 While medicate certificates are currently offered on a maximum of 5 year renewal cycles, a recent review of the older driver safety in Queensland by the Older Driver Safety Advisory Committee recommended introducing a 12 month maximum life for medical certificates issued to older drivers (aged 75 years and above). This is based on the opinion that medical conditions of older adults can change rapidly within 5 years.
6 While annual on-road tests were previously required after the age of 85, the Tasmanian government has announced in 2011 that drivers annual driving test is no longer required for licence renewal.
7 Medical examinations were previously required for every 3 years from the age of 75, and annually from the age of 80.
2.3.1.3. Effectiveness of Age-Based Testing (ABT)

The underlying goal of these ABT requirements is typically to identify potentially high-risk drivers for further evaluation. As previously noted, older drivers are a heterogeneous cohort, representing a diverse range of functional and driving abilities, driving behaviours and transport needs. The large variability of functional declines, if any, and the extent to which older drivers modify their driving behaviours to compensate for these functional impairments makes age a poor predictor of driver safety. Indeed, the finding that chronological age has been consistently demonstrated to be a poor predictor of crash rates per exposure (Fontaine, 2003; Hakamies-Blomqvist et al., 2002; Keall & Frith, 2006; Langford et al., 2006); challenges the utility of the current mandatory ABT procedures widely adopted in most US, European and Australian areas.

Currently, a lack of empirical consensus regarding what functional abilities, and to what extent these abilities, predict driving performance has contributed to inconsistent ABT requirements across jurisdictions. Indeed, as previously noted, visual acuity, the single most commonly assessed functional ability in ABT procedures internationally, has been demonstrated to be a weak predictor of driving performance. Previous research comparing the crash risk of older motorists from areas with mandatory ABT against jurisdictions without age-related controls revealed ABT to be ineffective in reducing the crash risks of older drivers (e.g. Grabowski et al., 2004; Hakamies-Blomqvist et al, 1998; Langford et al., 2004; 2008; Lange & McKnight, 1996; Levy et al., 1995; Mitchell, 2008; Rock, 1998; Seng & Meng, 2012). In a recent review of the effectiveness of ABT on crash risk, Langford et al. (2008) concluded that these assessment procedures resulted in no demonstrable safety benefits for older drivers themselves, nor any benefit for other road users.

Accumulating evidence suggests that ABT requirements may contribute to counter-productive safety and mobility outcomes by increasing the rate of older pedestrian fatalities. This may be a result of deterring safer, more conscientious driver (especially older female drivers) from seeking renewal of licenses, and causing them to shift to less protected, higher-risk modes of transportation, such as walking (Hakamies-Blomqvist & Wahlstrom, 1998; Hakamies-Blomqvist et al. 1996; Langford, 2004; 2008; Siren et al., 2004).
Besides counter-productive safety and mobility outcomes, a recent review of the older driver licensing system of Tasmania by the Anti-Discrimination Commissioner concluded the mandatory on-road assessment constitutes direct discrimination against older adults (Department of Infrastructure, Energy and Resources, 2010). As a result, the Registrar of Motor Vehicles (RMV) in Tasmania reviewed the older drivers licensing system in 2011 and proposed a new older driver licensing system that is non-age specific (i.e without ABT) and focuses on promoting mobility and self-assessment\(^8\) (DIER, 2011).

Given the lack of evidence for the efficacy of ABT procedures within the current literature, the continued use of (and the continued advocacy for) these procedures within the legislative and public domains is problematic, especially considering their potential negative impact upon the safety, mobility, and quality of life of older adults. In jurisdictions with mandatory ABT, this practice often results in a significant decline in re-licensing rates approaching and soon after the age of mandatory assessment, as can be seen in Langford et al. (2004). This significant decline in licensed older drivers in jurisdictions with mandatory ABT may cause many older people to either use alternative riskier modes of transport or else continue to drive unlicensed.

An Australian study by Charlton, Oxley et al. (2006) demonstrated that older Victoria drivers (no ABT) were more likely to practice self-regulation when compared with ACT and NSW drivers (with ABT; see Table 3). This finding is of considerable interest, given the differences in ABT requirements between these three jurisdictions. Some legislative authorities justify the continued use of ABT relicensing as a method to promote older drivers’ self-regulation through increased self-monitoring abilities (e.g. DTMR, 2011). Charlton et al.’s findings that older drivers from jurisdictions without ABT procedures reported greater self-regulatory behaviours contradicts this premise. Considering the inaccuracy in identifying at-risk older drivers, and the counteractive safety and mobility outcomes of ABT, an alternative strategy is required to manage older driver safety.

\(^8\) The New Older Driver Licensing System also strengthens the existing third party notification system. Under the new system, the Registrar of Motor Vehicle will not intervene unless there is evidence that a driver may be unsafe.
2.3.2. License restrictions

With the lack of empirical evidence for ABT, some researchers have advocated for the wider use of license restriction as an alternative strategy in managing older driver safety (Hanson & Hilderbrand, 2011; Langford & Koppel, 2011; Nasvadi & Wister, 2009). Examples of partial restrictions include, but are not limited to: with corrective lenses, not being allowed to drive at night, on highways or during certain times of day, being allowed only to drive in certain locations, and only driving when accompanied by another licensed driver. By delaying full license revocation, placing restrictions on licences can allow older drivers to continue to drive, but with limitations, thereby maintaining their independence and mobility. A recent study in British Columbia revealed that older drivers with restricted licenses retain their driver’s licence for longer than do those without licence restrictions (Nasvadi & Wister, 2009).

Licensing restriction has been adopted by several jurisdictions, most commonly in conjunction with ABT (most jurisdictions in Australia, Canada and United States), or in place of ABT (e.g. New South Wales, Australia). However, there is little consistency with regards to the specific types of restriction adopted by each jurisdiction. Further, there is no empirical evidence for the effectiveness of license restrictions, and whether some restrictions are more effective at reducing crash risks than others.

Currently, licence restriction is not a commonly practiced strategy in Australian jurisdictions. For instance, less than 10% of the over-65 licensed drivers had a licence restriction\(^9\) imposed over a ten-year period. The major category of restriction (95%) was a requirement to wear corrective lenses to compensate for visual deterioration (Langford & Koppel, 2011). While the number of possible restrictions that could be used to manage older drivers’ exposure to at-risk driving situations (i.e. requirement to drive within a specified distance from home, drive to specified areas only, and not being allowed to drive at night-time) have increased since 2002, these restrictions only account for 3% of older drivers who had

\(^9\) In Australia, these license restrictions are denoted on the drivers’ licenses.
Due to the low number of drivers who are placed on restrictions, the efficacy of licence restrictions has not been rigorously investigated. A recent study of older drivers in British Columbia found that after controlling for age and gender, drivers with speed, daylight, and geographic area restrictions had significantly lowered crash rates than did those driving with no restrictions (Nasvadi & Wister, 2009). However, due to the small proportion of drivers who were placed on restrictions (n = 7032; 4.6% of total sample of 151,284), Nasvadi and Wister (2009) combined all licence restriction types in their analysis, thus it is unclear whether some restrictions are more effective than others at reducing the crash risks of the older drivers in their study. Further, due to the descriptive nature of this study, it remains unclear whether the licensed restriction group's decrease in at-fault crashes was due to the licence restriction implemented, or the overall reduction in driving exposure.

In summary, the current strategies in managing older driver safety, i.e. age-based licensing (ABT) and license restrictions, are both age-specific strategies. Previous research has consistently demonstrated ABT to be ineffective in protecting older adults from crashing. Empirical evidence on the effectiveness of license restrictions remains lacking. Given the potential counterproductive safety and mobility outcomes of these strategies through 1) limiting older adults' functional mobility and 2) forcing them to use alternative, less protected mode of transport (e.g. walking), the continued use of these strategies, without any evidence to support their effectiveness, is problematic. In order to better manage older adult safety without unnecessarily limiting their functional mobility and independence, the effects of licence restrictions on crash risk in other jurisdictions, compliance rate, and their effectiveness in reducing crashes need to be rigorously tested before it can be widely implemented as a strategy to manage older driver safety.

In 2011, Langford & Koppel restrictions imposed in the most recent reporting year (2005; Langford & Koppel, 2011).

Types of licence restriction in Nasvadi and Wister’s (2009) study include driving during daylight only, no highway, maximum 80km/hr, maximum 60km/hr, and driving within restricted area only.
compromising their mobility, a new approach that considers the heterogeneity of older adults’ transportation needs and functional ability is needed.
2.4. Self-regulation as Alternative Older Driver Safety Strategy

Self-regulation strategies provide the potential to improve older driver safety while maintaining their functional mobility. Self-regulation typically refers to the practices that some older drivers adopt to adjust, or restrict, their driving to certain times and conditions to which they feel more confident (Oxley & Fildes, 2004). The adoption of self-regulation strategies may be in response to a perception that driving has become more challenging due to increased resource limitations (e.g. reduced visual acuity and cognitive abilities; Baldock et al., 2006; Ball et al., 1998; Charlton et al., 2006; Hakamies-Blomqvist & Wahlstrom, 1998; Kostyniuk & Molnar, 2005; 2008; Stalvey & Owsley, 2000) as well as general lifestyle changes (e.g. Baldock et al., 2006; Charlton et al., 2006). This interpretation is consistent with that provided by Horswill et al. (2011). Based on the Multifactorial Model for Enabling Driving Safety (Anstey et al., 2005), Horswill et al. (2011) theorized that self-regulation provides a potential escape route for older drivers with age-related declines in driving abilities, in that they can monitor their driving abilities and compensate for these perceived difficulties accordingly, thereby maintaining some functional mobility.

Older drivers commonly report that they voluntarily restrict their driving in light of progressive sensory, cognitive and physical declines. Examples of self-regulation reported by older drivers, particularly older women, include avoiding driving at night, in bad weather, in peak traffic times, on highways and complex manoeuvres such as left hand turns reducing driving (e.g. Baldock et al., 2006; Charlton et al., 2006; Eberhard, 1996; Hakamies-Blomqvist & Wahlstrom, 1998). A number of these strategies are similar to the previously discussed licence restrictions; however, the practice (both frequency and types) of self-regulation is voluntary, based on the assessment of older drivers themselves.

As a result, self-regulation is often promoted as a strategy that allows older drivers to: (a) extend functional mobility and (b) avoid a range of negative outcomes that have been associated with driving cessation, such as poorer physical and mental health trajectories (e.g. Freeman et al., 2006; Harrison & Ragland, 2003). Indeed, both research and government ABT reviews (e.g. Insurance Institute for Highway Safety [IIHS], 2010; Transport and Main Roads, 2012; Langford & Koppel, 2006; Ball et al., 1998) have previously suggested that additional screening procedures (e.g. cognitive
test) at licensure are unwarranted, based on the assumption that older drivers effectively self-regulate their driving to compensate for any functional declines.

2.4.1. Proportion of older drivers who self-regulate

Despite some enthusiasm for the use of self-regulation, the extent to which older drivers regulate their driving, and indeed, exactly how they do so, remains unclear (Ball et al., 1998, Baldock et al., 2006, Charlton et al., 2006; Molnar & Eby, 2008). There is considerable variation across studies in regards to the proportion of older drivers who practice self-regulation. For instance, some studies have demonstrated that the majority of older drivers reported some use of self-regulatory practices (e.g. 60%, Ruechel & Mann, 2005; 80%, Ball et al., 1998), whereas other studies demonstrated that self-regulation rates were low (8%, Baldock et al., 2006; 25%, Charlton et al., 2006; 27.5%, Horswill et al., 2011; 35-45%, Hakamies-Blomqvist & Wahlstrom, 1998; 25%, Molnar & Eby, 2008). The methodological differences between these studies are discussed in detail in the following Chapter.

The empirical inconsistencies in the proportion of self-regulating older drivers maybe due to the diversity in the definition of self-regulation. Specifically, studies that measured self-regulation as simply a reduction of mileage report a higher proportion of self-regulating older drivers than do studies that define self-regulation as reduction in driving under specific situations due to safety-related concerns. For instance, Dellinger et al. (2001) reported that two-thirds of older ex-drivers reported self-regulation prior to driving cessation, as indicated by driving less than 50 miles per week. Whereas assessing older drivers’ self-regulation to specific driving situations generally yields a lower proportion of self-regulating older drivers (with the exception of Ball et al., 1998). For instance, Molnar and Eby (2008) found that only 25% of subjects reported self-regulation of their driving in some way. Similarly, while 84% of the older drivers sampled by Tuokko, McGee et al. (2007) agreed that avoiding challenging road situations makes them feel protected against crashes, only 29% reported adoption of self-regulation. These findings of low self-regulation rates is consistent with findings from more recent studies that using similar methodologies (e.g. Baldock et al., 2006; Sullivan et al., 2011).
While research suggests that older drivers generally reduce driving distances and night-time driving due to general lifestyle changes, insightful a-priori self-restriction (i.e. self-selecting which specific situations to avoid) can be distinguished from driving somewhat less in general, but driving at significantly greater risk in certain situations. As noted previously, for example, older drivers are overrepresented at intersections and vehicle-to-vehicle collisions. Arguably, with similar mileage and all other factors held constant, older drivers who avoid driving through major intersections and during peak traffic times would yield lower crash risks than those do not. Thus, definition of self-regulation should be limited to a-priori, situation specific, self-restrictive driving practices.

Changes in driving exposure patterns (such as minimal driving at night) could be due to social and environmental factors (such as decreased social engagement and financial restrictions) unrelated to safety (e.g. Ball et al., 1998; Blanchard & Myers, 2010; Myers et al., 2008). Indeed, studies that defined self-regulation as limiting driving from specific driving situations due to safety-related reasons typically yield even lower proportion of self-regulating older drivers. For instance, Charlton et al. (2006) reported that the reasons drivers provided for driving less frequently were primarily due to change in employment status (34%) or changes in lifestyle (38%). Few drivers identified health (17%) and driving related factors (6%) as reasons for driving less. Similarly, Oxley et al. (2010) found only one-fifth of drivers sampled (N = 673) had reduced the amount of driving in the last 5 years, and very few of this subset of the sample had reduced their driving for safety related reasons. As the current program of research focuses on enhancing older driver safety through reducing driving exposure under high-risk situations, self-regulation will be henceforth defined as a-priori self-restriction strategies in reducing exposure to potentially harmful driving conditions.

### 2.4.2. Self-regulation for extending mobility

Driving cessation is typically described as a negative life event by older drivers, particularly older male drivers (Eisenhandler, 1993; Stutts, Wilkins, Reinfurt, Rodgman & Van Heisen-Causey, 2001). Older drivers commonly report a sense of loss and general sadness at the time of driving cessation, including a loss of independence, freedom and quality of life (Adler & Rottunda, 2006; Oxley et al.,
Driving cessation has also been associated with a range of negative outcomes such as poorer health trajectories and early entry to Long Term Care Institutions (Freeman et al., 2006; Harrison & Ragland, 2003; Marottoli et al., 1997; 2000).

Despite the obvious necessity of eventual driving cessation, none of the former drivers interviewed by Kostyniuk and Shope (2003) had made any specific preparations to address their transportation needs before they ceased driving. This finding is consistent with other qualitative and quantitative studies that report that very few current older drivers contemplate retiring from driving in the foreseeable future, and that many, particularly older male drivers, expect to keep driving for as long as they can (Charlton et al., 2006; Kostyniuk & Shope, 2003; Oxley et al., 2010). On the other hand, female drivers are more likely retire from driving while they are still fit to drive, unnecessarily limiting their mobility (Siren, Hakamies-Blomqvist et al., 2004).

Appropriate use of self-regulatory driving practices may safely prolong the driving life of older adults, thereby limiting the negative outcomes associated with driving cessation. Indeed, Okonkwo et al. (2008) demonstrated that self-regulation of driving did not result in reduced social engagement among study participants. Thus, reducing untimely driving cessation might extend the functional mobility of older adults. Self-regulation has also been proposed as a method to delay premature driving cessation, and provide older drivers with more time and resources to better prepare for their retirement from driving (Antin et al., 2012; Gwyther & Holland, 2012).

2.4.3. Application of Self-regulation in Health Promotional Context

Self-imposed restrictions to high-risk situations may be understood as a general risk reduction strategy among this cohort (Charlton et al., 2006). According to the Centre for Disease Control and Prevention (CDC, 2012), falls are the leading cause of injury death and hospital admissions for trauma. Falls often occur when older adults are exposed to high-risk situations (e.g. wet floors, dimly-lit areas, with tripping hazards), a context with some analogy to driving. Self-regulatory strategies have been demonstrated to be successful in improving other health behaviours among older adults, such as physical activity, exercise and dieting adherence (e.g. Umstattrd et al., 2006; Wrosch, et al., 2006; Wing et al; 2006). Besides older drivers, road users
of other age groups, particularly female drivers, have been demonstrated to adopt self-regulatory driving practices. Self-regulatory strategies have also been reported to be useful for improving other aberrant driving behaviours, such as drink-driving (Worden, Flynn et al., 1989). Thus, knowledge of the factors, and the process of these factors, which underlie older adults’ decision to self-regulate from high-risk driving activities will contribute to our current understanding of how individuals respond to risky behaviours and situations in general. Greater understanding of these factors may a) increase driver safety among this cohort, b) extend functional mobility of older drivers and c) potentially increase safety among this cohort against other high-risk injuries (e.g. falls).

2.4.4. Effectiveness of Self-regulation

Despite the preliminary findings for benefit in managing safety and extending mobility of older adults, the effectiveness of self-regulation on crash risk has not been rigorously investigated. To date, several retrospective studies have provided mixed results on the effects of self-regulation and crash risk. Encouragingly, De Raedt and Kristofferson (2000) reported “at-risk” drivers (based on expert ratings of on-road test performance) who restricted their driving reported fewer crashes than those who did not practice self-regulation. However, other studies reported no association between self-regulation and crash involvement for high-risk drivers (Owsley et al., 2004; Raitamen et al., 2003). Further, some studies reported crashes to be more prevalent among older drivers who reported use of self-regulatory driving practices (Charlton et al., 2006; Ball et al., 1998).

The retrospective design of these studies makes it impossible to identify the causality between self-regulatory practice and crash risks. As previously noted, drivers often report the use of self-regulation in response progressive functional declines. Thus, it is unclear whether the observed increase in crash risk is due to the self-regulation strategies, or to the functional declines that prompted the adoption of these strategies. Similarly, it remains unclear if, and to what extent, reduced overall driving exposure due to self-restrictive driving practices contribute to the elevated crash risk reported in studies reviewed above (see discussions on low mileage bias above). It is also plausible that drivers adopted self-regulatory driving practices following their crash involvement to minimise the risk of future crashes. According to
Man-Son-Hing et al. (2007), empirical evidence on the relationship between self-regulatory practices and prospective crash risk is currently lacking. A recent 5-year longitudinal study revealed that after accounting for baseline driving, age, sex and other driving performance measures, a “high-risk” group of participants increased their driving avoidance over the 5-year period (Ross et al., 2009). Despite their increased self-regulatory practice, the “high-risk” participants remained twice as likely to be involved in an ‘at-fault’ crash than their low-risk counterparts (Ross et al., 2009). These data suggest that the use of self-regulation alone is currently insufficient to protect “high-risk” drivers from crashing. However, due to the lack of control group, it is unclear whether “high-risk” drivers who did not practice self-regulation would yield even higher crash risks when compared to those who practiced self-regulatory behaviours.

2.4.5. Problems with current self-regulatory usage

Several explanations may account for the ineffectiveness of current self-regulatory practice in reducing older drivers’ crash risks reported in the above studies. First, there is accumulating evidence suggesting a discord between the choice to adopt self-regulation and an older adults’ driving ability (Baldock et al., 2006; Charlton et al., 2001; Cushman, 1996; Marottoli and Richardson, 1998). There is accumulating evidence that while some older adults are aware of their functional impairments and self-regulate their driving practices accordingly; overall, self-regulation is not associated reliably with driving performance as measured by on-road assessment. In a study of 404 potentially high-risk drivers (defined as those with significant visual impairments, high levels of driving exposure with a history of crash involvement), 75 per cent of the participants reported ‘never or rarely’ avoiding driving situations that exert high visual demands, despite the majority acknowledging that they would feel more protected if they avoided these situations (Stalvey & Owsley, 2000). Stalvey and Owsley’s findings are also consistent with other similar studies which demonstrate level of self-regulation to be overall unrelated to driving abilities (Charlton et al., 2001, Cushman, 1996; Marottoli & Richardson; Baldock et al., 2006).

Baldock et al. (2006) examined the association between the self-regulatory practices among 90 South Australian drivers and their on-road driving test performance. Baldock et al. reported that while participants’ on-road driving
performance was not related to their overall avoidance of challenging driving situations, stronger correlations were found between on-road driving performance and avoidance for several specific driving situations. These situations comprised, driving in the rain, driving at night, and driving at night in the rain. This finding suggests that if self-regulation is defined as avoiding driving in specific situations, the proportion of drivers who self-regulate, and the resulting differences in crash risk, might be more prominent than those reported in the above reviewed literature.

2.4.6. Summary of self-regulation

Self-regulation presents several advantages over existing older driver strategies of Age-Base Testing and licence restrictions. As previously stated, appropriate use of self-regulation can potentially lower older drivers’ crash risk through reducing their exposure of risky driving situations. Further, adoption of self-regulation can maintain older drivers’ functional mobility and social engagement. Maintenance of functional mobility and social engagements has been consistently demonstrated to be critical factors contributing to older adults’ physical and psychological wellbeing (Edwards et al., 2009). The adoption of self-regulation may also be extended as a general risk reduction strategy, protecting older adults from common non-driving related injuries due to increased functional declines, such as slips and falls.

Besides maintenance of mobility and safety, self-regulation differs from other current older drivers strategies because it addresses the heterogeneity of abilities, needs and challenges of older adults. As discussed, there is considerable inter-individual variability in the prevalence, severity and development of health and medical conditions among older adults. The driving styles and transportation needs also vary greatly among this cohort. The importance of considering older drivers’ individual needs and abilities is further emphasised in the recent report by the Tasmanian Anti-Discrimination Commissioner, who found Age-Based Testing and blanket use of license restriction to constitute prima-facie discrimination towards older individuals (DIER, 2011). The discriminatory nature and ineffectiveness of ABT and age-based license restrictions necessitates research into alternative, more flexible, non age-specific strategies in managing older driver safety, such as self-regulation.
Following the preliminary findings for benefit in managing safety and extending mobility of older adults, self-regulation has been promoted by road safety authorities and researchers as a strategy that allows older drivers to continue to drive safely for longer (e.g. DTMR, 2011). However, the effectiveness of self-regulation in reducing older adults’ crash risk has not been rigorously investigated. The level of usage of self-regulation among older adults, and the factors that underlie its use, remains unclear. Recent studies have demonstrated that while some older adults are aware of their functional impairments and self-regulate their driving practices accordingly; overall, self-regulation usage is not related to older adults’ driving abilities. Thus, the current program of research focused on better understanding older adults’ use of self-regulation through identifying 1) the level of usage of self-regulation among different cohorts of older drivers, 2) the factors that underlie their adoption of self-regulation, 3) the association between self-reported self-regulation and actual driving behaviours. Ultimately, the aim was to examine whether this compensatory strategy could be used to improve older driver safety, mobility and quality of life, and to identify modifiable factors that could be used to promote the use of self-regulation.

2.5. Research Questions

As discussed in this literature review, the usage of older adults’ self-regulation in regards to driving demands greater empirical attention. Four research questions were developed to systematically/scientifically/rigorously address this knowledge gap.

*Research Question 1: What do we know about older adults’ driving behaviours, in particular, self-regulation?*

The volume of research activity on older drivers’ use of self-regulation has increased rapidly in recent years. Initial review of this literature revealed a diversity of methodologies and findings, and a lack of an explicit integrated understanding. In order to effectively address the methodological and theoretical gaps in this area of literature, a thorough and comprehensive review is required. Such a review is important to provide a foundation for developing and testing a theoretical model that accurately predicts older drivers’ practice of self-regulation.
Research Question 2: What are the personal, social, situational factors that contribute to self-regulation of older adults?

This research question forms the basis of this program of research. Identifying the factors, the relative influence of these factors, and the underlying processes to which these factors, influence older adults’ self-regulatory driving behaviours is critical for developing and testing a comprehensive theoretical model that account for these behaviours. Such knowledge can also provide a foundation for developing effective interventions through targeting salient modifiable factors.

Research Question 3: How do older adults self-regulate?

This research question addresses a fundamental issue in the transportation and aging literature. The current body of knowledge on older drivers’ behaviours, including self-regulation, is based mostly on self-report information. This research question provides the opportunity to examine the reliability and validity of the current self-report measures of self-regulation. This is particularly important as the outcome of older driver safety is often objectively measured (e.g. crash risk, mortality and morbidity). Further, current knowledge of the factors underpinning older adults’ driving behaviours, including self-regulation, may need to be revised if self-reported self-regulation is not predictive of objectively measured driving behaviours. If self-report self-regulation is not related to objectively measured driving behaviours, alternative strategies may be needed to manager older driver safety, at least for subsets of older drivers.

Research Question 4: How can we improve older adults’ practice of driving-related self-regulation?

This final research question is based on the need to improve older driver safety and mobility through promoting more widespread, as well as more appropriate, use of self-regulation. Thus, it provides a stronger practical emphasis than the previous questions. It is important to understand older drivers’ preferences towards obtaining driving-related information and future interventions. Knowledge regarding preferences of delivery content and context, as well as the transportation needs and preferences of older drivers, is important for effective intervention development.
2.6. Chapter summary

Given the rapid growth of the Australian older driver cohort and the reliance upon private vehicles as the main form of transportation, managing older driver safety has become an increasingly prevalent social, legislative and public health concern. Due to the increased functional impairments and fragility of older drivers, previous research has focused on identifying at-risk drivers (i.e. who) and the appropriate time to cease driving (i.e. when). Following the limited success in accurately identifying and assessing the predictors of older adults’ driving capacity, empirical attention has been directed towards better understanding older drivers’ driving behaviours.

Current strategies used to manage older driver safety include Age-Based Testing and license restriction. Previous research has identified ABT to be ineffective in reducing the crash risk for older drivers, and other motorists. Further, ABT has been found to produce counterproductive safety and mobility outcomes by discouraging self-screening and self-regulation of older drivers, and pushing older drivers to take up alternative, potentially less safe, modes of transportation. Both ABT and license restrictions are inflexible, non-evidenced based strategies that do not consider the heterogeneity of abilities, challenges and transportation needs of older drivers, and have been found to constitute direct discrimination towards older adults. Given the lack of evidence of any safety benefits, and the significant mobility limitations it imposes on older independent drivers, the continued use of ABT and license restrictions remains problematic.

Recent research has directed its efforts towards identifying alternative, more flexible, strategies to manage older driver safety and mobility. One such alternative strategy is self-regulation – the voluntary reduction of driving under risky situations in light of progression functional declines. Despite its potential to be applied to 1) reduce the risk exposure and crash risk of older drivers, 2) extend functional mobility and social engagement of older adults, and 3) reduce non-driving related injuries, research on older drivers’ adoption of self-regulation remains scant and inconsistent. The proportion of older adults who self-regulate, how they do so, the factors and processes that underlie their self-regulatory behaviours remains unclear. The significant discord between older drivers’ driving abilities and adoption of self-regulation indicate this strategy to be ineffectively used among the older driver cohort. Clearly there is a need
to rigorously investigate the issues surrounding the use of self-regulation among older adults, particularly since self-regulation has been promoted by road safety authorities and researchers as a strategy to maintain older driver safety (e.g. DTMR, 2011).

In order to address this significant gap in the literature, the current program of research 1) systematically reviewed the current self-regulation literature to identify the proportion of self-regulators and the factors that contribute to this behaviour, 2) developed a theoretical model that incorporates the factors and the pathways that predicts older drivers’ adoption of self-regulation, 3) tested components of the model to allow re-specification and refinement of model, and 4) compared this model and its findings to the objectively measured driving behaviours of older drivers.
Chapter 3: Study 1A – Systematic Review of Self-regulation of Older Drivers

3.1. Introductory comments

This chapter forms the first study, and the foundation, for the current program of research. Following the limited success in developing accessible, reliable and accurate assessment to identify at-risk older drivers (i.e. with minimum false positives and false negatives), older driver research has focused increasingly towards identifying alternative strategies to reduce older drivers’ crash risks without significantly limiting their functional mobility. One such strategy is the use of self-regulation. This chapter presents a systematic review of the current literature, critically appraising and synthesising studies that investigate the factors that influence older drivers’ adoption of self-regulation. This chapter concludes with the findings and methodological limitations of the current literature.

3.2. Purpose of the study

A recent review of the transportation and aging literature has revealed the need to identify the factors that mediate the usage of self-regulation as well as ways to promote adaptive strategies and pathways to driving self-regulation (Dickerson et al., 2007). The need to better understand the factors that underlie older drivers’ driving decisions, in particular decisions regarding self-regulation, has been identified by the Transportation and Aging Interest Group of the Gerontological Society of America as one of the areas to have potential for achieving the critical, and complementary, goals of safety and mobility for current and future generations of older adults (Dickerson et al., 2007). This review also emphasised the severe lack of theoretical and empirical attention towards addressing the social and psychosocial influences on older drivers’ driving decisions (Dickerson et al.).

While research activity on older drivers’ self-regulation, in particular the factors that contribute to this decision, has increased rapidly over the last decade, studies have yet to review (systematically or unsystematically) the current growing body of literature. Study one presents a systematic review of transportation and aging literature on older drivers’ self-regulation usage.
Unlike traditional (unsystematic) narrative reviews that only include research selected by the authors, a systematic review limits bias by systematically assembling, critically appraising and synthesising all relevant studies of a specific topic (Wright et al., 2007; Cook et al., 1995). Further, unlike meta-analysis, systematic review offers greater flexibility by allowing the pooling of studies that have adopted diverse methodologies (Wright et al.). This methodology provides an approach to consolidating the diversity of methodologies adopted in the older driver self-regulation literature. Such information would facilitate the development of a theoretical model that accurately predicts older drivers’ self-regulatory behaviours. Results from the systematic review will also enable accurate appraisal of how the current program of studies contributes to the existing older driver self-regulation literature. Finally, the formal steps taken in conducting systematic reviews allow replication of the studies’ results.

3.3. Study aims

As discussed above, this study reviewed the existing transportation and aging literature regarding the factors that contribute to older drivers’ adoption of self-regulation. Additionally, this study aimed to examine the methodological rigour of the current body of literature on older drivers’ self-regulation. This systematic review addressed the first two research questions of the current research program, detailed in section 2.5. These are: 1) what do we know about older adults’ driving behaviours, in particular, self-regulation? And 2) what are the personal, social, situational factors that contribute to self-regulation of older adults?

A systematic review of existing knowledge and methodological gaps is crucial to the development (and subsequent testing) of a comprehensive theoretical model that accounts for older drivers’ adoption of self-regulation. As a systematic review, this study did not have specific hypotheses. Instead, this study provided information to address the research question.

Specifically, in order to critically evaluate and synthesise the current older driver self-regulation literature, a systematic review was conducted to:

1) Ascertain the proportion of older drivers who self-regulate;
2) Identify the factors that influence older drivers’ adoption of self-regulation; and

3) Quantify the effects of these factors on older drivers’ self-regulation.

3.2.1 Method

3.2.1.1. Search Strategy

The current systematic review adopted the methodology described by Wright et al. (2007). This method was similar to that used by Man-Son-Hing et al. (2007) in reviewing the driving risk and efficacy of compensatory strategies in persons with dementia.

Relevant data was gathered by performing systematic literature searches of the MEDLINE, PsychInfo, Ejournal, ScienceDirect and EMBASE databases. These databases were selected to provide a comprehensive search of journals relevant to road safety and driver behaviour. For instance, while Medline includes over 10 million articles published since 1966, the majority of the journals referenced are published within the United States. Thus, EMBASE (contains 8 million articles published since 1974) was also included in the search to provide better coverage of European journals.

Pertinent articles were identified using the following search terms (English language, peer reviewed only; published within the year 1998-2013): self-regulat* (i.e. included search terms such as self-regulate, self-regulating, self-regulatory and self-regulation), self-restrict*, self-limit*, compensat*, avoidance older, senior, elderly and driv*. As per Man-Son-Hing et al. (2007) and Wright et al., (2007), the bibliographies of each identified articles were then hand searched to identify potential additional articles. As per Man-Son-Hing et al., technical, government, and internal reports, non-peer reviewed articles and conference abstracts (i.e. sometimes referred to as the “grey literature”) were not included due to the lack of a commonly accepted, systematic and comprehensive way of doing so. A significant proportion of government and internal reports rely on secondary data sources. Further, the review was not intended to be exhaustive, but identify potential factors and key issues that
underlie older adults’ self-regulation for consideration in the development of a theoretical model in the remaining studies of the current research program. Due to the exploratory nature of this study, the concentration on peer reviewed journal papers provided a direct means of focusing on what would generally be the more rigorous research.

High quality systematic review is commonly limited to high-level evidence studies (e.g. Randomized Control trials), the research question necessitated the inclusion of studies with lower level evidence, such as retrospective cross-sectional studies (Wright et al., 2007). Studies that utilised qualitative methodologies such as focus groups and interviews could be rated alongside quantitative studies within the systematic review. Nonetheless, due to the common use of qualitative methodologies within the area, these studies were separately tabulated and discussed (but not rated) in order to identify incidence of results and areas for further investigations (Wright et al., 2007).

Included articles all met the following criteria: collected primary data, studied the predictors of older drivers’ adoption of self-regulation, and published within the year 1998 and 2013. Pertinent information including year of publication, quality score, study designs, sample size and characteristics, outcome measures used and main findings were extracted and tabulated from each relevant article.

3.2.1.2. Quality Assessment

To assess the methodological quality of the relevant studies, the Newcastle-Ottawa Scale (NOS) was used (Wells et al. 2006). The NOS consist of eight items with three subscales: Selection, Comparability, and Outcome. Selection assesses the representativeness of sample and measurement of predictors (range from 0-4); Comparability refers to the control of potential confounds (range from 0-2); Outcome refers to the validity of outcomes measures and follow-up procedures (range from 0-3). The NOS range from 0 to 9, with high scores indicated higher methodological quality of studies.\(^\text{11}\)

\(^{11}\) Some systematic reviews perform Chi-square (or Fisher’s exact) tests to examine whether quality score is statistically related to findings; however, due to the heterogeneity of predictors involved, this step is not possible in the current study.
3.2.3. Results

3.2.3.1. Search Strategy

The initial search strategy identified 51 references from MEDLINE, PsychInfo and Ejournal, with EMBASE providing references for 37 journal articles and Science Direct providing references for 59 journal articles. EMBASE provided 8 reference journals that were not identified from MEDLINE. Science Direct provided two reference articles that were not identified from either database.

After the initial perusal of the titles and abstracts, 51 were selected to be potential studies that meet the inclusion criteria. These were reviewed in full (Wright et al., 2007), and 38 were identified as meeting the inclusion criteria. Four articles were excluded (Okonkwo et al., 2007; Braitman & McCartt 2008; Baldock et al., 2006; Meng & Siren, 2012), as they appeared to study the same group of participants as previously included studies. Two studies were excluded as they were poster presentation abstracts and lack the information required for inclusion in a systematic review (Devlin & McGillivray, 2012; Cox & Cox, 1998). A further three studies were excluded due to the use of qualitative methodologies (Donorfio et al., 2008; Donorfio et al., 2009; Rudman, Friedland, Chipman & Sciortino, 2006). This data extraction process resulted in 29 included studies (Tables 4 and 5). Table 3 demonstrates a frequency distribution of the overall studies’ scores.

Table 3: Frequency distribution of NOS scores of studies (N = 29)

<table>
<thead>
<tr>
<th>Newcastle-Ottawa Scale scores</th>
<th>No. of studies (N= 29)</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowest quality</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>(0%)</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>(6.9%)</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>(10.3%)</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
<td>(34.5%)</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>(17.2%)</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>(13.8%)</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>(3.4%)</td>
</tr>
<tr>
<td>7</td>
<td>2</td>
<td>(6.9%)</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
<td>(3.4%)</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
<td>(0%)</td>
</tr>
</tbody>
</table>
3.2.3.2. Study quality

As can be seen in Table 4 and Table 5, the majority of studies adopted cross-sectional designs to examine the effects of various factors on older drivers’ adoption of self-regulation \( (n = 24) \), with two studies used prospective cohort, one with retrospective cohort and two with case-control design. Cohort designs received higher NOS scores \( (M = 7, n = 3) \) than cross-sectional studies \( (M = 3.38) \) and case-control studies \( (M = 1.5) \).

The majority of studies utilised self-report (written and interview) outcome measures of self-regulation \( (n = 27) \). Predictably, studies that used self-report outcome measures generally scored lower on the Outcome subscale of the NOS \( (M = 0.29) \) than studies that used objectively assessed self-regulation as outcome measures \( (M = 1.5) \). However, studies that used objective measures of self-regulation obtained relatively low scores on the Selection subscale of the NOS. In terms of the control of confounds (assessed by the Comparability subscale of the NOS), the majority of studies that rely on self-report measures reported and subsequently controlled for age and/or gender main effects on adoption of self-regulation.
Table 4: Summary of Studies Using Self-Report Self-regulation as Outcome Measure

<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>NOS</th>
<th>Sample</th>
<th>Recruitment</th>
<th>Outcome measures</th>
<th>Proportion of self-regulators</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ball et al. (1998)</td>
<td>Cross-sectional</td>
<td>3+0+0 = 3</td>
<td>N = 257 Age = 55+</td>
<td>Alabama MV registry</td>
<td>Interview self-report scenarios</td>
<td>80%</td>
<td>UFOV, attentional impairments and at fault crashes influence self-regulation</td>
</tr>
<tr>
<td>Rimmo &amp; Hakamies-Blomqvist (2002)</td>
<td>Cross-sectional</td>
<td>2+2+0 = 4</td>
<td>N = 939 Age = 55+</td>
<td>Sweden MV registry</td>
<td>Written self-report (categorical)</td>
<td>60%</td>
<td>Health, gender, driving experience and mileage predict self-regulation</td>
</tr>
<tr>
<td>West et al. (2003)</td>
<td>Cross-sectional</td>
<td>2+2+0 = 4</td>
<td>N = 629 Age = 55+</td>
<td>Smith Kettlewell Eye Research Institute</td>
<td>Interview self-report (categorical)</td>
<td>53.5%</td>
<td>Age, gender, education, health and visual abilities predict self-regulation</td>
</tr>
<tr>
<td>Ruechel &amp; Mann (2005)</td>
<td>Cross-sectional</td>
<td>1+0+0 = 1</td>
<td>N = 30 Age = 64+</td>
<td>Florida</td>
<td>Interview self-report (categorical)</td>
<td>70%</td>
<td>Visual abilities and gender predict self-regulation</td>
</tr>
<tr>
<td>Baldock et al. (2006)</td>
<td>Cross-sectional</td>
<td>2+1+0 = 3</td>
<td>N = 104 Age &gt; 60yo</td>
<td>South Australia</td>
<td>Written self-report scenarios</td>
<td>M = 13.9 (5.6) Range 9-45</td>
<td>Driving confidence but not driving ability relayed to driving ability</td>
</tr>
<tr>
<td>Charlton et al. (2006)</td>
<td>Cross-sectional</td>
<td>2+0+0 = 2</td>
<td>N = 656 Age = 55+</td>
<td>Victoria, Australia</td>
<td>Written self-report scenarios</td>
<td>25%</td>
<td>Age, gender, principal driver, recent crash, visual abilities and driving confidence predict self-regulation</td>
</tr>
<tr>
<td>Vance et al. (2006)</td>
<td>Cross-sectional</td>
<td>3+2+2 = 7</td>
<td>N = 697 Age &gt; 55</td>
<td>Maryland MV locations following license renewal</td>
<td>Phone interview self-report DHQ</td>
<td>Not reported</td>
<td>Gender and Age influence self-regulation via health, cognitive and physical functioning</td>
</tr>
<tr>
<td>Tuokko et al. (2007)</td>
<td>Cross-sectional</td>
<td>1+0+0 = 1</td>
<td>N = 86 Age = 55+</td>
<td>Volunteers to attend one of six driving education sessions, location not reported</td>
<td>Written self-report</td>
<td>29%</td>
<td>Self-regulators were older. Not gender, exposure or prior crashes effects Reliance on physicians as decision-</td>
</tr>
</tbody>
</table>

12 Ragland et al. (2004): 5% of participants never drove
<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>NOS score (0-9)</th>
<th>Sample</th>
<th>Recruitment</th>
<th>Outcome measures</th>
<th>Proportion of self-regulators</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Okonkwo et al. (2008)</td>
<td>Cross-sectional</td>
<td>3+2+0 = 5</td>
<td>N = 1543 Age = 75+</td>
<td>Senior Driver Research Project; State Farm Manual Auto Insurance (Alabama)</td>
<td>Written self-report DHQ;</td>
<td>Low risk: 3.4%-42.9% self-regulate High risk: 13.1%-52.4% self-regulate</td>
<td>Age, gender, health status, vision, driving exposure, UFOV, crash involvement predict self-regulation</td>
</tr>
<tr>
<td>D'Ambrosio et al. (2008)</td>
<td>Cross-sectional</td>
<td>2+1+0 = 3</td>
<td>N = 3859 Age = 50+</td>
<td>U. S.</td>
<td>Written self-report scenarios</td>
<td>M = 1.5 (.63) Range = 1-4 36% self-regulate in some way</td>
<td>Health, age and gender influence self-regulation</td>
</tr>
<tr>
<td>Kostyniuk &amp; Molnar (2008)</td>
<td>Cross-sectional</td>
<td>2+1+0 = 3</td>
<td>N = 961 Age = 65+</td>
<td>Michigan, U.S.</td>
<td>Self-reported scenarios</td>
<td>25-65%</td>
<td>Gender, age, mobility and visual abilities associated with self-regulation</td>
</tr>
<tr>
<td>MacDonald et al. (2008)</td>
<td>Cross-sectional</td>
<td>2+1+0 = 3</td>
<td>N = 71 Age = 65+</td>
<td>Southwest Ontario</td>
<td>Written self-report</td>
<td>M = 8.8 (5) Range = 0-20</td>
<td>Self-regulation related to perceived abilities, rather than actual driving performance. Drivers who lack insight less likely to self-regulate</td>
</tr>
<tr>
<td>Molnar &amp; Eby (2008)</td>
<td>Cross-sectional</td>
<td>2+1+0 = 3</td>
<td>N = 68 Age = 65+</td>
<td>Medical patients referred by GP</td>
<td>Interview self-report scenarios</td>
<td>25%</td>
<td>Gender, visual impairment and decreased driving performance associated with increased self-regulation</td>
</tr>
<tr>
<td>Windsor et al. (2008)</td>
<td>Cross-sectional</td>
<td>3+2+0 = 5</td>
<td>N = 304 Age = 65+</td>
<td>Canberra, Australia</td>
<td>Telephone interview self-report scenarios</td>
<td>Not reported</td>
<td>Health, perceived control and ability influence self-regulation</td>
</tr>
<tr>
<td>Ross et al. (2009)</td>
<td>Prospective cohort</td>
<td>4+2+2 = 8</td>
<td>N = 645 Age = 75+</td>
<td>Maryland MV Registry</td>
<td>Telephone Interview self-report DHQ</td>
<td>16.6-19.7 at baseline Range = 10-50</td>
<td>UFOV at-risk drivers more likely to increase self-regulation over 5 years</td>
</tr>
<tr>
<td>Loftipour et al. (2010)</td>
<td>Cross-sectional</td>
<td>2+0+0 = 3</td>
<td>N = 151 Age = 65+</td>
<td>A senior centre in Southern California</td>
<td>Interview self-report adapted</td>
<td>Not reported</td>
<td>Poor visual acuity influence self-regulation</td>
</tr>
<tr>
<td>Study</td>
<td>Study design</td>
<td>NOS score (0-9)</td>
<td>Sample</td>
<td>Recruitment</td>
<td>Outcome measures</td>
<td>Proportion of self-regulators</td>
<td>Main Findings</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------</td>
<td>-----------------</td>
<td>--------</td>
<td>----------------------------------</td>
<td>-------------------------------------------</td>
<td>---------------------------------</td>
<td>--------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Ackerman et al. (2011)</td>
<td>Prospective cohort</td>
<td>3+2+1=7</td>
<td>N = 129 Age = 75+</td>
<td>Senior Driver Research Project, Alabama</td>
<td>Telephone interview self-report DHQ</td>
<td>Not reported</td>
<td>Gender, age, cognitive and medical conditions: significant predictor of self-regulation at baseline Feedback significant predictor of self-regulation at 3 month follow-up</td>
</tr>
<tr>
<td>Braitman &amp; Williams (2011)</td>
<td>Cross-sectional</td>
<td>2+2+1=5</td>
<td>N = 2057 Age = 65+</td>
<td>Connecticut, Kentucky and Rhode Island License Renewal Offices</td>
<td>Telephone interview self-report scenarios (categorical)</td>
<td>Avoided 2.1 to 3.8 situations (out of 10)</td>
<td>Memory, vision, mobility, medical conditions, age, gender employment and residential locations influence self-regulation</td>
</tr>
<tr>
<td>Horswill et al. (2011)</td>
<td>Cross-sectional</td>
<td>3+1+0=4</td>
<td>N = 307 Age = 65+</td>
<td>Local electoral roll</td>
<td>Written self-report</td>
<td>27.5%</td>
<td>No relationship between perceived and actual HPT performance Perceived test performance, (not actual performance related to self-regulation</td>
</tr>
<tr>
<td>Naumann et al. (2011)</td>
<td>Cross-sectional</td>
<td>2+1+0=3</td>
<td>N = 8129 Age = 18-75+</td>
<td>The 2nd Injury Control &amp; Risk Survey (ICARIS-2) U.S.</td>
<td>Written self-report</td>
<td>&gt;65 yo women = 30-65% &gt;65 yo men = 20-52%</td>
<td>Female, low-income and low annual travel distance associated with increased self-regulation</td>
</tr>
<tr>
<td>Sargent-Cox et al. (2011)</td>
<td>Cross-sectional</td>
<td>2+2+0=4</td>
<td>N = 322 Age 65+</td>
<td>Canberra, Australia</td>
<td>Written self-report</td>
<td>70%</td>
<td>Health literacy not as important as health experience and medical conditions on self-regulation</td>
</tr>
<tr>
<td>Sullivan et al. (2011)</td>
<td>Cross-sectional</td>
<td>3+1+0=4</td>
<td>N = 75 Age = 65+</td>
<td>Queensland, Australia</td>
<td>Semi-structured interview, self-report</td>
<td>69% practice at least some self-regulation</td>
<td>DHQ did not cover all situations that older drivers avoid</td>
</tr>
<tr>
<td>Meng et al.</td>
<td>Case-control</td>
<td>1+0+0</td>
<td>N = 25</td>
<td>Convenience sample</td>
<td>Interview self-report</td>
<td>Avoided M= 5.3</td>
<td>The importance of driving-related</td>
</tr>
</tbody>
</table>

Chapter 3: Study 1A 73
<table>
<thead>
<tr>
<th>Study</th>
<th>Study design</th>
<th>NOS score (0-9)</th>
<th>Sample</th>
<th>Recruitment</th>
<th>Outcome measures</th>
<th>Proportion of self-regulators</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crizzle et al. (2013)</td>
<td>Case-control</td>
<td>1+0+1 = 2</td>
<td>26 drivers w PD 20 controls</td>
<td>Age = 70+</td>
<td>GPS and self-report</td>
<td>69% PD drivers report self-regulation; 73% PD drivers drove in these situations 42% controls report self-regulation</td>
<td>Self-estimate distance inaccurate for both groups, but discrepancy more pronounced among PD drivers PD drivers reported greater self-regulation, but also drove more in these situations</td>
</tr>
</tbody>
</table>

**Note:** NOS score = Selection + Comparability + Outcome. Range from 0-9 (9 indicate higher methodological quality)

DHQ = Driving Habits Questionnaire (Owsley, Stalvey, Wells, & Slocan, 1999; Stalvey, Owsley, Sloan & Ball, 1999)

Proportion of self-regulators: expressed in %, unless Means and SDs were provided; SDs were expressed in parentheses
### Table 6: Summary of Self-regulation Studies Using Qualitative Methodologies

<table>
<thead>
<tr>
<th>Study</th>
<th>Sample</th>
<th>Recruitment</th>
<th>Design</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donorfio et al.</td>
<td>N = 3824</td>
<td>U.S.</td>
<td>Unstructured telephone interview (Items not reported)</td>
<td>Household composition and health status influence self-regulation (those live in 2-person household more willing to self-regulate)</td>
</tr>
<tr>
<td>(2009) Age= 50+</td>
<td></td>
<td></td>
<td></td>
<td>The emphasis of psychological processes surrounding independence and self-worth in decisions to self-regulate</td>
</tr>
<tr>
<td>Donorfio et al.</td>
<td>N = 81</td>
<td>Illinois &amp; Florida</td>
<td>Focus Groups</td>
<td>Older drivers aware of age-related changes to driving;</td>
</tr>
<tr>
<td>(2008) Age = 58+</td>
<td></td>
<td></td>
<td></td>
<td>Self-regulation behaviours change with age, and circumstances;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Alternative transportation viewed as limited or non-existent;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gender differences in awareness and willingness to driving-related interventions</td>
</tr>
<tr>
<td>Rudman et al.</td>
<td>N = 79</td>
<td>Toronto, Ontario</td>
<td>Focus groups</td>
<td>Social beliefs about driving, alternative transportation, family/physician comments and near-accidents (or accidents) influence older drivers’</td>
</tr>
<tr>
<td>(2006) Age = 55+</td>
<td></td>
<td></td>
<td></td>
<td>decisions to self-regulate</td>
</tr>
</tbody>
</table>
3.2.3.3. Proportion of self-regulators

The percentage of older drivers who reported self-regulation is reported in Table 5 and 6. Several studies did not provide average percentage of older drivers who regulate. Thus, the means and standard deviations of self-regulation scales (e.g. Drivers Habit Questionnaire, DHQ) were presented instead. Older drivers who reported self-regulation range from 25% to 80%. Table 5 demonstrates a general lack of consensus on the proportion of older drivers who adopt self-regulation, regardless of sample size, minimum age and recruitment methods. Further, while the relationships between self-regulation scores and predictor variables (e.g. age and gender) are generally investigated, not all studies report the proportion of older drivers who adopt self-regulation.

3.2.3.4. Factors that contribute to older drivers’ adoption of self-regulation

3.2.3.4.1. Demographics variables

As per Table 4 and 5, the most commonly examined demographics variables are age and gender. All examined studies reported that for both male and female senior drivers, driving self-regulation typically increases with age. While several cross-sectional studies have questioned whether the effects of age to be a cohort effect, as the number (and severity) of medical conditions tend to increase with drivers’ age (Braitman & McCartt, 2008; Ragland et al., 2004), both retrospective and prospective cohort studies, with moderately high NOS scores, demonstrated significant declines in self-reported driving over the 5-year study period (Ross et al., 2009; O’Connor et al., 2012).

With the exception of Tuokko et al. (2007), all studies examined revealed a significant main effect of gender on older drivers’ adoption of self-regulation, with women uniformly more likely to practice self-regulatory driving behaviours (and at a younger age) than male older drivers. Cross-sectional studies examined also revealed a consistent negative relationship between distance driven and self-regulation. However, the causality between annual driving distance and self-regulation remain unexamined.

Besides age, gender and mileage, studies typically report inconsistent findings between other demographics variables and adoption of self-regulation. Four studies examined the relationship between prior crash involvement and self-regulation. Ball et al., (1998) and Charlton et al. (2006) reported significant associations between prior crash
involvement and self-regulation, whereas Okonkwo et al. (2008) and Tuokko et al. (2007) did not. These studies also had relatively low NOS scores (range = 1-5).

Two studies demonstrated that self-regulating older drivers are likely to have lower annual household income (Naumann et al. 2011; Ragland et al. 2004). However, West et al. (2003) found no significant difference in the annual household income between self-regulators and non-self-regulators. These studies received low NOS scores, ranged from 3 to 4. The correlation between low household income and self-regulation also contrasts with the qualitative findings of Donorfio et al. (2008), that older drivers report the high cost of alternative transport to be a major perceived barrier of self-regulation.

In regards to living arrangements, Charlton et al. (2006) reported that those who were not the principal driver of the household were more likely to report adoption of self-regulation. This finding is consistent with that generated from the qualitative study conducted by Donorfio et al. (2009; Table 6), that older drivers who live in two-person households were more willing to self-regulate. Contrastingly, Ragland et al. (2004) reported living arrangements did not differ significantly between participants who reported self-regulation and those who did not. Further, Braitman and McCartt (2008) reported participants who were single, divorced or widowed were 53% more likely to self-regulate than those who were married.

As can be seen in Table 6, the empirical evidence on employment status and adoption of self-regulation is scant. Braitman and Williams (2011; NOS score = 5) reported that those older drivers without employment and who relocated into retirement or family homes during the study period (4 years) drove less (distance per year) than those who remained employed and did not relocate. However, no employment status and residential locations effects were found when self-regulation was further defined as number of specific driving situations avoided. Braitman and Williams postulate that this is because participants who are unemployed and/or relocated have greater flexibility to limit their driving. This hypothesis is also consistent with findings from qualitative studies by Donorfio et al. (2008) and Rudman et al. (2006) (Table 6).
3.2.3.4.2. Health and Medical variables

Similar to research into older drivers’ driving capacity, Table 4 shows that visual and cognitive abilities remain the most investigated functional abilities in the current body of literature. The Useful Field of View (UFOV) test emerged as the most commonly used measure in investigating the effects of visual abilities and visual attention on older drivers’ adoption of self-regulation (Ackerman et al., 2011; Ball et al., 1998; Okonkwo et al., 2008; Ross et al., 2009; Vance et al., 2006). Other studies investigate visual abilities using a range of clinical instruments such as the Snellen Visual Acuity test and the Motor-Free Visual Perception Test (MVPT) (Ross et al., 2009; Loftipour et al., 2010; O’Connor et al., 2011; Vance et al., 2006; West et al., 2003). Self-reported visual abilities or impairments are also commonly used in the studies examined (Braitman & Williams, 2011; Charlton et al., 2006; Siren & Meng, 2012; Rimmo & Hakamies-Blomqvist; 2002; Ruechel et al., 2005; Sargent-Cox et al., 2010; Windsor et al., 2008). Regardless of measures used, studies examined uniformly demonstrated a significant negative correlation between visual abilities and adoption of self-regulation. However, it should be noted that while visually impaired drivers were more likely than their non-impaired counterparts to report self-regulation, a significant proportion of visually impaired drivers did not restrict their driving in difficult situations (Okonkwo et al., 2008; Ross et al., 2009).

In terms of cognitive functions, besides UFOV, a range of measures have been used to assess memory, processing speed and general cognitive functions, such as the Mattis Organic Mental Status Syndrome Examination (MOMSSE), the Modified Telephone Interview for Cognitive Status (TICS-M), Trail Making test, the Rivermead Behavioral Memory Test (RBMT) (Ackerman, 2011; Ball et al., 1998; Ross et al., 2009; Vance et al., 2006). Self-reported cognitive abilities are also adopted in the studies examined (Braitman & Williams, 2011; Kostyniuk & Molnar, 2008; Siren & Meng, 2012). Similar to visual abilities, decline (both in objectively assessed and self-report studies) in cognitive abilities is typically associated with increased self-regulatory practice. However, the positive associations between cognitive impairments and self-reported self-regulation must be interpreted with caution. Using objectively measured self-regulation as outcome measure, a recent case-control study by Crizzle et al. (2013; Table 5) demonstrated that while drivers with Parkinson’s Disease (PD) self-reported greater practice of self-regulation (69%) than healthy controls (42%), a significant proportion of PD drivers
(73%) drove in the situations that they self-report avoiding, thus questioning the validity of findings from studies that utilised self-report outcome measures. Further, while mild cognitive impairments among relatively healthy older adults demonstrated a direct, positive correlation between cognitive impairment and *self-reported* adoption of self-regulation, no existing studies have reported the self-regulation practices of drivers with more severe cognitive impairment. This paucity of research could be, in part, due to the difficulty in assessing accurate information regarding the driving practices of older drivers with more severe cognitive impairment.

Studies that investigated the relationship between other health conditions and overall health using self-reported items and older drivers’ adoption of self-regulation also demonstrated a significant positive relationship between these variables (Braitman & Williams, 2011; D’Ambrosio et al., 2008; Okonkwo et al., 2008; Windsor et al., 2008; Kostyniuk & Molnar, 2008; Ruechel et al., 2005; Sargent-Cox et al., 2011; Siren & Meng, 2013; O’Connor et al., 2012; Vance et al., 2005; West et al., 2003;). Other health conditions that have been found to influence older drivers’ adoption of self-regulation includes stroke, arthritis, hearing impairment, neck and trunk rotation, pain in limbs\(^{13}\) (Charlton et al., 2006; Ruechel et al., 2005; West et al., 2003). However, the strength of the relationships between these conditions and self-regulation remains inconsistent, and that the NOS scores of these studies are generally low (NOS < 4).

Finally, older drivers’ ability to acknowledge their health conditions appears to be an important mediating factor in the relationship between self-regulation and health conditions (Okonkwo et al., 2008; NOS = 5). This finding indicates that it is older drivers’ understanding of their health conditions, rather than their objective health levels, that influence their self-regulatory practices.

3.2.3.4.3. *Psychosocial variables*

Several, more recent, studies have investigated the psychosocial variables that underlie older drivers’ adoption of self-regulation (Blanchard & Myers, 2010; Gwyther & Holland, 2012; MacDonald et al., 2008; Meng et al., 2013; Windsor et al., 2008). Studies that used self-report self-regulation as outcome measure consistently demonstrate a

\(^{13}\) While neurological disorders such as Alzheimer’s and Parkinson’s Diseases have also been found to influence older drivers’ adoption of self-regulation, this is discussed in the cognitive ability section (2.4.5.7).
significant correlation between driver’s insight of functional abilities, perceived abilities, driving confidence and adoption of self-regulation. Indeed, Baldock et al. (2006) reported that driving confidence is a significantly stronger predictor of participants’ self-regulation than their driving abilities, as assessed by an independent driving instructor. Supporting the validity of these findings, Blanchard and Myers reported that participants who reported lower driving-related comfort and perceived driving abilities recorded less overall driving exposure, night driving and radii from home (i.e. travelled distance from home).

Based on the premise that one must have an accurate understanding of functional limitations before adopting appropriate self-regulatory strategies to compensate for these declines, MacDonald et al., (2008), Horswill et al., (2011) and Sullivan et al., (2001) (NOS = 3-4) demonstrated participants’ insight into their functional abilities and test performance to be significant predictor of their self-regulatory behaviours. A prospective cohort study by Ackerman et al. (2011; NOS = 7) demonstrated the importance of insight in older drivers’ self-regulatory practices through providing them with negative feedback about their UFOV performance, Ackerman et al. (2011) demonstrated a significant increase in self-regulation among those who failed the UFOV test at 3 months follow-up.

Besides insight, driving comfort and perceived driving abilities, Gwyther and Holland (2012) is the only study that has examined other psychosocial factors on older drivers’ adoption of self-regulation, demonstrating that affective and instrumental attitude mediate the well-established relationship between age and self-regulation. However, due to the lack of generalizability of sample and the use of self-report information as its only outcome measure, this study received a low NOS score (NOS = 2).

3.2.4. Discussion

The results of this systematic review demonstrate a diversity of study findings in regards to 1) the proportion of older drivers who self-report that they self-regulate their driving, and 2) the factors that correlate with their adoption of self-regulation. For instance, estimates of the proportion of older drivers who report adoption of self-regulation varies greatly, from as low as 25% to 80%. As none of the cohort studies reported percentage of self-regulating older drivers, comparison between any potential relationships between proportions of self-regulators and study designs was not possible.
Comparing the proportion of older drivers who report self-regulation was made more challenging by the different self-regulation scales adopted. For instance, while a number of studies used the Driving Habits Questionnaire (DHQ; Owsley et al., 1999), the methodology of data collection differed greatly. Specifically, several studies recorded responses through telephone or face-to-face interviews, whereas others were via written questionnaires. Further, instead of utilising the scale in its original form, studies such as Gwyther and Holland (2012) adapted only several items from the DHQ, making comparison of scale scores between studies difficult. Finally, due to the lack of studies that investigated objectively measured self-regulation, the current systematic review was only able to summarise the literature with self-report self-regulation in mind.

The studies included in the review also differed greatly in regards to the factors that correlate with older drivers’ adoption of self-regulation. The factors that received most consensus were age, gender, mileage, visual impairments, number of medical conditions and driving confidence. However, due to the diversity of data collection and analysis methods, the extent to which these factors, and the underlying process they influence older drivers’ self-regulation remains unclear. Using Structural Equation Modelling, Vance et al. (2006) demonstrated the interactive nature of these factors and the complex relationships some of these factors shared. However, Vance’s study did not include any psychosocial factors. Thus, the underlying mechanism through which demographics factors influence older drivers’ decisions to self-regulate remains unexplored.

Through systematically reviewing the current body of literature, several methodological limitations and knowledge gaps have been identified. These areas of research needs include improved study designs, data analysis methods, measurement of outcome variables and psychosocial factors of self-regulation. Further research addressing these issues is critical to better understand and promote the use of *appropriate* self-regulation within the older driver population.

3.2.4.1. Study design

The majority of studies examined adopted cross-sectional survey designs. Cross-sectional studies (especially using written questionnaires) allow cheap and efficient ways to simultaneously study multiple variables in a relatively large group of participants without experimental manipulation (Mann, 2003). However, direction of causality cannot
be established using cross-sectional methods. This is particularly pertinent in examining the complex relationships between some of the examined factors and their overall impact on older drivers’ adoption of self-regulation. For instance, direction of causality between adoption of self-regulation and annual distance travelled; driving experience, driving confidence and adoption of self-regulation, cannot be inferred from cross-sectional studies.

3.2.4.2. Data analysis issues

The potential multicollinearity between driving experience, age, number of medical conditions, gender and confidence is also not adequately addressed in most studies. The difficulty in establishing causality is compounded by the common use of relatively simple statistical techniques among the studies examined (e.g. Ball et al., 1998; Charlton et al., 2006; Ruechel & Mann, 2005; Kostyniuk & Molnar; Loftipour et al., 2010; Naumann et al., 2011; Siren & Meng, 2013; Tuokko et al., 2007).

The simple statistical techniques utilised (e.g. bivariate regressions and chi-squares) also cannot identify potential mediating or moderating effects of the variables of interests. This issue is problematic considering the often complex and dynamic nature of the factors involved in the aging process. As an illustration, while many of the examined studies report an apparent direct positive correlation between self-regulation and number of health and medical conditions, Okonkwo et al., (2008) demonstrated that it is older drivers’ understanding of their heath conditions, rather than their objective heath levels, that influence their self-regulatory practices. Okonkwo et al.’s findings illuminated the potentially mediating role of cognitive capacity and insight in the relationship between health conditions and self-regulation. Failing to examine any systematic interaction of particular combinations of factors may prevent the identification of salient factors of older drivers’ adoption of self-regulation, and potentially effective strategies in promoting such use.

3.2.4.3. Outcome Measures

A major limitation of the self-regulation literature is the diversity of measures used to assess the extent to which older drivers self-regulate. As noted in Table 4, some studies have used only one or two items to assess self-regulation, making it impossible to determine the psychometric properties (e.g. internal consistency and unidimensionality) of these measures. More recent studies assess levels of self-regulation based on multi-item,
often continuous, scales (e.g. DHQ); nonetheless, very few of these measures have been subjected to rigorous psychometric examination. Further, some studies only adapted several items from the DHQ. The diversity of measures utilised prevent accurate comparison between studies’ findings.

Historically within the traffic psychology literature, travel behaviour was established using self-report methods such as questionnaires, interviews and focus groups. Despite the apparent advantages such as cost-effectiveness and easier to obtain wider and larger sample sizes, these techniques rely on the participants’ ability and willingness to recall trip information, and are thus subject to a range of recall and social desirability biases (Lajunen & Summala, 2003). While it is important to have reliable measures of self-regulation, self-reported information needs to be validated against measures of objectively measured driving behaviours to ensure validity and reliability of results.

3.2.4.4. Psychosocial factors

There is a significant paucity of research addressing the psychosocial influences on older drivers’ adoption of self-regulation. Specifically, besides driving confidence and perceived driving abilities, only one study, rated as low quality using the NOS scale, investigated the psychosocial influences that underlie older adults’ driving self-regulation (Gwyther & Holland, 2012). Thus, the underlying mechanism between demographics and health-related factors and resulting self-regulation remains unexplored. As an illustration, Okonkwo et al. (2009) demonstrated that while high-risk drivers are more likely to practice self-regulation than their low-risk counterparts, a significant proportion of high-risk drivers do not self-regulate. Besides acknowledgement of their health conditions, studies have yet to investigate other factors that influence high-risk older drivers’ against self-regulation. Gwyther and Holland (2012) demonstrated the potential importance of psychosocial variables by demonstrating the mediating effects of affective and instrumental attitude on the well-established relationship between age and self-regulation.

One important role for psychosocial variables may be in the promotion of appropriate use of self-regulation to older drivers. Previous research on behaviour change (e.g. smoking cessation, exercise and risky driving behaviours) has demonstrated that understanding the psychosocial factors that underlie the behaviour is important, if behaviours are to be modified. Further, without accurate understanding of the
psychosocial variables that underlie older drivers’ adoption of self-regulation, interventions may be ineffective in producing enduring behavioural changes.

3.2.5. Conclusion of current self-regulation studies

In summary, the results from this study do not form a consistent picture of older drivers’ use of self-regulation and the underlying factors of their decisions to self-regulate. Research with more refined and rigorous methodology (e.g. multilevel statistical modelling, objectively measured self-regulation) is needed to better understand the self-regulatory behaviours of older drivers. Further, there is a pressing need to better understand the psychosocial factors that influence older drivers’ self-regulation. Advancement in these research areas would assist in identifying salient groups and modifiable factors for the development of effective interventions to promote self-regulation.
4.1. Introductory comments

This chapter reviews the existing older driver behaviour models and a variety of self-regulation models that have been proposed to facilitate health behaviour change. This chapter then presents the new Multilevel Older Person’s Transportation and Road Safety Model (MOTRS), developed to provide a theoretical model to rigorously investigate older drivers’ adoption of self-regulation, with a particular focus on the psychological processes that underlie this behaviour. This model was intended to build the foundation for the remainder of the research program.

The current chapter consists of two sections. The first section presents a brief overview of current older driver behaviour and general health behaviour change model, with the primary purpose of reviewing their strengths and weakness in accounting for older drivers’ self-regulation. The second section presents the overall structure and theoretical assumptions of the MOTRS model. This section then presents an overview of the factors within the model and how they are anticipated to influence older drivers’ adoption of self-regulation.

4.2. Models of older driver behaviours

As demonstrated by the systematic review (study 1A), older drivers’ use of self-regulation is influenced by a wide range of demographic, social and environmental factors, which are not directly related to actual driving abilities. Following the recent increase of research activity into older driver safety, several older adults’ driving behaviour models have been proposed to explain older driver’s driving behaviours.

Early general driver models such as Michon’s (1985) hierarchical model (Figure 4) typically provided somewhat simplistic views of driver’s competence and failed to account for the impact of the various environmental and personal factors that may impact upon older drivers’ driving behaviours, particularly their self-regulation and subsequent changes in driving exposure. For instance, it has been demonstrated that older drivers may continue to drive in situations where they believe they are beyond their capabilities and confidence if their ‘significant other’s rely upon them
for transportation (Rothe, 1992). The diversity of older drivers’ needs and challenges necessitates the need for a model of self-regulation that is capable of explaining the complex, dynamic and systematic interactions between the various factors discussed above, as well as generate testable hypotheses about these factors.

Figure 4: Michon's Hierarchical Driver Behavior Model (Michon, 1985)

The Multifactorial Model of Older Driver Safety (Anstey et al., 2005) provided the first older driver behaviour model specifically for older drivers (see Figure 5). Anstey’s model forms a foundation for understanding both older drivers’ capacities (e.g. cognitive, visual and other physical abilities) and driving style (i.e. self-monitoring behaviours and beliefs about driving), as well as illuminating the potential use of self-regulation in managing older driver safety. Further, Anstey’s model indicated the interactive nature of the factors that influence older adults’ driving behaviours. However, Anstey et al.’s model did not consider how environmental factors (e.g. availability of alternative transport, community resources) and personal factors (e.g. individual’s internal beliefs and attributes) influence older drivers’ driving behaviours. Further, Anstey’s Multifactorial Model of Older Driver Safety lacked operationalization of the factors involved and specificity for the relationships between them.
Figure 5: the Multifactorial model of Older Driver Safety (Anstey et al., 2005)

The Driving as an Everyday Competence (DEC) model (Lindstrom-Forneri, Tuokko, Garrett & Molnar, 2010; see Figure 7) improves upon previously developed models of older driver’s driving behaviours by incorporating the influence of sociocultural factors (e.g. availability of alternative transportation options) and psychosocial factors (e.g. beliefs about driving). The interactive factors and the inclusion of psychosocial factors present a clear conceptual advantage over previous older driver behaviour models. However, the DEC lacks specificity regarding its factors and the relationship between these factors (e.g. how it is defined and how it can be measured), decreasing its ability to formally test systematic interactions between factors. Further, the mechanism with which the individual and environmental factors interact was not specified. Finally, the explanation for the selection of factors, and the empirical evidence for the importance of these factors on driving behaviours were inadequate.
While some theoretical models have been put forward in the transportation and aging literature to account for older drivers’ driving behaviours, none of these models have been explicitly tested. Further, these models are mostly linear-regression based models that are not dynamic, limiting their abilities to account for the systematic interactions between the factors that influence older drivers’ adoption of self-regulation. Nevertheless, the progression of these older driver behaviour models reflects the overall need to incorporate the interaction of socio, environmental, and personal factors on older adults’ driving behaviours.

4.3.5. Health Behaviour Models and Self-regulation of Driving

To date, the Theory of Planned Behavior (TPB) (Ajzen, 1985, 1988, 1991) remains the only health behaviour model that has been applied to older driver’s driving behaviours. The Theory of Planned Behavior (TPB) (Ajzen, 1985, 1988, 1991) assumes that people make rational decisions about their behaviours based on their attitudes and beliefs about the behaviour. TPB states that behavioural intentions are formed through three sets of attitudes and beliefs: 1) attitude towards the behaviour, 2) subjective norms, and 3) perceived behavioural control.

While Lindstrom-Forneri et al. (2007) reported TPB variables accounted for 30% of the sampled participants’ intention to change their driving behaviours, these
variables have yet to be modelled on older drivers’ adoption of driving self-regulation (self-reported or objectively measured). Both other health behaviour models, such as the Health Belief Model (HBM) and the Transtheoretical Model of Behaviour Change (TTM) contain variables that could influence older drivers’ adoption of self-regulation. These variables include self-efficacy, perceived severity and barriers, cues to action and the dynamic nature of behaviour change. While neither HBM nor TTM has been modelled on older drivers’ self-regulation, their application towards other self-regulating health behaviours such as dieting and physical exercise warrants empirical attention towards these variables within the older driver context. The examination of these factors in the older driver context may offer complimentary evidence in the identification of self-regulatory factors, particularly psychosocial factors, which have been demonstrated to be lacking in the current body of older driver self-regulation literature.

4.4. Developing a new Multilevel Older Person’s Transportation and Road Safety Model

Until now, there has been little theoretical advancement in our understanding of the mechanism that underlies older drivers’ driving style, in particular their decisions on whether, and to what extent, they self-regulate. The Multilevel Older Person’s Transportation and Road Safety Model (MOTRS; Figure 7) was developed to account for older drivers’ self-regulatory driving behaviours. The MOTRS model advances the current self-regulation literature both theoretically and methodologically through 1) providing a theoretical model to empirically predict older drivers’ adoption of self-regulation, and 2) addressing the methodological issues identified from the systematic review of the current literature.
As previously noted, self-regulatory practice is considered important in managing the older driver cohort through its use to 1) maintain driver safety, 2) sustain functional mobility, and its potential to 3) be applied as a general safety strategy in reducing risk exposure. The MOTRS model defines driving self-regulation as a-priori, situational specific, self-restrictive driving practices, such as avoidance of driving at night, in the rain, on expressways and during peak traffic hours. The MOTRS is a multilevel model that incorporates factors found in the previous systematic review to influence older drivers’ adoption of self-regulation. The MOTRS model also contains relevant components of health behaviour models such as affective and instrument attitudes, subjective norm, perceived behavioural control, self-efficacy, perceived barriers to action and cues to action. The MOTRS model is categorized into socio-demographic and driving specific variables, psychosocial factors, and self-regulatory driving behaviours (outcome variable).

As discussed, none of the existing models focus on driving self-regulation, an important precursor to driving cessation, and a behaviour that holds promise to improving the safety and extending the functional mobility of older adults. Additionally, previous models do not consider the influence of both psychological and social factors or illustrate any dynamic interactions between these constructs. Finally, none of the existing models of older driver safety allow model specification and testing of any systematic interaction between these factors.

Compared to other previously mentioned models of older driver safety, the MOTRS model is intended to focus on older drivers’ practices of self-regulation, and considers driving skills (or driving competence) as a latent variable that is not directly...
measurable. This is because one’s driving skills continuously varies depending on changes to personal and environmental factors. For instance, a driver who is experiencing reduced cognitive capacities due to an undiagnosed sleep disorder may have a lower level of driving skills, especially when the driver lacks insight into his condition and continues to drive in situations that exerts high attentional demands. However, the drivers’ behaviours would change if any changes occur to the following factors: increased insight into reduced cognitive capacity and self-regulate to only drive in confident road situations; receive medical treatment and reverse the effects of his/her conditions; increase use of alternative transportation options.

Indeed, some functional abilities critical to driving performance, such as cognitive abilities and hazard perception abilities, have been demonstrated to be quite malleable and responsive to intervention that involves intensive training (e.g. Cassavaugh & Kramer, 2009; Horswill et al., 2010). Empirical evidence suggests improvement on cognitive tasks following cognitive training is associated with improved performance on simulated and on-road driving activities (e.g. Cassavaugh & Kramer, 2009; Marottoli et al., 2007). Similarly, a recent meta-analysis reported cataract surgery to be associated with 88% reduction in risk of driving-related difficulties, supporting the efficacy of remedial treatments to improve driver safety among older drivers (Subzwari, Desapriya et al., 2008).

4.5. A connectionist model of Self-regulation

The MOTRS model adopts a connectionist framework (also termed Parallel Distributed Processing or PDP) (McClelland & Rumelhart, 1985). Connectionist frameworks, originally developed as neural network models within the field of cognitive psychology, has been successfully applied and empirically validated to explain and predict observations in areas such as language processing, memory, cognitive dissonance and cognitive development (Rogers & McClelland, 2004; Seidenberg & Zevin, 2006; Shultz & Lepper, 1996; Van Overalle & Labiouse, 2001).

Due to its novel ability to account for the dynamic interactions between factors, the connectionist framework has received increasing interest within the field of social psychology (Overwalle & Siebler, 2005). Connectionist approaches have been applied to a diverse range of social psychological phenomena such as impression formation
(Smith & DeCoster, 1998; Van Overwalle & Labiouse, 2004), causal attribution (Van Overwalle; 2007; Read & Miller, 1998), group formation and biases (Kashima & Kereke, 1994; Queller & Smith, 2002).

Through adopting a connectionist approach, the MOTRS model possesses several important characteristics that is intended to address gaps identified in earlier older driver models by accounting for older drivers’ self-regulation as well as addressing the methodological limitations highlighted in the above systematic review. It should be noted, that while connectionist models are typically tested using computational modelling techniques, the preliminary investigations of the MOTRS model within this research program were conducted using a regression-based approach, which is more conventional within the domain of health psychology. Eventually, a computational approach in testing the MOTRS model will be required to model outcomes from different legal or social intervention. For detailed information of connectionist networks and their applications, see McClelland, (1988) and Rumelhart, Hinton and McClelland, (1986). These characteristics are detailed below.

4.5.1. Parallel Excitatory and Inhibitory activation of units

In contrast to the inherently sequential processing of traditional older driver models, the MOTRS model assumes that each input would generate simultaneous excitatory and inhibitory activation into the network. These activation signals flow directly from socio-demographic to Driving-specific factors, followed onto the psychosocial factors, determining older drivers’ self-regulatory behaviours. Put simply, the MOTRS model assumes that older drivers’ self-regulatory behaviours are determined by a combination of excitatory and inhibitory activation received from various individual and environmental factors, through their collective influence on their psychosocial variables.

As an illustration of this premise in Figure 8, the relocation to an urban area, at the individual socio-demographic factor level, would generate excitatory (i.e. positive) activation to factors at the Driving-specific input unit level, such as better road conditions and increased availability of alternative transportation options. Simultaneously, the relocation from existing social networks would also generate
inhibitory (i.e. negative) activation to factors such as decreased availability of driving partners. These activations would then travel in a forward manner in the model, and provide simultaneous excitatory and inhibitory activation to psychological factors, such as changes in the instrumental attitude of the vehicle, ultimately determining older drivers’ decision to self-regulate. As such, information is not inputted into the network in a sequential manner like most existing models. Rather, input is distributed to all parts in the network at once in a parallel, simultaneous manner.

Figure 8 Example of the excitatory and inhibitory activation network of MOTRS. Red arrows represent excitatory (i.e. positive) activation; blue arrows represent inhibitory (i.e. negative) activation

This parallel distribution of excitatory and inhibitory activation is necessary in the older driver context to account for the complex interaction, particularly mediating and moderating relationships, between factors observed in the current literature. By allowing specification and testing of complex interactions between factors, this characteristic also addresses a major limitation identified from the systematic review. Unlike previous driver models that typically adopt serial pathways of information processing, the MOTRS model views older drivers’ self-regulation is a result of complex interactions between multiple input units, operating in a parallel manner.

4.5.2. The process of learning

Further, and more importantly, there is abundant behavioural and neurological evidence that we are capable of learning (and re-learning) over time. Perhaps because
they are often developed using information contained from cross-sectional surveys, most current driver behaviour models, and traditional health behaviour models, are based on unidirectional causal pathways (Smith, 1996; 2009). For instance, the TPB holds that beliefs cause attitudes, which influence behaviours through intentions. The lack of mechanism for updating existing pathways implies that our attitudes and beliefs are fixed and are resistant to change. However, there is abundant empirical evidence that behavioural influences are seldom unidirectional. While attitudes can influence behaviour through a bottom-up processing approach, behaviour can also cause changes in beliefs and attitudes through top-down processing. One such example is the well-established phenomenon of cognitive dissonance, that is the change in one’s beliefs and attitudes to avoid disharmony, or dissonance (Festinger, 1957). Indeed, there is evidence of this top-down processing in road safety relating to drink driving. An example within the older driver context is that a ‘near-miss’ could influence the driver to reconsider their beliefs about their driving abilities. Indeed, one could argue that the use of self-regulatory strategies in face of increased functional impairments is a direct result of adaptive learning. Thus, the fixed nature of existing models represents a significant limitation to accounting for older drivers’ adoption of self-regulation.

The MOTRS model accounts for the process of learning through the use of bidirectional causal pathways, particularly at the level between self-regulatory behaviours the psychosocial factors. These bi-directional pathways allow learning to occur whenever error responses (e.g. a ‘near-miss’) are noted and sent back through the network, a process called back propagation (McClelland & Rumelhart). Specifically, back propagation occurs when erroneous signals are sent back to the model to provide information on how the pathway weights between factors should be changed (e.g. a reduction Perceived Behavioural Control – “maybe I am not controlling the vehicle as well as I thought I was”). Consistent with the notion that attitudes and beliefs can be modified through back propagation, when compared to current older drivers, older ex-drivers reported more positive attitudes towards driving cessation (Edwards, 2009). This change in attitudes following driving cessation demonstrates the dynamic interaction between behaviours and attitudes.
**4.5.3. Incremental learning through increased accessibility of pathways**

In addition to explaining the changes of attitudes and beliefs using back propagation, the MOTRS model also accounts for the incremental process of such changes. In a connectionist network, the recency and frequency with which a pattern has been activated influence the ease and speed of subsequent activation when elicited by similar cues. This assumption is based on the incremental nature of the learning process (Smith, 1996). Thus, when a stimulus is introduced, learning changes weight of related activation pathways, making the current and similar pathways easier to reproduce in the future, sometimes at the expense of other unrelated pathways.

Consider the example provided above, as a result of the recent relocation to an urban area, the pathways between availability of alternative transportation option-instrumental attitude of vehicle-self-regulation pathways would be activated. The frequent access of this pathway via increased use of public transportation system would strengthen this pathway, thereby increasing the weight of this pathway. This learning process might be to the detriment of other, less used pathways, such as the connection between availability of driving partners, instrumental attitude and self-regulation. Put simply, over time, the availability of alternative transportation option may become a stronger predictor of self-regulation behaviour then the availability of driving partners. This novel prediction of the importance of recent and frequent exposure, though common among connectionist models, is not intrinsic to most theoretical frameworks within the transportation, aging and social psychology literature.
4.6. Overall structure of the MOTRS model

The MOTRS model is proposed as a hierarchical multilevel model. This model consists of four levels: 1. Socio-demographic variables, 2. Driving-Specific variables, 3. Psychosocial variables and 4. Self-regulatory Driving Behaviours.

Briefly, Socio-demographic variables are encompassing factors that influence many aspects of older drivers’ daily living and provide endogenous, unidirectional input into the model. Driving-specific variables are factors that are specifically related to older drivers’ driving-related activities. Both Socio-demographic and Driving-specific variables categorize factors at the individual and environmental levels. The central premise of the MOTRS model is that socio-demographic and Driving-specific variables influence older drivers’ self-regulatory driving behaviours through their psychosocial influences. The following section explains each level of factors, following a concise explanation of the inclusion of these factors. For clarity, the following section briefly reiterates the factors that have been discussed in the systematic review of the previous chapter.

4.6.1. Socio-demographic variables

Socio-demographic variables refers to both individual and environmental variables that impact upon the various aspects of older drivers’ daily activities, but are not specifically related to their self-regulatory driving practices. These variables include individual factors such as health and medical conditions, and environmental variables such as urban density and community resources.

4.6.1.1. Individual variables

Besides age-related changes in sensory, cognitive and physical functioning, other general individual factors have been found to influence older drivers’ daily activities and decisions to self-regulate.

Gender

As identified in the previous systematic review, the most consistent general individual predictor of self-regulation is gender, with female drivers adopting more restrictive driving behaviours than men. Kostyniuk and Molnar (2005) reported that
the effect of gender on self-regulatory driving practices was greater than that of age and physical functioning.

However, recent studies have suggested this to be a cohort effect, since older generation of women have less driving experience than their male counterpart (Kostyniuk & Shope, 1998; Marotolli et al., 1993; Rosenbloom, 1993), and generally feel less confident about their driving abilities than men (e.g. Blachard & Myers, 2010; Gwyther & Holland, 2012; Myers et al., 2008; 2011; Tuokko et al., 2007; 2012). The hypothesised gender – driving experience – driving confidence – self-regulation relationship is also consistent with the previously noted empirical evidence on the importance of driving confidence on self-regulatory practice. Nonetheless, this pathway has yet to be rigorously explored.

\textit{Age}

As identified in the systematic review, driving self-regulation typically increases with age. However, the general effect of age on self-regulation should be interpreted with caution. Studies have yet to identify whether the effect of age is a cohort effect, as the old-old (>80 years of age) are more likely to have greater number of (and more severe) medical conditions than those who are young-old (60-69 years of age). Through the use of hierarchical path analysis, Rimmo and Hakamies-Blomqvist (2002) demonstrated older drivers’ self-reported health condition (and aberrant driving behaviour) contributed an extra 10% explanatory power towards their self-regulation. Further, the age effect may also be due to change in life conditions. Specifically, those who are over the age of retirement may have an advantage to choose driving times and conditions compared to their young-old drivers who remain in the workforce.

\textit{Health conditions}

As previously identified, health conditions (self-reported) and self-rated overall health are predictive of older drivers’ decision to self-regulate. Perhaps in response to the emphasis on visual ability in ABT requirements, older drivers who reported visual impairments are more likely to hold negative perceptions of their driving abilities and therefore adopt self-regulation compared to older drivers who
suffers from other health conditions such as mobility issues (Kostyniuk & Molnar, 2008; Tuokko et al., 2012). Further, older drivers’ ability to acknowledge their health conditions have been identified to be an important mediating factor in the relationship between self-regulation and health conditions.

Health literacy

Appropriate use of self-regulation requires older drivers to have the knowledge of factors that may place them at greater crash risk. Older drivers’ capacity to self-regulate may be influenced by older adults’ health literacy, that is, their knowledge of 1) the effects of health conditions on driving safety, and 2) the effects of the medications used to treat these conditions (i.e. health literacy) on driving safety. Indeed, interventions which focus on raising older driver’s awareness of the effects of medical conditions, medications and functional impairments on driving performance have been demonstrated to result in increased self-regulatory driving behaviours among older drivers (Eby et al., 2003; Owsley et al., 2003).

A recent study by Sargent-Cox, Windsor and Anstey (2010) reported that despite 74.4% of those who reported at least one medical condition (n = 129) have adapted their driving as a result of their condition(s), up to 85.7% of these participants reported not receiving advice about the potential effects of their medical condition on their driving ability from their physicians. Further, Sargent-Cox et al. reported no significant interactions between having a medical condition and health literacy, indicating the observed influence of medial conditions on self-regulation to be mediated by factors other than health literacy.

Cognitive abilities

As identified from the systematic review, cognitive ability has been demonstrated to be an important factor of older drivers’ adoption of self-regulation. Though included in the MOTRS model, it should be noted that rigorously assessing older drivers’ levels of cognitive ability is outside the scope of the current program of research.
Financial resources

Previous research has identified the high costs associated with using alternative transportation options to be a main perceived barrier to alternative transport use for older drivers (Allan & McGee, 2003; Kostyniuk & Shope, 2003).

Residential area

Rural areas typically have limited alternative transportation options other than private vehicles. Rural older drivers have been demonstrated to retain their license longer than those reside in urban areas (Hilderbrand & Myrick, 2001). Further, Hilderbrand and Myrick reported that compared to urban older drivers, those who reside in rural areas recorded increased driving exposure in terms of total daily travel time, daily distance and average speed travelled. While the relationship between older drivers’ adoption of self-regulation and the urban density of their residential locations has not been directly examined, the lack of alternative transportation options and increased proximity to amenities in rural areas would presumably limit their ability to self-regulate.

Employment status

As discussed, older drivers who remain in the workforce maybe required to drive in road conditions they would otherwise avoid, decreasing their capacity to self-regulate. To date, empirical evidence on the relationship between employment status and self-regulatory behaviours is remains inconclusive.

4.6.1.2. Driving-Specific variables

Driving-specific variables refer to individual and environmental factors that directly influence older drivers’ driving activities. These factors include individual factors such as availability of driving partners and environmental factors such as proximity to amenities.
4.6.1.2.1. Individual driving-specific parameters

Availability of driving partners

While studies have speculated that drivers who live in 2-person households might have greater flexibility to self-regulate, empirical data to date have revealed inconsistent results regarding the relationship between living arrangements and self-regulation.

Proximity to amenities

Preliminary evidence provided by qualitative studies has demonstrated that proximity to amenities may be a contributing factor to older drivers’ adoption of self-regulation. Intuitively, the ability to readily access amenities may decrease to instrumental value of driving and provide greater flexibility to self-regulate.

4.6.1.2.2. Environmental driving-specific parameters

Availability of public transport

The lack of acceptable public transportation has been identified from qualitative studies to be a contributing factor on older drivers’ reluctance to restrict or retire from driving. Presumably, the presence of acceptable alternative transportation options is paramount to maintain older adults’ quality of life if they were to restrict or retire from driving.

Road conditions

Participants from qualitative studies have highlighted the effects of road conditions on their decisions to self-regulate. Specifically, poor road conditions (e.g. dimly lit roads) have been mentioned as one of the contributing factors towards their decisions to drive less at certain times of day.
Social beliefs regarding aging drivers and their abilities

Social beliefs about aging drivers have also emerged from qualitative studies to be a contributing factor of older drivers’ decision to drive. Specifically, participants have reported being more cautious as a result of these, often negative, opinions.

ABT requirements

As demonstrated above in section 2.3.1.3, Charlton et al. (2006) reported that older Victoria drivers (no ABT) were more likely to practice self-regulation when compared with ACT and NSW drivers (jurisdictions with ABT). Charlton et al postulate the reduced rate of self-regulating older drivers within ABT jurisdictions could be due to their (and their family members’) reliance upon ABT results as indicators of driving capacity. To date, the study by Charlton et al. remains the only study that has investigated the relationship between adoption of self-regulation and ABT requirements.

4.6.2. Psychological variables

Psychological variables are factors that mediate the effects of Socio-demographic and Driving-specific variables on self-regulatory behaviours. Previous research on behaviour change (e.g. smoking cessation, exercise and risky driving behaviours) has demonstrated that understanding the psychosocial factors that underlie the behaviour is important, if behaviours are to be modified. As previously noted, besides insight and driving confidence, there is a significant paucity of research into the psychological factors that influence older drivers’ self-regulation. To address this literature gap, the current program of research will use the MOTRS model to investigate 1) the psychosocial variables that underlie older drivers’ self-regulation, 2) the extent these factors predict older drivers’ self-reported and objectively measured self-regulation, and 3) the underlying mechanism with which these factors influence their self-regulation.

Insight

As discussed above, older drivers’ insight into their functional abilities has been demonstrated to significantly predict their self-regulatory driving behaviours.
This is based on the premise that one must have an accurate understanding of the functional limitations before they can adopt appropriate self-regulatory strategies to compensate for these declines.

*Driving confidence*

Studies of the systematic review consistently demonstrated driving confidence to be an important factor of older drivers’ adoption of self-regulation. However, the hypothesized insight – confidence – self-regulation meditational relationship has yet to be empirically tested. Thus, this program of research will test this proposed meditational relationship and its relation with other factors associated with self-regulation (e.g. community resources). The current study will also test this proposed meditational hypothesis, in conjunction with other factors that influence drivers’ self-regulation, and its relation to actual driving self-regulation, which to the authors’ knowledge, has not been investigated in the transportation and aging literature.

*Driving-related attitudes and beliefs*

Driving related self-regulation includes a number of aspects that are similar to other health protective behaviours (e.g. exercise, dieting and binge drinking), such as active planning and preparation of trips, as well as a-priori arrangements to reduce exposure of potentially risky situations. Conceptualising self-regulation as a general risk reduction strategy, emerging research have proposed applying theoretical decision making models about risky health behaviours to better understand self-regulatory driving behaviours (Gwyther & Holland, 2012; Lindstrom-Forneri et al., 2007).

The theory of planned behaviour (TPB; Ajzen, 1985; 1991) has been applied to predict the self-regulation of a range of health behaviours (e.g. exercise, dieting, binge drink, smoking cessation and risky sexual behaviours) (see Armitage & Conner, 2001, for a meta-analytic review). Presumably, older drivers’ beliefs and attitudes about the driving task may influence their decisions to self-regulate. Indeed, Lindstrom-Forneri et al. (2007) demonstrated older drivers’ beliefs and attitudes about driving (as measured via TPB factors) accounted for approximately 30% of their intention to continue driving in the foreseeable future. Similarly, Gwyther and Holland (2002) found affective attitude and instrumental attitude significantly
correlated with drivers’ (self-report) self-regulation, irrespective of genders. However, other factors of TPB (perceived behavioural control and subjective norm) were not assessed in this study. Further, components of TPB have not been tested against objectively measured driving self-regulation.

4.7. Outcome variable: Self-regulation

Self-regulation is the action resulting from the interactive activations of the Socio-demographic, Driving-specific and Psychosocial variables. Figure 9 below presents the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model in full, integrating the factors drawn from the systematic review. Most of the factors identified above, and the empirical evidence associated with these factors, are generated from self-report measures of self-regulation. Consequently, the current MOTRS model is developed initially with self-reported self-regulation as the primary outcome measure. However, since the ultimate goal of this model is to predict and facilitate the promotion of actual self-regulation, the current MOTRS model will also be tested against objectively assessed self-regulation. This is particularly important given the evident disparity between self-report and objectively measured self-regulation emerged from the systematic review (Study 1A).
Chapter summary

The MOTRS model addresses the knowledge gap in the driving and aging literature for a comprehensive model of self-regulation (Dickerson et al., 2007). As identified by the Transportation and Aging Interest Group of the Gerontological Society of America (GSA), there is a critical need for a theoretical model that considers the driver, the environment, and the interaction between the two, as well as self-beliefs and societal influences. As previously discussed, the MOTRS model incorporates all of these aspects, as well as salient factors that have been identified in the existing literature of health behaviour change, such as perceived behavioural abilities and behavioural attitudes.

In addition, the MOTRS model is the first older driver self-regulation model that systematically incorporates the necessary factors and assumptions identified from the systematic review, and other health-behaviour factors that have found potential to be important predictors of self-regulation. The MOTRS model is also the first model...
to comprehensively assess older driver’s psychosocial factors and its relationship to their self-regulation, a significant literature gap identified in the Dickerson et al. (2007) review of the current driving and aging literature. Most importantly, the MOTRS model goes beyond the existing, mostly descriptive, models. It allows the generation of specific and testable pathways about the dynamic interactions of factors within the model. These theoretical and methodological strengths allow the model to better account for the adoption of self-regulation of older drivers, representing significant advancement of the older driver literature.
Chapter 5: Study 2 – examining older adults’ driving self-regulation

5.1. Introductory comments

The previously chapters provided a systematic explanation of the potential factors that influence older drivers’ adoption of self-regulation (Chapter 3). Further, they introduced a new theoretical model, the Multilevel Older Person’s Transportation and Road Safety Model (MOTRS), which incorporated these factors and the characteristics (Chapter 4). Building on that foundation, this study is a quantitative investigation to formally test the pathways of the proposed MOTRS model, focusing on how a broad range of individual and psychosocial variables influence the adoption of self-regulation.

The results of this study are presented across two chapters, Chapter 5 and 6. This chapter presents the results regarding older adults’ self-report driving self-regulation, and the relationship between self-regulation and various Socio-demographic, Driving-specific and Psychosocial variables drawn from the systematic review in Chapter 3. The following chapter, Chapter 6, expands upon these findings, and examines the structural nature of the MOTRS model.

5.2. Purpose of the Study

As discussed in Chapter 3, the proportion of older drivers who adopt self-regulation remains uncertain. Further, there is a general empirical inconsistency regarding the factors that contribute to older drivers’ adoption of self-regulation.

The Multilevel Older Person’s Transportation and Road Safety (MOTRS; Chapter 4) model was proposed as a theoretical model that integrates factors that contribute to older drivers’ adoption of self-regulation. The model provides a foundation for formally testing these factors, and their dynamic interactions. Simultaneous testing of these factors is critical to understanding the relative importance and interaction between these factors, as well as the potentially mediating (and moderating) influence of these factors on older drivers’ self-regulation (detailed in section 3.2.4). Better understanding of the factors, particularly modifiable psychosocial factors that underlie older drivers’ adoption of self-regulation is pertinent
to promote appropriate and more widespread use of self-regulation use among this cohort of drivers.

Using a cross-sectional survey of older drivers recruited throughout Australia, this study was intended to simultaneously measure individual, environmental and psychosocial variables on older drivers’ adoption of self-regulation. This has not been done previously: other studies have typically focused on one type of variable, or a limited number of variables at a time. This study contributes to the empirical and theoretical understanding of older drivers’ self-regulation by clarifying the empirical inconsistencies discussed in the systematic review, and by formally testing the MOTRS model that incorporated these variables. Further, this study explores ways to effectively promote appropriate use of self-regulation among older drivers and the potential barriers to educational interventions among this cohort.

5.3. Study aims

This study presents quantitative examination of the factors that underlie older drivers’ adoption of self-regulation, and the transportation needs and challenges of older drivers. The current study addresses the second question of the research program (detailed in section 2.5): what are the personal, social, situational factors that contribute to self-regulation of older adults? In addition, through sampling older adults’ transportation needs and preferences of delivery content and context of future interventions, this study also addresses the last research question: How can we improve older adults’ practice of driving related self-regulation?

Specifically, this study aims to:

1) Characterize the main factors that are likely to influence older drivers’ adoption of self-regulation (discussed in Chapter 3);

2) Examine the psychosocial variables that contribute to older drivers’ adoption of self-regulation;

3) Quantifying the relative importance of these factors on older drivers’ self-regulation; and

4) Formally test the pathways of the proposed MOTRS model
5.4. Study hypotheses

A number of hypotheses were developed from the systematic review, research questions, and theoretical basis provided by the MOTRS model (detailed in section 4.5.). Following the structure of the MOTRS model, the hypotheses were categorised into Socio-demographic factors, Driving-specific factors, Psychosocial factors, overall structure of the MOTRS model, and interaction between factors. It should be noted that due to the scope of the current research, not all components and pathways of the MOTRS model were formally tested within this study. Factors that could not be assessed using cross-sectional survey methodology, such as road conditions and proximity to amenities, were therefore not included in the formal measurement model.

**Overall structure of the MOTRS model**

The first and primary hypothesis was developed based on the overall structure of the MOTRS model (detailed in section 4.5.). It should be noted, that as this is the first experiment to examine the MOTRS model, this hypothesis was comparatively less specific than the ones outlined below, and concerns only the overall structure of the model.

*H1: Psychosocial variables will mediate the effects of Socio-demographic and Driving-specific variables on Self-regulation (see Figure 10 below). As such, the correlations between psychosocial variables and levels of self-regulation will be greater than the correlations between Socio-demographic, Driving-specific variables and self-regulation (specific pathways of these variables will be tested in the following chapter).*

Figure 10: Hypothesized overall structure of the MOTRS model

**Psychosocial factors**

Seven hypotheses on the relationship between psychosocial filters and participants’ report of self-regulation were proposed. Due to the lack of existing
studies in this area at the time of writing this thesis, the hypotheses outlined below were based on the research aims, and were mostly exploratory in nature.

\[ H_2: \text{Driving confidence will be negatively correlated with self-regulation (self-report)} \]

\[ H_3: \text{Perceived behavioural control of the vehicle will be negatively associated with levels of self-regulation (self-report), such that older drivers who have low perceived behavioural control over driving will be more likely to self-regulate} \]

\[ H_4: \text{Subjective norms will be associated with levels of self-regulation, such that greater perceived social reliance on driving will be negatively associated with self-report levels of self-regulation} \]

\[ H_5: \text{Instrumental and affective attitudes will be associated with (self-report) self-regulation, such that more positive attitudes towards driving will be associated with less self-regulation} \]

\[ H_6: \text{Intention to change driving behaviours will be negatively associated with (self-report) self-regulation, such that those who have less intention to continue driving will be more likely to self-regulate} \]

\[ H_7: \text{Instrumental and affective attitudes, perceived behavioural control and subjective norm will be negatively associated with participants’ intention to change driving} \]

\[ H_8: \text{Cues to action will be positively correlated to (self-report) self-regulation, such that participants who report cues to self-regulation will be more likely to self-regulate} \]

**Socio-demographic variables**

Six hypotheses on the relationship between individual variables and participants’ self-reported self-regulatory practice were proposed. These hypotheses were based on the findings from the systematic review detailed in section 3.2.3.4.
H9: Age and gender will be significantly related to self-reported self-regulation, such that participants who are older and female will report greater self-regulation.

H10: Drivers who report greater number of health conditions, particularly those who report visual impairments, will report greater self-regulation.

H11: While participants with MCI were hypothesised to report greater level of self-regulation; those with more severe level of impairment are hypothesised to report lower levels of self-regulation.

H12: Participants who report greater confidence in their financial income will report greater self-regulation.

H13: Participants who reside in urban areas will report greater self-regulation.

H14: Participants who were not employed full-time will report greater self-regulation.

**Driving-specific parameters**

Two hypotheses on the relationship between Driving-specific variables and participants’ report of self-regulation were proposed. These hypotheses were based on the findings from the systematic review, detailed in section 3.2.3.4.

H15: Participants who report greater dependency on other drivers will report greater self-regulation

H16: Participants who report more positive attitudes, and usage, of alternative transportation will report greater levels of self-regulation

**Interaction between factors**

Four hypotheses regarding the interaction between individual, Driving-specific and psychosocial factors were proposed. These hypotheses were on the findings discussed in the systematic review (detailed in section 3.2.3.4.). Due to the prior investigations on the interactions between these factors and older drivers’ self-regulation, the following hypotheses were largely exploratory in nature.
$H_{17}$: Number of health conditions will moderate the effects of age on levels of self-regulation

$H_{18}$: Driving confidence will mediate the effects of gender on levels of self-regulation

$H_{19}$: Driving confidence will mediate the effects of cognitive impairment on levels of self-regulation. That is, cognitive impairments influence levels of self-regulation throughs its impact upon drivers’ driving confidence

$H_{20}$: Availability and acceptance of alternative transportation options will mediate the effects of residential location on levels of self-regulation

5.5. Method

5.5.1. Participants

A total of 282 Australian drivers aged 65 years or over took part in this study. Potential participants were told that the research was interested in their opinions on the driving experience and the transportation needs of older drivers, that the questionnaire would take approximately 30 minutes to complete, and that they had to be aged 65 years or over and current drivers to take part. They were recruited through a combination of convenience sampling via snowballing, accessing members of various older adults organisations (including Country Womens’ Association, University of the 3rd Age, health clinics, Council On the Aging, and several community aged care activity centres), as well as through newspaper, magazine, radio and email advertisements. To improve accessibility, a web-based version of the survey was developed to enhance participation and to access a wider range of older drivers.

All participants received entry to a prize draw of one of five $100.00 shopping vouchers upon completion of the experiment. Four participants did not meet the inclusion criteria (aged 65 years or above and current drivers). One participant did not complete the questionnaire, thus was not included in the present analyses. The final sample size was 277. Participants’ age ranged from 65 to 92 ($M_{age} = 71.64; SD = 5.87$). All participants were current drivers and held an open drivers’ license. More detailed information on the sample characteristics is presented in section 5.5.5.
5.5.2. Design

This study used a cross-sectional survey. The independent variables were derived from the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model. In addition, several other concepts related to older drivers’ transport needs, and attitudes towards potential interventions were examined. These independent variables were operationalized using individual difference manipulation. The dependent variable was levels of self-regulation reported by participants, indexed by scores on the Driving Avoidance Questionnaire. Items on the survey were randomised to minimise order effects\(^{14}\). Anonymity and confidentiality of participation was emphasised to reduce participant effects such as demand characteristics and positive self-presentation.

5.5.3. Materials

A questionnaire (contained in Appendix A), Participant Information Sheet (Appendix B) and fliers (Appendix C) were developed for this study. These materials were available through written as well as web-based questionnaire (more detail in section 5.5.4.) Questionnaire item development was based on the findings from the systematic review (discussed in section 3.2.3.4.), the theoretical foundation provided by the Theory of Planned Behavior Model (TPB; Ajzen, 1985, 1988, 1991) and the Health Belief Model (HBM; Rosenstock, Stretcher & Becker, 1988). Items of existing older driver questionnaires, specifically the Driving Mobility Questionnaire (Baldock et al., 2006) and the Driving Habits Questionnaire (DHQ; Owsley et al., 1999), were also considered in the development of the current questionnaire.

The questionnaire was pilot tested on 12 acquaintances of the researcher (age range 55-86, 41.7% male) to ensure the questions were understood, and the completion of the questionnaire was not too straining for the participants. Clarification regarding the confidentiality and anonymity of the questionnaire, especially in relation to participants’ driving licenses, were emphasised on the questionnaire, Participant Information Sheet and fliers. Minor changes were made to the questionnaire to enhance comprehension and readability. Items regarding

\(^{14}\text{All questionnaires began with demographics items. Items within each scale, and the order to which these scales were presented, were randomised.}\)
employment and financial income were changed to reflect the demographics of this cohort. The operationalized variables and their corresponding questionnaire items are outlined below.

5.5.3.1. Dependent variable: Self-regulation

Participants’ driving self-regulation (Q23A-U) was measured by an extended version of the avoidance subscale of the Driver Mobility Questionnaire (DMQ-A), originally developed by Baldock et al. (2006). Revisions to the original DMQ-A have recently been suggested by Sullivan et al. (2011), hence twelve new items from the set generated by Sullivan et al. (2011) were added. These new items represent driving situations not covered in the original DMQ-A, but are ones that were perceived as potentially unsafe, and hence avoided, by older Australian drivers.

Participants were asked to rate on a 5-point Likert scale from 1 “never” to 5 “always”, the extent to which they avoid driving in 21 potentially risky driving situations (such as at night or on freeways). This measure of overall driving avoidance was used as an index of participants’ driving self-regulation. Summary scores for participants’ driving avoidance were derived by averaging scores on the 21 situations in each item, with higher scores indicating greater levels of self-regulation. Alpha reliability statistic revealed this scale possessed high internal consistency ($\alpha = .94$).

5.5.3.2. Independent variables

Socio-demographic variables

Individual variables included age (Q2), gender (Q1), postcode (i.e. residential area; Q3), employment (Q4), current and future financial confidence (Q5-6), advanced driving training (Q10), general driving areas and purposes (Q11, Q25), preferred mode of transportation (Q13), driving experience as indicated by length of time (years) since the participant had his/her open drivers’ licence (Q9), and average distance travelled as indicated by the length of time (hrs/wk) the participant estimated he/she would drive over the last three years (Q12).
Health conditions, health literacy and barriers to treatment (Q15-17, 36A-F)

Participants were asked to state the medical conditions they have experienced. Additionally, participants were asked whether they think the stated condition(s) impact upon their driving ability, whether their physicians discussed with them about the potential effects these condition(s) have on driving, and whether they adapted their driving behaviours due to the condition(s). Participants were also asked to rate on a 5-point Likert scale from 1 (not at all concerned) to 5 (extremely concerned), the extent to which they were concerned that their health conditions might affect their driving and quality of life, whether seeking diagnosis/treatment will have an impact on their driver license. Finally, they were asked to rate on a 5-point Likert scale from 1 (never) to 5 (a great deal), the extent to which such concerns prevented them from seeking diagnosis/treatment.

Driving space (Q22A-E)

Driving space items assess the distance participants generally drive away from their home base over the past year (e.g. within the immediate neighborhood, outside the state). Participants were asked to rate from 1 (never) to 5 (always), how often they drove under various road distances over the past year. Summary scores of participants’ driving space were derived by averaging scores across all five items, with lower scores indicating a smaller driving space (Owsley et al., 1999).

Dependence on driving partners (Q29A-C)

Participants were asked to indicate who they regularly travelled with in a car over the past year, and who is usually the driver. These items were adapted from the dependency on driving partners measure developed by Owsley et al., (1999). An estimate of “dependency on driving partners” was generated, ranged from 1 to 4, with higher scores indicating greater dependency on driving partners.

Driving confidence (Q21A-U)

Driving confidence was assessed using the same scale as driving avoidance (revised DMQ-A), except that participants were instructed to rate on a 5-point Likert scale from 1 (never) to 5 (always), the extent to which they felt confident driving in
those situations. Similar to driving avoidance, summary scores for participants’
driving confidence was derived by averaging scores on the 21 situations. Alpha
reliability analysis revealed this scale possessed high internal consistency ($\alpha = 0.96$).

**Self-report health and driving performance (Q14, 18 and 19)**

Participants’ perception of their health and driving performance was also
measured. Self-reported health and driving performance were assessed by asking
respondents to rate their health and driving performance on 5 point Likert scales from
1 (very poor) to 5 (excellent). Participants were also asked to rate from 1 (much
slower) to 5 (much faster), how fast they usually drive compared to the general flow
of traffic.

**Clock Drawing Test (Q24)**

The Clock Drawing Test is a screening test that relies on a range of cognitive
abilities, including comprehension, memory, visuospatial abilities, abstract thinking
and executive functioning (Shulman, 2000). The CDT correlates highly with other
cognitive screening tasks, such as the mini-mental state examination (Samton et al.,
2005; Royall et al., 1999). It has been used in a variety of older driver studies to
identify individuals who are more likely to make driving errors (Freund et al., 2005,
2008; Mathias and Lucas, 2009). The CDT was included in the package of
questionnaires mailed to participants. Written instructions were provided at the top of
a white A4 sheet of paper, printed with the outline of a circle in the middle of it.
These instructions asked participants to draw a clock face in the circle by placing all
of the required numbers in their correct positions. In this study, participants were
asked to draw the hands to indicate the time at 10 min after eleven. This instruction
was chosen because previous research has suggested that it is sensitive to
neurocognitive dysfunction (Freedman et al., 1994). The CDT was scored using the
Shulman scoring method (Shulman et al., 199315). This scoring method was used

---

15 As per Shulman et al. (1993), the midpoints for the CDT classification are applied as
follows: a score of 2 indicates “minor visuospatial errors”; a score of 3 indicates
“inaccurate representation of 10 after 11 when visuospatial organization is perfect or
show only minor deviations”; a score of 4 indicates “moderate visuospatial dis-
organization of times such that accurate denotation of 10 after 11 is impossible”; and
a score of 5 indicates “severe level of disorganization as described in scoring of 4”
because when compared to other scoring methods (Doyon et al., 1991; Tuokko et al., 1992; Watson et al., 1993; Wolf-Klein et al., 1989), the Shulman method produced high sensitivities (.93) and high area under the ROC curve (.79), making it particularly useful as a screening measure (Tuokko et al., 2000). Further, the Shulman method has high intra and inter-rater reliability \((r = .9\) and \(.83\) respectively), and correlates highly with other scoring methods (Tuokko et al., 2000). The Shulman scoring method ranks the clocks on a scale from 1 (perfect) to 6 (no reasonable representation of a clock). Scores of 3 or above are suggestive of possible cognitive impairment, whereas scores of 1 and 2 are considered within normal limits (Shulman et al., 1986, 1993). It should be noted that due to the nature of the test, the CDT was not available for the Internet version of the questionnaire, which was subsequently developed to enhance participant recruitment.

**Attitudes and beliefs towards driving, and intention to change driving behaviours (Q20A-N)**

These items were adapted from the Attitudes and Beliefs Questionnaire developed based on the Theory of Planned Behavior (Lindstrom-Forneri et al., 2007). The Attitudes and Beliefs Questionnaire contained 14 items, providing five subscales in accordance with the Theory of Planned Behavior (REF): affective attitude, instrumental attitude, subjective norm, perceived behavioural control and intention. Participants were asked to rate on a 5-point Likert scale from 1 (strongly agree) to 5 (strongly disagree), the extent to which they agree with each of the 14 driving related statements. Summary scores for participants’ attitudes and beliefs towards driving were derived by averaging scores on the subscales. Alpha reliability analysis revealed this scale possessed good internal consistency \((\alpha = 0.81)\).

**Restriction of activities due to driving problems (Q27 and 28)**

These two items were developed to measure whether driving problems restrict the daily and social activities of older drivers. Participants were asked to indicate what they would do if they did not want to drive themselves. Participants were also asked

(see Shulman et al., 1993). The midpoints on the confidence and avoidance were labeled as follows, 2 = “rarely”, 3 = “sometimes”, and 4 = “often”.

to rate on a 5-point Likert scale from 1 (not at all) to 5 (all the time), the extent to which they had to pass up opportunities (e.g. shopping or visit friends) due to driving-related concerns.

_Perception and usage of alternative transport (Q30-32)_

These items assessed participants’ perception and usage of alternative transportation (e.g. buses, trains). Participants were asked to rate on a 5-point Likert scale from 1 (not at all) to 5 (all the time), the extent to which they use alternative transport; from 1 (poor) to 5 (excellent) the quality of the alternative transport available in their areas. Participants were also asked to indicate how alternative transportation in their areas could be improved (e.g. lighting, frequency of routes).

_Cues to self-regulation (Q 33-35)_

Participants were asked to indicate whether anyone has suggested over the past year that they should change their driving behaviours, who made this suggestion (e.g. family member, medical professionals), and what they did in response to their suggestions. They were also asked to indicate whose suggestion to change driving behaviours they would most likely listen to, and how they think they would respond if anyone ever suggested that they should change their driving behaviours.

_Perceptions of driving programs (Q37-40)_

To measure interest in older driver programs, participants were asked to rate on a scale from 1 (strongly disagree) to 5 (strongly agree), whether they think there is a need for information sessions targeted for older drivers. In addition, respondents were asked to rate on a scale from 1 (very unlikely) to 5 (very likely), the likelihood that they would attend older driver programs. Participants were also asked what kind of information they would like to be included in these programs and their preference towards modality of program delivery.

5.5.4. Procedure

Ethical clearance for this project was provided by the institutional review board of Queensland University of Technology (Human Research Ethics Committee #
118

10000460). With the exception of the Clock Drawing Test, respondents completed
the same questionnaire regardless of their response type (pen-and-paper and web-
based questionnaire) as described above\textsuperscript{16}. Under the approved protocol, informed
consent was inferred from the return of a completed questionnaire. Interested
participants were encouraged to contact the research team for a postal questionnaire.
Web link of the online version of the questionnaire was provided through email
advertisements, web based fliers and upon request. Potential participants were told
that the research was interested in their opinions on the driving experience and the
transportation needs of older drivers, that the questionnaire would take approximately
30 minutes to complete, and that they have to be aged 65 years or over and current
drivers to take part.

Questionnaires were presented in 16-point font for ease of reading. A
randomized-order battery was prepared and mailed to interested participants. The
battery assessed: (a) levels of self-regulation (i.e. driving avoidance), (b) socio-
demographic information, (c) health conditions, health literacy and barriers to
treatment, (d) driving space, (e) dependence on driving partners, (f) driving
confidence, (g) self-report health and driving performance, (h) cognitive ability (i.e.
CDT), (i) attitudes and beliefs towards driving and intention to change driving
behaviours, (j) restriction of activities due to driving problems, (k) perception and
usage of alternative transport, (l) cues to self-regulation, and (m) perceptions of
driving programs. Postal questionnaires were returned in a replied paid envelope.

5.6. Results

5.6.1. Data cleaning and assumption testing

Data was initially screened for accuracy of data entry, missing, values outliers
and the assumptions of univariate and multivariate analyse through visual inspection
of data and descriptives. Twenty-six participants did not provide answers for all of the
questions on the questionnaire. A Missing Value Analysis using SPSS was conducted,
with Little’s MACR test revealed to be non-significant, \( \chi^2 (4671.711) = 5631, p > .99, \)

\textsuperscript{16} Due to the manual nature of the Clock Drawing Test, it was not available as a web-
based test. No other readily accessible web-based cognitive measure was available.
This variable was therefore excluded in the web-based survey.
indicating that the data were missing completely at random. Four cases were excluded from analysis as they were missing at least 80% of responses on key variables (avoidance and/or psychosocial factors), thus, considered inadequate sources of information.

In regards to outliers, visual inspection of the histograms identified two univariate outliers related specifically to self-reported driving exposure, specifically distance travelled. Both cases were retained because both cases represented professional fleet drivers, and were considered to be a probable representation of the general older driver population. Mahalanobis distances of key variables were examined, and revealed five multivariate outliers using Barnett and Lewis’s (1978) recommended critical values. Regression analyses were performed with and without these cases resulting in no notable difference in the results. These five outliers were subsequently retained.

With the exception of estimated travel distance (skewness = 3.32), all variables satisfied the normality assumption as recommended by West, Finch and Curran (1995). Square root transformation of estimated travel distance was performed and revealed notable changes in the regression when using transformed and non-transformed data. Thus, the square-root transformed data was used for subsequent analyses. In regards to multivariate normality, as recommended by Bollen and Stine (1993), the Bollen-Stine bootstrapping procedure was used in SEM analyses to adjust for multivariate normality.

Additional data treatment was required because structural equation modelling (SEM) analyses were conducted on this data. Due to the calculations required to compute modification indices, SEM procedures do not tolerate missing data. Expectation-maximisation (EM) imputation was conducted for the remaining variables to allow AMOS to compute modification indices (Scheffer, 2002). The EM method was conducted because this method has been found to be more consistent and accurate in producing parameter estimates than methods such as list-wise deletion (Graham, Hofer, Donaldson, MacKinnon, & Schaffer, 1997). It also produces the least bias in missing values and is considered acceptable data treatment when data are missing completely at random (Graham et al., 1997).
5.6.2. Equivalence testing of samples

Due to the different sampling methods (web-based, n = 104; pen-and-paper, n = 169), equivalence testing was conducted to determine whether the participants sampled through these methods were comparable. Equivalency testing was used instead of the more commonly used null hypothesis significance testing (NHST). According to Rogers, Howard and Vessey (1993), Rusticus and Lovato (2011) and Tryon (2001), a statistically non-significant finding in NHST procedures such as Analysis of Variance (ANOVA) only indicates a lack of evidence to support that the groups are statistically different, rather than that the groups are comparable.

According to Rusticas and Lovato (2011), +/- 20% is most commonly used in the domains of biostatistics and social science. However, a more stringent criterion (+/- 10%) was used in the current study due to the leptokurtic distribution of some of the key variables, and the small range of the Likert scales used. The current study utilised the postal questionnaire sample as the reference group as 1) it was collected first; and 2) it was the original sampling method.

A range of socio-demographics and driving-related key variables were selected for equivalence testing to provide a thorough investigation. These variables were: age, hours driven per week, financial confidence, driving space, attitudes and beliefs towards driving, and driving confidence and avoidance. Table 7 presents the means, deviations, and equivalency test results for each of the selected variables. As indicated by the significant results, criterion for equivalency was met across all variables. In other words, the postal and sample groups are comparable on each of the 11 variables. Thus, both samples were combined for all subsequent analyses.
Table 7: Equivalence tests and mean differences statistics for the Postal and Internet sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Postal (n = 104)</th>
<th>Internet (n = 169)</th>
<th>M_Diff</th>
<th>SE</th>
<th>Criterion^a</th>
<th>Z</th>
<th>p^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>72.04</td>
<td>70.95</td>
<td>1.09</td>
<td>.39</td>
<td>+/-7.21</td>
<td>21.28</td>
<td>.0001</td>
</tr>
<tr>
<td>Hrs driven/wk</td>
<td>8.99</td>
<td>9.04</td>
<td>.05</td>
<td>.50</td>
<td>+/- .90</td>
<td>1.90</td>
<td>.029</td>
</tr>
<tr>
<td>Financial confidence</td>
<td>2.79</td>
<td>2.26</td>
<td>0.53</td>
<td>.07</td>
<td>+/- .28</td>
<td>11.57</td>
<td>.0001</td>
</tr>
<tr>
<td>Affective Attitude</td>
<td>3.21</td>
<td>3.48</td>
<td>.27</td>
<td>.05</td>
<td>+/-.32</td>
<td>11.8</td>
<td>.0001</td>
</tr>
<tr>
<td>Instrumental Attitude</td>
<td>4.26</td>
<td>4.46</td>
<td>-.20</td>
<td>.04</td>
<td>+/- .43</td>
<td>15.75</td>
<td>.0001</td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>4.33</td>
<td>4.50</td>
<td>-.23</td>
<td>.04</td>
<td>+/- .43</td>
<td>15.75</td>
<td>.0001</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td>3.64</td>
<td>3.75</td>
<td>-.11</td>
<td>.06</td>
<td>+/- .36</td>
<td>7.83</td>
<td>.0001</td>
</tr>
<tr>
<td>Intention</td>
<td>4.50</td>
<td>4.55</td>
<td>.05</td>
<td>.04</td>
<td>+/- .45</td>
<td>12.5</td>
<td>.0001</td>
</tr>
<tr>
<td>Driving space</td>
<td>3.12</td>
<td>3.32</td>
<td>-.20</td>
<td>.05</td>
<td>+/- .31</td>
<td>10.2</td>
<td>.0001</td>
</tr>
<tr>
<td>Confidence</td>
<td>4.02</td>
<td>3.78</td>
<td>.24</td>
<td>.06</td>
<td>+/- .40</td>
<td>10.66</td>
<td>.0001</td>
</tr>
<tr>
<td>Avoidance</td>
<td>1.91</td>
<td>1.57</td>
<td>.34</td>
<td>.05</td>
<td>+/- .19</td>
<td>10.6</td>
<td>.0001</td>
</tr>
</tbody>
</table>

^a Equivalence criterion equals +/- 10% for all variables, with the Postal sample as the reference group
^b As per Rogers et al. (1993), the greater of the two p values (calculated from the smaller z values) are shown here
^c significant p values indicates the means of the two groups are determined to be equivalent; All p value are significant at p < .05

5.6.3. Sample characteristics

The final sample was 273 (62.6% female; $M_{age} = 71.36$, $SD = 6.41$). Participants’ demographic information is shown in Table 8. This table presents the age, gender, residential location (urban vs. rural), employment status and health of the sample. Given the gender differences apparent in the older driver safety literature, the descriptive statistics were also calculated separately for each gender. Due to the number of independent sample t-tests performed on participants’ Socio-demographics and Driving-related characteristics, significance level was set at $p < .001$ to control for...
family-wise error rate. No significant gender differences were found in participants’ socio-demographics characteristics, $p < .001$.

The majority of participants were retired, living in inner-city and inner regional areas, as identified by the Accessibility/Remoteness Index of Australia (ARIA; ABS, 2011). Participants were relatively confident that their income was sufficient for their current and future needs. They also rated their heath as “fair”, with almost 85% of participants reporting that they have either no or one medical condition.
Table 8: Sample characteristics ($N = 273$), and separate descriptives for female ($n = 171$) and male ($n = 102$) older drivers

<table>
<thead>
<tr>
<th>Sample characteristic</th>
<th>Total ($N = 273$)</th>
<th>Females ($n = 171$)</th>
<th>Males ($n = 102$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (M/SD)</td>
<td>71.29 (7.09)</td>
<td>71.05 (6.53)</td>
<td>71.70 (7.95)</td>
</tr>
<tr>
<td>Employment (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not employed/</td>
<td>3 (1.1%)</td>
<td>0</td>
<td>3 (1.1%)</td>
</tr>
<tr>
<td>No voluntary work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not employed/</td>
<td>20 (7.3%)</td>
<td>16 (5.8%)</td>
<td>4 (1.5%)</td>
</tr>
<tr>
<td>Voluntary work</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Retired</td>
<td>205 (78.8%)</td>
<td>142 (51.4%)</td>
<td>76 (27.5%)</td>
</tr>
<tr>
<td>Part time</td>
<td>29 (10.6%)</td>
<td>16 (5.8%)</td>
<td>13 (4.7%)</td>
</tr>
<tr>
<td>Full time</td>
<td>6 (2.2%)</td>
<td>1 (0.4%)</td>
<td>5 (1.8%)</td>
</tr>
<tr>
<td>Residential location (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major city</td>
<td>92 (33.7%)</td>
<td>57 (20.9%)</td>
<td>35 (12.8%)</td>
</tr>
<tr>
<td>Inner Regional</td>
<td>109 (39.9%)</td>
<td>66 (24.2%)</td>
<td>43 (15.8%)</td>
</tr>
<tr>
<td>Outer Regional</td>
<td>65 (23.8%)</td>
<td>43 (15.8%)</td>
<td>22 (8.8%)</td>
</tr>
<tr>
<td>Remote</td>
<td>6 (2.2%)</td>
<td>5 (1.8%)</td>
<td>1 (.4%)</td>
</tr>
<tr>
<td>Very remote</td>
<td>1 (.4%)</td>
<td>-</td>
<td>1 (.4%)</td>
</tr>
<tr>
<td>Financial confidence (current)</td>
<td>2.80 (.77)</td>
<td>2.79 (.79)</td>
<td>2.80 (.73)</td>
</tr>
<tr>
<td>Financial confidence (future)</td>
<td>2.47 (1.23)</td>
<td>2.35 (1.31)</td>
<td>2.69 (1.05)</td>
</tr>
<tr>
<td>Health rating</td>
<td>3.06 (.64)</td>
<td>3.05 (.64)</td>
<td>3.06 (.66)</td>
</tr>
<tr>
<td>Medical conditions (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>128 (46.9%)</td>
<td>93 (34.1%)</td>
<td>35 (12.8%)</td>
</tr>
<tr>
<td>1</td>
<td>101 (37.0%)</td>
<td>61 (22.3%)</td>
<td>40 (14.7%)</td>
</tr>
<tr>
<td>&gt;2</td>
<td>44 (16.1%)</td>
<td>17 (6.2%)</td>
<td>27 (9.9%)</td>
</tr>
</tbody>
</table>

5.6.3.1. Driving characteristics

Table 9 presents the participants’ Driving-related characteristics by gender. Males were more likely to have advanced driver training experience such as
defensive driving course or in a profession that requires further driving training, $\chi^2 (1) = 10.26$, $p < .001$.

In regards to driving exposure, participants were asked to nominate the number of hours they drove per week, and indicated on a scale from 1 (never) to 5 (always) the frequency they drove to various driving spaces. On average, participants drove 1.27 hours each day, and that a significant proportion of participants (42.1%) drove less than 5 hours per week, and only 12% of participants drove more than 15 hours per week. Overall, participants rated their quality of driving as “good” and that they generally drove at “about the same” speed as the general flow of traffic. In regards to cues to self-regulation, only 7.7% of the sample had relatives or friends who suggested that they should limit or stop driving.

In terms of transport preference, the majority of participants preferred to drive themselves. Most participants rated the alternative transportation options in their areas as “poor”, with rare usage of these transportation options. Female participants were demonstrated to have greater dependence on other drivers, $t (271) = 3.74$, $p < .001$, 95% CI: .25 to .80, with a moderate effect size, $r = .22^{17}$.

Significant gender difference in preferred person to discuss potential driving changes was also found, $\chi^2 (5) = 36.01$, $p < .001$. While the majority of both male and female participants preferred to discuss driving changes with their medical practitioners, males prefer to discuss these changes with their partners, while female participants preferred to discuss these changes with their other family members.

The majority of participants (73%) agreed or strongly agreed that there is a need for information sessions for older drivers. Similarly, approximately 61% of participants indicated that they would be “likely” or “very likely” to go to these information sessions. Females were more likely to agree that information sessions for older drivers are needed, $t (271) = 4.09$, $p < .001$, 95% CI: .23 to .65, $r = .24$, and to attend these sessions, $t (271) = 3.5$, $p = .001$, 95% CI: .21 to .75, $r = .21$.

---

$^{17}$ Pearson’s correlation coefficient $r$ was used as an effect size measure because it is constrained between 1 (a perfect effect) to 0 (no effect) (Field, 2009). Using Cohen’s (1988, 1992) standard, $r = .10$ represents a small effect, explaining 1% of total variance; $r = .30$ represents a medium effect, explaining 9% of total variance; $r = .50$ represents a large effect, accounting for 25% of total variance.
Table 9: Participants' driving characteristics (N= 273), and separate descriptive statistics for female (n = 171) and male (n = 102) older drivers

<table>
<thead>
<tr>
<th>Driving characteristic</th>
<th>Total (N = 273)</th>
<th>Females (n = 171)</th>
<th>Males (n = 102)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years licensed (M/SD)</td>
<td>4.38 (.68)</td>
<td>4.29 (.67)</td>
<td>4.54 (.68)</td>
</tr>
<tr>
<td>Advanced driver training (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>40 (14.7%)</td>
<td>16 (5.9%)</td>
<td>24 (8.8%)</td>
</tr>
<tr>
<td>No</td>
<td>233 (85.3%)</td>
<td>155 (56.8%)</td>
<td>78 (28.6%)</td>
</tr>
<tr>
<td>Hrs/wk driving (M/SD)</td>
<td>9.02 (8.27)</td>
<td>9.16 (8.12)</td>
<td>8.80 (8.56)</td>
</tr>
<tr>
<td>Driving space (M/SD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate</td>
<td>4.57 (.60)</td>
<td>4.60 (.55)</td>
<td>4.52 (.69)</td>
</tr>
<tr>
<td>Places beyond</td>
<td>3.95 (.89)</td>
<td>3.96 (.89)</td>
<td>3.93 (.89)</td>
</tr>
<tr>
<td>Neighbourhood</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighbouring cities</td>
<td>3.20 (1.19)</td>
<td>3.09 (1.26)</td>
<td>3.38 (1.04)</td>
</tr>
<tr>
<td>More distant cities</td>
<td>2.50 (1.20)</td>
<td>2.37 (1.23)</td>
<td>2.72 (1.12)</td>
</tr>
<tr>
<td>Outside the state</td>
<td>2.04 (1.13)</td>
<td>1.78 (1.00)</td>
<td>2.47 (1.22)</td>
</tr>
<tr>
<td>Driving performance</td>
<td>3.92 (.60)</td>
<td>3.88 (.55)</td>
<td>3.98 (.66)</td>
</tr>
<tr>
<td>Driving speed</td>
<td>2.96 (.43)</td>
<td>2.92 (.41)</td>
<td>3.02 (.47)</td>
</tr>
<tr>
<td>Predominant driving environment (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>City</td>
<td>15 (5.5%)</td>
<td>10 (3.7%)</td>
<td>5 (1.8%)</td>
</tr>
<tr>
<td>Suburban</td>
<td>73 (26.8%)</td>
<td>44 (16.2%)</td>
<td>29 (10.7%)</td>
</tr>
<tr>
<td>Rural</td>
<td>46 (16.9%)</td>
<td>28 (10.3%)</td>
<td>18 (6.6%)</td>
</tr>
<tr>
<td>Mixed</td>
<td>138 (50.7%)</td>
<td>88 (32.4%)</td>
<td>50 (18.4%)</td>
</tr>
<tr>
<td>Cues to self-regulation (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>21 (7.7%)</td>
<td>8 (2.9%)</td>
<td>13 (4.8%)</td>
</tr>
<tr>
<td>No</td>
<td>252 (92.3%)</td>
<td>163 (59.7%)</td>
<td>89 (32.6%)</td>
</tr>
<tr>
<td>Transport preference (n/%)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use public transport/taxi</td>
<td>7 (2.6%)</td>
<td>7 (2.6%)</td>
<td>-</td>
</tr>
<tr>
<td>Have someone drive you</td>
<td>10 (3.7%)</td>
<td>4 (1.5%)</td>
<td>6 (2.2%)</td>
</tr>
<tr>
<td>Driving characteristic</td>
<td>Total (N = 273)</td>
<td>Females (n = 171)</td>
<td>Males (n = 102)</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-----------------</td>
<td>-------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Drive yourself</td>
<td>256 (93.8%)</td>
<td>160 (58.6%)</td>
<td>96 (35.2%)</td>
</tr>
<tr>
<td>Rate alternative transport</td>
<td>1.22 (1.25)</td>
<td>1.15 (1.19)</td>
<td>1.34 (1.36)</td>
</tr>
<tr>
<td>Use alternative transport</td>
<td>.72 (.75)</td>
<td>.65 (.71)</td>
<td>.82 (.80)</td>
</tr>
<tr>
<td>Dependence on other drivers</td>
<td>2.41 (1.16)</td>
<td>2.61 (1.13)</td>
<td>2.08 (1.13)</td>
</tr>
</tbody>
</table>

Preferred person to discuss driving changes (n/%):

| Person of authority                        | 19 (7.0%)       | 14 (5.1%)         | 5 (1.8%)        |
| Friend                                      | 5 (1.8%)        | 4 (1.5%)          | 1 (.4%)         |
| Medical Practitioner                        | 158 (58.1%)     | 100 (36.8%)       | 58 (21.3%)      |
| Partner                                     | 30 (11.0%)      | 6 (2.2%)          | 24 (8.8%)       |
| Other                                       | 8 (2.8%)        | 3 (1.1%)          | 5 (1.8%)        |

Need for information session:

| Likelihood to attend session                | 2.57 (1.1)      | 2.26 (1.13)       | 2.75 (1.09)     |

Preference of sessions delivery (n/%):

| Mail-out materials                          | 84 (32.1%)      | 53 (20.2%)        | 31 (11.8%)      |
| In groups                                   | 135 (51.5%)     | 92 (35.1%)        | 43 (16.4%)      |
| Internet modules                            | 43 (16.4%)      | 22 (8.4%)         | 21 (8%)         |

Notes: Italics font indicates significant gender differences as measured by chi-square statistics or independent sample t-test, p <.001

### 5.6.3.2. Participants’ driving confidence and avoidance

As can be seen below in Table 10, participants were fairly confident driving in various situations. Consistent with this finding, Table 10 shows that their level of avoidance of these situations as relatively low. The three situations that participants felt least confident were *driving at night*, *in the rain* and *at night in the rain*. These potentially hazardous driving situations are also conditions that participants described as those that they most likely avoided.
Compared to female participants, male participants reported higher confidence driving in all the sampled driving situations. The gender difference in driving confidence was significant at \( p < .001 \) in the following situations, with small to moderate effect sizes: at night in the rain, \( t = -4.62, 95\% \text{ CI} = -1.09 \text{ to } -1.44, r = .27 \), in the rain \( t = -3.84, 95\% \text{ CI} = -1.90 \text{ to } -1.29, r = .23 \), parallel parking \( t = -3.32, 95\% \text{ CI} = -1.75 \text{ to } -1.19, r = .20 \), unfamiliar roads \( t = -3.45, 95\% \text{ CI} = -1.74 \text{ to } -1.20, r = .21 \), high traffic roads \( t = -3.33, 95\% \text{ CI} = -1.82 \text{ to } -1.21, r = .20 \), peak hour \( t = -3.44, 95\% \text{ CI} = -1.84 \text{ to } -1.23, r = .20 \), at night \( t = -3.78, 95\% \text{ CI} = -1.87 \text{ to } -1.28, r = .22 \), long distance driving \( t = -3.72, 95\% \text{ CI} = -1.88 \text{ to } -1.27, r = .22 \), other people’s car \( t = -3.22, 95\% \text{ CI} = -0.78 \text{ to } -0.19, r = .19 \), and through tunnels \( t = -4.44, 95\% \text{ CI} = -1.02 \text{ to } -0.39, r = .26 \).
Table 10: Participants’ driving confidence (5 = most confident), and separate
descriptive statistics for female (n = 171) and male (n = 102) older drivers

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>t</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Familiar roads</td>
<td>-1.22</td>
<td>4.40</td>
<td>.98</td>
</tr>
<tr>
<td>When alone</td>
<td>-1.41</td>
<td>4.26</td>
<td>1.03</td>
</tr>
<tr>
<td>With adult passengers</td>
<td>-1.89</td>
<td>4.18</td>
<td>1.04</td>
</tr>
<tr>
<td>Right turns(^{18})</td>
<td>-1.71</td>
<td>4.18</td>
<td>1.00</td>
</tr>
<tr>
<td>Roundabouts</td>
<td>-1.49</td>
<td>4.17</td>
<td>1.00</td>
</tr>
<tr>
<td>Parallel parking</td>
<td>-3.32</td>
<td>4.03</td>
<td>1.15</td>
</tr>
<tr>
<td>Roadworks</td>
<td>-2.16</td>
<td>4.03</td>
<td>1.04</td>
</tr>
<tr>
<td>Lane changes</td>
<td>-2.41</td>
<td>4.00</td>
<td>1.06</td>
</tr>
<tr>
<td>With passengers (children)</td>
<td>-3.17</td>
<td>3.97</td>
<td>1.20</td>
</tr>
<tr>
<td>At the start/end of school times</td>
<td>-3.17</td>
<td>3.93</td>
<td>1.13</td>
</tr>
<tr>
<td>Long distance driving</td>
<td>-3.72</td>
<td>3.88</td>
<td>1.26</td>
</tr>
<tr>
<td>Freeways</td>
<td>-3.12</td>
<td>3.87</td>
<td>1.23</td>
</tr>
<tr>
<td>In the rain</td>
<td>-3.84</td>
<td>3.30</td>
<td>1.27</td>
</tr>
<tr>
<td>Unfamiliar roads</td>
<td>-3.45</td>
<td>3.77</td>
<td>1.11</td>
</tr>
<tr>
<td>High traffic roads</td>
<td>-3.33</td>
<td>3.71</td>
<td>1.26</td>
</tr>
<tr>
<td>At night</td>
<td>-3.78</td>
<td>3.69</td>
<td>1.30</td>
</tr>
<tr>
<td>Tunnels</td>
<td>-4.44</td>
<td>3.67</td>
<td>1.35</td>
</tr>
<tr>
<td>Peak hour</td>
<td>-3.44</td>
<td>3.61</td>
<td>1.26</td>
</tr>
<tr>
<td>Other people’s car</td>
<td>-3.22</td>
<td>3.45</td>
<td>1.34</td>
</tr>
<tr>
<td>At night in the rain</td>
<td>-4.62</td>
<td>3.26</td>
<td>1.38</td>
</tr>
<tr>
<td>In foggy conditions</td>
<td>-2.78</td>
<td>3.34</td>
<td>1.28</td>
</tr>
</tbody>
</table>

Notes: *Italic font indicates significant gender differences measured by independent-sample t-test, p < .001.*

Participants’ driving avoidance scores are presented in Table 11. Females consistently reported significant higher levels of avoidance under the majority of

\(^{18}\) “Right turn” is equivalent to the complex “left turn” in territories where motorists drive on the right-hand side of the road (e.g. the U.S.)
potentially hazardous situations sampled at p < .001, with moderate effect sizes. These are at night in the rain (t = 4.16, 95% CI = .35 to .98, r = .25), in the rain (t = 4.56, 95% CI = .42 to 1.06, r = .27), at night (t = 4.32, 95% CI = .33 to .89, r = .25), when alone (t = 3.87, 95% CI = .14 to .42, r = .23), parallel parking (t = 3.47, 95% CI = .16 to .58, r = .26), freeways (t = 4.34, 95% CI = .24 to .78, r = .25), high traffic roads (t = 3.66, 95% CI = .24 to .78, r = .22), peak hour (t = 3.25, 95% CI = .17 to .71, r = .19), roadworks (t = 3.54, 95% CI = .16 to .57, r = .21), long distance driving (t = 4.61, 95% CI = .41 to .94, r = .27), lane changes (t = 3.50, 95% CI = .16 to .58, r = .26), right turns (t = 4.16, 95% CI = .31 to .86, r = .25), in foggy conditions (t = 3.84, 95% CI = .23 to .71, r = .23), and through tunnels (t = 5.45, 95% CI = .43 to .92, r = .31).
Table 11: Participants’ driving avoidance (1 = least avoid), and separate descriptives for female (n = 171) and male (n = 102) older drivers

<table>
<thead>
<tr>
<th>Condition</th>
<th>Total M</th>
<th>SD</th>
<th>Females M</th>
<th>SD</th>
<th>Males M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Familiar roads</td>
<td>2.86</td>
<td>.75</td>
<td>1.35</td>
<td>.91</td>
<td>1.10</td>
<td>.36</td>
</tr>
<tr>
<td>When alone</td>
<td>3.26</td>
<td>.69</td>
<td>1.40</td>
<td>.82</td>
<td>1.12</td>
<td>.37</td>
</tr>
<tr>
<td>With adult passengers</td>
<td>1.23</td>
<td>.68</td>
<td>1.33</td>
<td>.74</td>
<td>1.22</td>
<td>.58</td>
</tr>
<tr>
<td>Right turns</td>
<td>3.80</td>
<td>.90</td>
<td>2.06</td>
<td>1.36</td>
<td>1.48</td>
<td>.94</td>
</tr>
<tr>
<td>Roundabouts</td>
<td>3.37</td>
<td>.89</td>
<td>1.56</td>
<td>1.03</td>
<td>1.19</td>
<td>.53</td>
</tr>
<tr>
<td>Parallel parking</td>
<td>3.47</td>
<td>.87</td>
<td>1.64</td>
<td>.99</td>
<td>1.26</td>
<td>.58</td>
</tr>
<tr>
<td>Roadworks</td>
<td>3.22</td>
<td>.93</td>
<td>1.70</td>
<td>1.02</td>
<td>1.33</td>
<td>.69</td>
</tr>
<tr>
<td>Lane changes</td>
<td>3.22</td>
<td>.93</td>
<td>1.70</td>
<td>1.01</td>
<td>1.33</td>
<td>.72</td>
</tr>
<tr>
<td>With passengers (children)</td>
<td>.96</td>
<td>.83</td>
<td>1.44</td>
<td>.85</td>
<td>1.34</td>
<td>.82</td>
</tr>
<tr>
<td>At the start/endpoint of school</td>
<td>2.43</td>
<td>1.76</td>
<td>1.07</td>
<td>.96</td>
<td>1.37</td>
<td>.68</td>
</tr>
<tr>
<td>Long distance driving</td>
<td>4.61</td>
<td>1.17</td>
<td>2.08</td>
<td>1.29</td>
<td>1.41</td>
<td>.91</td>
</tr>
<tr>
<td>Freeways</td>
<td>4.00</td>
<td>1.18</td>
<td>1.06</td>
<td>1.27</td>
<td>1.39</td>
<td>.92</td>
</tr>
<tr>
<td>In the rain</td>
<td>3.36</td>
<td>1.39</td>
<td>2.62</td>
<td>1.43</td>
<td>1.88</td>
<td>1.21</td>
</tr>
<tr>
<td>Unfamiliar roads</td>
<td>2.86</td>
<td>.89</td>
<td>1.75</td>
<td>.93</td>
<td>1.43</td>
<td>.82</td>
</tr>
<tr>
<td>High traffic roads</td>
<td>3.45</td>
<td>1.20</td>
<td>2.06</td>
<td>1.27</td>
<td>1.55</td>
<td>1.01</td>
</tr>
<tr>
<td>At night</td>
<td>4.02</td>
<td>1.24</td>
<td>2.30</td>
<td>1.32</td>
<td>1.70</td>
<td>.98</td>
</tr>
<tr>
<td>Tunnels</td>
<td>4.83</td>
<td>1.16</td>
<td>1.98</td>
<td>1.28</td>
<td>1.30</td>
<td>.77</td>
</tr>
<tr>
<td>Peak hour</td>
<td>3.25</td>
<td>.10</td>
<td>2.05</td>
<td>1.12</td>
<td>1.61</td>
<td>1.02</td>
</tr>
<tr>
<td>Other people’s car</td>
<td>3.02</td>
<td>.89</td>
<td>1.76</td>
<td>.99</td>
<td>1.43</td>
<td>.65</td>
</tr>
<tr>
<td>At night in the rain</td>
<td>4.16</td>
<td>1.31</td>
<td>2.73</td>
<td>1.32</td>
<td>2.07</td>
<td>1.19</td>
</tr>
<tr>
<td>In foggy conditions</td>
<td>3.84</td>
<td>.99</td>
<td>2.07</td>
<td>1.03</td>
<td>1.60</td>
<td>.87</td>
</tr>
</tbody>
</table>

Notes: Italic font indicates significant gender differences measured by independent-sample t-test, p < .001.

19 “Right turn” is equivalent to the complex “left turn” in territories where motorists drive on the right-hand side of the road (e.g. the U.S.)
5.6.3.3. Attitudes and beliefs towards driving

Participants’ attitudes and beliefs towards driving were measured using the Attitudes and Beliefs Questionnaire developed based on the Theory of Planned Behavior (Lindstrom-Forneri et al., 2007). Male participants (M = 4.08, SD = .89) agreed to a greater extent that driving is pleasurable than female (M = 3.65, SD = .97) participants (t = -3.68, p<.001, r = .21), no other significant gender differences were found in participants’ attitudes and beliefs towards driving.

As can be seen in Table 11, participants’ held relatively positive attitudes and beliefs towards a range of driving-related statements. Specifically, 96% of participants either agreed or strongly agreed that they plan to continue driving in the foreseeable future; whereas 97.1% of participants either agreed or strongly agreed that they intend to keep driving when they want to in the near future. Participants’ instrumental attitude (beta = .40, p <.001) and normative influence (beta = .24, p <.001) significantly positively associated with their intention to drive. Participants’ attitudes and beliefs accounted for 29.8% of the variance in intention.
Table 12: Descriptives and standard multiple regression of subscale scores of participants’ Attitudes and Beliefs towards driving (5 = strongly agree) in predicting intention to drive

<table>
<thead>
<tr>
<th>Subscale</th>
<th>M</th>
<th>SD</th>
<th>r</th>
<th>B</th>
<th>SE</th>
<th>β</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Affective Attitude</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Driving a vehicle is pleasurable</td>
<td>3.81</td>
<td>.96</td>
<td>.27</td>
<td>-.01</td>
<td>.05</td>
<td>-.01</td>
<td></td>
</tr>
<tr>
<td>2. I am experiencing increasing apprehension about driving</td>
<td>2.22</td>
<td>1.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. I am becoming more concerned about the unsafe behaviour of other drivers</td>
<td>3.46</td>
<td>.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Instrumental Attitude</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Being able to drive is important to me</td>
<td>4.50</td>
<td>.66</td>
<td>.49</td>
<td>.36</td>
<td>.05</td>
<td>.40</td>
<td></td>
</tr>
<tr>
<td>5. Driving is necessary to my life to give me the flexibility I desire</td>
<td>4.36</td>
<td>.80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Driving is central to my independence</td>
<td>4.29</td>
<td>.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Normative influence</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Some people think I should stop driving</td>
<td>1.38</td>
<td>.69</td>
<td>.38</td>
<td>.25</td>
<td>.06</td>
<td>.24</td>
<td></td>
</tr>
<tr>
<td>8. People close to me disapprove of my driving</td>
<td>1.46</td>
<td>.83</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. My friends drive their vehicles regularly</td>
<td>4.17</td>
<td>.79</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. The physical demands of driving a vehicle are becoming a challenge</td>
<td>1.98</td>
<td>1.15</td>
<td>.31</td>
<td>.20</td>
<td>.04</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>11. The financial cost of driving and maintaining a vehicle are becoming a challenge</td>
<td>2.71</td>
<td>1.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Perceived Behavioural Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Parking is becoming more difficult for me</td>
<td>2.21</td>
<td>1.13</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. I plan to continue driving in the foreseeable future</td>
<td>4.53</td>
<td>.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. I intend to keep driving when I want to in the near future</td>
<td>4.53</td>
<td>.63</td>
<td></td>
<td></td>
<td></td>
<td>.55</td>
<td></td>
</tr>
</tbody>
</table>

Notes: Italic font = p<.001
r = zero-order correlations, demonstrating correlations between each predictor and intention in isolation
5.6.3.4. Overall scale characteristics

Overall scale scores were calculated as per section 5.5.3.2, to provide a preliminary assessment of the scale characteristics for Structural Equation Modelling. The overall scale characteristics, including internal consistency, are displayed in Table 13 below. The Attitudes and Beliefs towards driving scale (Lindstrom-Forneri et al., 2007), the Driving Space scale, the Driving Avoidance and Confidence scales demonstrated adequate to excellent internal consistency. Males reported significantly higher levels on affective attitude, $t(271) = -3.40, p = .001, 95\% \text{CI} = -.50$ to $-.13, r = .20$), greater driving space, i.e. greater degree of driving exposure in terms of distance from home, $t(271) = -3.33, p < .01, 95\% \text{CI} = -.53$ to $-.13, r = .20$, as well as greater degree of driving confidence, $t(271) = -3.64, p < .001, 95\% \text{CI} = -.67$ to $-.19, r = .22$, and lower levels of driving avoidance, $t(250.01) = 4.87, p < .001, 95\% \text{CI} = -.52$ to $-.14, r = .28$.

Table 13: Scale characteristics (N = 273), and separate descriptive statistics for female (n = 171) and male (n = 102) older drivers

<table>
<thead>
<tr>
<th>Scale</th>
<th>$\alpha$</th>
<th>Skew</th>
<th>Kurtosis</th>
<th>$M$</th>
<th>$SD$</th>
<th>Females $M$</th>
<th>Females $SD$</th>
<th>Males $M$</th>
<th>Males $SD$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attitudes and Beliefs Scale</td>
<td>.86</td>
<td>-.89</td>
<td>.94</td>
<td>4.06</td>
<td>.53</td>
<td>4.01</td>
<td>.51</td>
<td>4.13</td>
<td>.57</td>
</tr>
<tr>
<td>Affective Attitude</td>
<td>.59</td>
<td>-.32</td>
<td>-.28</td>
<td>3.38</td>
<td>.75</td>
<td>3.26</td>
<td>.71</td>
<td>3.58</td>
<td>.79</td>
</tr>
<tr>
<td>Instrumental Attitude</td>
<td>.88</td>
<td>-.90</td>
<td>-.03</td>
<td>4.39</td>
<td>.67</td>
<td>4.40</td>
<td>.68</td>
<td>4.38</td>
<td>.64</td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>.63</td>
<td>-1.33</td>
<td>1.53</td>
<td>4.44</td>
<td>.58</td>
<td>4.46</td>
<td>.53</td>
<td>4.41</td>
<td>.67</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td>.79</td>
<td>-.49</td>
<td>-.44</td>
<td>3.68</td>
<td>.97</td>
<td>3.56</td>
<td>.97</td>
<td>3.89</td>
<td>.92</td>
</tr>
<tr>
<td>Intention</td>
<td>-</td>
<td>-1.93</td>
<td>6.35</td>
<td>4.54</td>
<td>.64</td>
<td>4.55</td>
<td>.65</td>
<td>4.53</td>
<td>.62</td>
</tr>
<tr>
<td>Driving Space Scale</td>
<td>.80</td>
<td>.23</td>
<td>-.32</td>
<td>3.25</td>
<td>.80</td>
<td>3.12</td>
<td>.81</td>
<td>3.45</td>
<td>.76</td>
</tr>
<tr>
<td>Driving confidence</td>
<td>.98</td>
<td>-.61</td>
<td>-.68</td>
<td>3.87</td>
<td>.97</td>
<td>3.71</td>
<td>.94</td>
<td>4.14</td>
<td>.97</td>
</tr>
<tr>
<td>Driving avoidance</td>
<td>.96</td>
<td>1.19</td>
<td>.66</td>
<td>1.70</td>
<td>.77</td>
<td>1.86</td>
<td>.80</td>
<td>1.43</td>
<td>.63</td>
</tr>
</tbody>
</table>

Notes: Italic font indicates significant gender differences measured by independent-sample t-test, $p < .001$
5.6.4. Relationships between study variables and self-regulation

5.6.4.1. Demographic and exposure variables associated with self-regulation

Bivariate correlations between demographic and driving exposure variables and levels of self-regulation, as measured by their scores on the Driving Avoidance Scale, are presented in Table 14. With the exception of gender, self-rated driving speed and driving space, all the demographic and exposure variables revealed to be weak predictors (if statistically significant) of participants’ scores of driving avoidance. The direction of the relationships indicates that female drivers with lower scores on the driving space scale and lower self-reported driving speed reported greater levels of driving avoidance.

Due to unequal sample size, Mann-Whitney U analysis was used to calculate whether levels of self-regulation differed between participants who received cues to self-regulation from friends and family members, and those who did not. Results revealed similar self-regulation levels between these two groups, \( p = .75 \). Mann-Whitney U analysis also revealed levels of self-regulation did not differ between those who reported a visual condition (\( n = 83 \)) and those who did not (\( n = 190 \)), \( p = .79 \).
Table 14: Bivariate correlations for demographic and driving exposure variables and self-reported self-regulation

<table>
<thead>
<tr>
<th>Demographic and driving exposure variables</th>
<th>Mean driving avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td>.14</td>
</tr>
<tr>
<td>Years of licensure</td>
<td>.07</td>
</tr>
<tr>
<td>Gender^1</td>
<td>-.33</td>
</tr>
<tr>
<td>ARIA</td>
<td>-0.02</td>
</tr>
<tr>
<td>Financial confidence (current needs)</td>
<td>.04</td>
</tr>
<tr>
<td>Financial confidence (future needs)</td>
<td>-.03</td>
</tr>
<tr>
<td>Advanced driving training^2</td>
<td>-.24</td>
</tr>
<tr>
<td>Hrs driven/week</td>
<td>.10</td>
</tr>
<tr>
<td>Driving Space</td>
<td>-.51</td>
</tr>
<tr>
<td>Health rating</td>
<td>-.19</td>
</tr>
<tr>
<td>Driving speed rating</td>
<td>-.28</td>
</tr>
<tr>
<td>Driving performance rating</td>
<td>-.18</td>
</tr>
<tr>
<td>Dependency on other drivers</td>
<td>.23</td>
</tr>
<tr>
<td>Usage of alternative transport</td>
<td>.12</td>
</tr>
<tr>
<td>Rating of alternative transport</td>
<td>.18</td>
</tr>
<tr>
<td>Pass up opportunities due to driving concerns</td>
<td>.19</td>
</tr>
<tr>
<td>Need for information sessions</td>
<td>.09</td>
</tr>
<tr>
<td>Likelihood to attend sessions</td>
<td>.10</td>
</tr>
</tbody>
</table>

Italic font = p<.05; r = Pearson’s r; r^2 = % of variance in driving avoidance accounted for by demographic or driving exposure variable

^1 Scored 0 = Female, 1 = Male, point-biserial correlation coefficient was used in place of Pearson’s r

^2 Scored 0 = No, 1 = Yes, point-biserial correlation coefficient was used in place of Pearson’s r
5.6.4.2. Psychosocial variables associated with self-regulation

Bivariate correlations between Psychosocial variables and scores of the Driving Avoidance Scale are presented below in Table 15. The data demonstrated moderate to strong negative correlations between each of the psychosocial variables and participants’ scores on the Driving Avoidance Scale. In other words, participants who reported low driving confidence, and negative attitudes and beliefs towards driving reported greater levels of self-regulation.

Table 15: Bivariate correlations between psychosocial variables and mean driving avoidance

<table>
<thead>
<tr>
<th>Psychosocial variables</th>
<th>Mean avoidance</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>r²</td>
<td>p</td>
</tr>
<tr>
<td>Driving confidence</td>
<td>-.46</td>
<td>0.21</td>
<td>.001</td>
</tr>
<tr>
<td>Affective Attitude</td>
<td>-.58</td>
<td>0.34</td>
<td>.001</td>
</tr>
<tr>
<td>Instrumental Attitude</td>
<td>-.53</td>
<td>0.28</td>
<td>.001</td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>-.34</td>
<td>0.12</td>
<td>.001</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td>-.58</td>
<td>0.34</td>
<td>.001</td>
</tr>
<tr>
<td>Intention to continue driving</td>
<td>-.32</td>
<td>0.10</td>
<td>.001</td>
</tr>
</tbody>
</table>

Italic font *p*<.001

5.6.4.3. Associations between all variables

Bivariate correlations between all key Socio-demographic, Driving exposure and Psychosocial variables are presented below in Table 16. Compared to Socio-demographic and Driving exposure variables, Psychosocial variables demonstrated stronger associations with driving avoidance scores as well as stronger correlations with other predictor variables.
Table 16: Bivariate correlations (Pearson's r) between all key variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
<th>20</th>
<th>21</th>
<th>22</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Avoidance</td>
<td></td>
<td>.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Age</td>
<td>.51*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Years license</td>
<td>.33**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. ARIA</td>
<td>.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Income (current)</td>
<td>.16*</td>
<td>-.16*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Income (future)</td>
<td>.15</td>
<td>.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Advanced training</td>
<td>-.24*</td>
<td>-.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Hrs/week driving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Driving Space</td>
<td>.19</td>
<td>-.12</td>
<td>.25*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Health</td>
<td>-.19*</td>
<td>-.15</td>
<td>.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Driving speed</td>
<td></td>
<td>-.16</td>
<td>.22**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Driving performance</td>
<td>-.18</td>
<td></td>
<td>.21**</td>
<td>.20**</td>
<td>.31**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Dependency on others</td>
<td>.23**</td>
<td>.16*</td>
<td>.17</td>
<td>-.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Pass up opportunities</td>
<td>.19**</td>
<td>.16*</td>
<td>.17</td>
<td>-.14</td>
<td>-.16*</td>
<td>-.12</td>
<td>-.18*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Rate of alt. transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Usage of alt. transport</td>
<td>-.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Confidence</td>
<td>.46**</td>
<td>.28**</td>
<td>.21*</td>
<td>-.24*</td>
<td>.34**</td>
<td>.19**</td>
<td>.29**</td>
<td>.27**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Affective Attitudes</td>
<td>-.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Instrumental Attitude</td>
<td>-.21</td>
<td>.20**</td>
<td>.21**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Subjective Norm Attitude</td>
<td>-.15</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. PBC</td>
<td>.14</td>
<td>.25**</td>
<td>.19*</td>
<td>.15</td>
<td>-.14</td>
<td>-.14</td>
<td>-.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Intention</td>
<td>.32**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: *p<.01; **p<.001

*Gender and Advanced driver training used point-biserial correlation.
5.6.4.4. Hierarchical multiple regressions of Socio-demographic, Driving exposure and Psychosocial variables on self-regulation

Hierarchical Multiple Regression (HMR) analysis was conducted to assess the ability of the Psychosocial variables (Driving Confidence Scale, Attitudes and Beliefs Towards Driving Scale) to predict levels of self-regulation (Driving Avoidance Scale), after controlling for the influence of Socio-demographic and Driving exposure variables. As Socio-demographic and Driving exposure variables have been commonly used within the older driver literature as predictors of their self-regulatory behaviours (detailed in Chapter 3), the current analysis focused on determining the contribution of psychosocial variables, beyond the variables taken from existing driving self-regulation research. Thus, Socio-demographic variables that were significant predictors of driving avoidance (see section 5.6.8) were entered as step 1, whereas psychosocial variables were entered as step 2. The results of the HMR of predicting participants’ levels of self-regulation (Driving Avoidance Scores) are reported in Table 17.
Table 17: Hierarchical Multiple Regression results of socio-demographic, driving exposure and psychosocial variables on self-regulation

<table>
<thead>
<tr>
<th>Scale</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>R</th>
<th>R2</th>
<th>Adj R</th>
<th>Δ R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Step 1 Socio-demographic and driving exposure variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>.10</td>
<td>.006</td>
<td>.08</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>-.21</td>
<td>.08</td>
<td>-.14*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanced training</td>
<td>-.07</td>
<td>.11</td>
<td>-.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving Space</td>
<td>-.38</td>
<td>.05</td>
<td>-.41**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Health</td>
<td>-.15</td>
<td>.06</td>
<td>-.13*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving speed</td>
<td>-.27</td>
<td>.09</td>
<td>-.17**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving performance</td>
<td>-.01</td>
<td>.07</td>
<td>-.01</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dependency on other drivers</td>
<td>.08</td>
<td>.03</td>
<td>.12*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.59**</td>
<td>.34</td>
<td>.33</td>
<td></td>
</tr>
<tr>
<td><strong>Step 2 Psychosocial variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affective attitude</td>
<td>-.26</td>
<td>.05</td>
<td>-.25**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Instrumental attitude</td>
<td>-.24</td>
<td>.06</td>
<td>-.21**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective Norm</td>
<td>.07</td>
<td>.06</td>
<td>.06</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBC</td>
<td>-.19</td>
<td>.04</td>
<td>-.24**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intention</td>
<td>-.04</td>
<td>.06</td>
<td>-.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence</td>
<td>-.15</td>
<td>.03</td>
<td>-.18**</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>.80**</td>
<td>.65</td>
<td>.63</td>
<td>.30**</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: PBC= Perceived Behavioural Control; *p < .05 **p < .001

At step 1, socio-demographic and driving exposure variables significantly predicted participants’ levels of self-regulation, $F (8, 264) = 17.82, p < .001$, accounting for 34% of the variance in self-regulation. After entry of the Psychosocial variables at Step 2 of the HMR, the total variance of self-regulation explained by the model as a whole was 65%, $F (14, 258) = 33.55, p < .001$. This additional 31% of variance in self-regulation, explained by psychosocial variables was significant, $F$ change (6, 258) = 35.78, $p < .001$. These results demonstrated that Psychosocial variables significantly predicted participants’ self-reported self-regulation, after controlling for their Socio-demographic and Driving exposure characteristics.
Once psychosocial variables were entered into the model in Step 2, *gender, health, driving speed and dependency on other drivers* were no longer significant predictors of levels of self-regulation. There are seven variables that made a statistically significant independent contribution ($p < .05$) to the overall model. In order of strength of relationship, they were: *age* ($\beta = -.10$, $p < .05$), *driving performance* ($\beta = .10$, $p < .05$), *affective attitude* ($\beta = -.25$, $p < .001$), *perceived behavioural control* ($\beta = -.24$, $p < .001$), *instrumental attitude* ($\beta = -.21$, $p < .001$), *driving space* ($\beta = -.19$, $p < .001$), and *driving confidence* ($\beta = -.18$, $p < .001$). These results indicate that older drivers who hold less favourable attitudes towards driving, who perceive less behavioural control over driving, who report driving to be less important to their daily functioning, who report less driving space (prefer to drive close to home), and who have less confidence about driving, self-regulate to a greater extent.

### 5.6.5. Mediation analyses on interactions between variables

Mediation analysis was used to assess the interaction of variables specified in Hypotheses 17 to 20 (section 5.4.). Specifically, the direct and indirect effects of *age, health, gender, cognitive impairment, driving confidence, residential location* and *alternative transport* on participants’ levels of self-regulation were examined. Analyses were conducted using the bootstrapping method developed by Preacher and Hayes (2004; Shrout & Bougler, 2002). This method is a nonparametric resampling procedure based on 5000 bootstrapped resamples, to test the direct and indirect effects of these predictor variables on self-regulation. Significance of the indirect effect is shown if zero is not contained within the 95% CIs for the indirect path of the two variables (path $a*b$) (Baron & Kenny, 1986; Roelofs et al., 2008).

#### 5.6.5.1. Mediating influence of health conditions on the relationship between age and self-regulation

The analysis revealed a significant positive correlation between *age* (IV) and self-regulation (DV) ($r = .14$, $p < .05$), and *age* and reported *number of medical conditions* (mediating variable; MV), ($r = .32$, $p < .001$). However, the relationship between reported *number of medical conditions* and self-regulation was not significant ($r = .05$, $p > .05$). Further, once *number of medical conditions* was entered
into the model, age remained a significant predictor of self-regulation (β = .14, p > .05). Therefore, the meditational hypothesis between age, number of medical conditions, and self-regulation was not supported.

5.6.5.2. Mediating influence of driving confidence on the relationship between gender and self-regulation

The analysis revealed a significant correlation between gender (IV) and self-regulation (DV) (r = -.27, p < .001), and a strong significant negative correlation between driving confidence (MV) and self-regulation (r = -.46, p < .001). Gender and driving confidence were also significant correlated (r = .22, p < .001). Overall, 24.2% of the variance in self-regulation was explained by gender and driving confidence.

When self-regulation was regressed on both gender and driving confidence, the relationship between gender and self-regulation decreased markedly, but remained significant (β = -.18, p = .001). A Sobel test revealed that driving confidence significantly mediated the relationship between gender and self-regulation, z = -.328, p = .001, SE = .04. Bootstrapping with 5000 samples also confirmed these results; the mediation effect was significant with a 95% confidence interval from -.06 to -.04. These results indicate driving confidence partially mediated the effects of gender on self-regulation.

5.6.5.3. Mediating influence of cognitive impairment on driving confidence on self-regulation

Mann-Whitney (U) analyses were used to investigate driving confidence and avoidance between participants who passed the cognitive screen (Clock Drawing Test) and those who failed this screening test. The analysis revealed no group difference in confidence ratings; on average, both “cognitively normal” and “cognitively impaired” groups were ‘very’ confident in a range of high-risk driving situations), U = 440.50, Z = -.78, p = .44, r = .00. Those that failed the cognitive screen were significantly less likely to self-regulate, U = 336.50, Z = -2.14, p < .03, with a medium effect size r = .26. Because no significant relationships between cognitive impairment (IV) and driving confidence (MV) was found, full meditation analysis was not conducted.
5.6.5.4. Mediating influence of the perception and usage of alternative transport on residential location and self-regulation

Both frequency of usage and perception of alternative transportations (MV) were significantly correlated with self-regulation (DV) ($r = -.12, p < .05; r = .18, p < .01$ respectively). However, remoteness of residential location (IV) was not significant correlated with self-regulation ($r = -.02, p = .40$). Therefore, mediation analysis was not conducted.

5.7. Discussion

This second study was a quantitative investigation of the Socio-demographic; Driving exposure and Psychosocial factors that influence older drivers’ self-regulation using a cross-sectional survey design. The current study is, to the author’s knowledge, the first to simultaneously examine the Socio-demographic, Driving exposure and Psychosocial variables in the investigation of older adults’ use of driving self-regulation. The following section presents a summary of results and conclusions drawn from this study.

5.7.1. Research findings

This section discusses the research findings in relation to the research hypotheses outlined in section 5.4.

5.7.1.1. Overall structure of the MOTRS model

H1: Bivariate correlations (section 5.6.4.1. and 5.6.4.2) and Hierarchical Multiple Regression (HMR; section 5.6.4.4.) analyses demonstrated support for this hypothesis. At the bivariate level, while Socio-demographic and Driving exposure variables demonstrated weak to moderate correlations with levels of self-regulation, psychosocial variables demonstrated moderate to strong predictors of self-regulation. Further, HMR demonstrated that many socio-demographic and driving exposure variables were no longer significant once psychosocial variables were entered into the model. Finally, HMR showed a substantial amount of variance of self-regulation (63%) could be explained by the combination of Socio-demographic, Driving
exposure and Psychosocial variables selected, demonstrating the proposed factors within the MOTRS model were proficient in predicting older adults’ driving self-regulation. Overall, these results provide support for the proposed content and structure of the MOTRS model.

5.7.1.2. Psychosocial factors and self-regulation

With the exception of cues to self-regulation, all the proposed hypotheses on psychosocial variables were supported. These findings are discussed below.

H2: A strongly negative correlation between driving confidence and self-regulation was found. This is consistent with the existing body of literature that demonstrates older adults who report greater confidence in their driving ability are less likely to self-regulate, supporting the hypothesis.

H3 -6: As demonstrated by the bivariate correlations in section 5.6.4.2, each of the variables measured by the Attitudes and Beliefs towards driving scale (Lindstrom-Forneri et al., 2007) was significantly negatively correlated with self-regulation. That is, older adults who perceived to have less control over the vehicle, less social acceptance towards their driving, perceived the driving task to be less enjoyable and important to the maintenance of their daily activities, and reported to be less intention to continue driving in the near future reported greater levels of self-regulation. This provides support for the hypotheses, and is consistent with the findings of Gwyther and Holland (2002), who found that affective and instrumental attitudes correlate significantly with older adults’ self-regulation.

H7: As demonstrated by the bivariate correlations (see section 5.6.4.3), instrumental and affective attitudes, perceived behavioural control and subjective norm were significant predictors of older drivers’ intention to drive. Older adults who perceived themselves as having less control over the vehicle, less social acceptance towards their driving, perceived the driving task to be less enjoyable and important to the maintenance of their daily activities reported less intention to continue driving in the foreseeable future. This finding supports the hypothesis and is consistent with that of Lindstrom-Forneri et al. (2007).
Results revealed that participants who received cues to self-regulate demonstrated similar levels of self-regulation compared to those who did not, rejecting this hypothesis. However, this result should be interpreted with caution, as only 21 participants within the current sample received these cues to self-regulate.

5.7.1.3. Socio-demographic factors

With the exception of employment status, all the proposed hypotheses on the relationship of socio-demographic factors and self-regulation were supported. These findings are discussed below.

H9: Bivariate correlations in section 5.6.4.1 showed age and gender to be significant predictors of older adults’ self-regulation, such that participants who were older, and female, reported greater levels of self-regulation, supporting this hypothesis. This result is also consistent with that reported in the older driver literature reviewed in Chapter 3.

H10, 12 and 13: Participants’ health conditions, confidence in financial income, and remoteness of residential location were not significantly correlated with their reported levels of self-regulation, rejecting these hypotheses.

Two studies demonstrated that self-regulators are likely to have lower annual household income (Ragland et al. 2004; Naumann et al. 2011). However, West et al. (2003) found no significant difference in the annual household income between self-regulators and non-self-regulators.

H11: Consistent with the hypothesis, those who failed the cognitive screening test (CDT) demonstrated significant lower levels of self-regulation than those who passed this screening test.

H14: Only 6 participants were in full time employment at the time of the study. Such a small, and unequal sample size means no reliability statistics could be generated. Therefore, this hypothesis could not be tested.

5.7.1.4. Driving exposure and self-regulation

H15-16: Bivariate correlations revealed significant correlations between participants’ dependency on other drivers, perception and usage of alternative
transportation and their levels of self-regulation. That is, older adults who are more
dependent on other drivers for transportation, reported more positive perception and
greater usage of alternative transportation, reported greater levels of self-regulation.
These results provide support for these two hypotheses.

5.7.1.5. Interaction between examined variables

H17-20: These four hypotheses were mediating hypotheses that concerned the
interaction between Socio-demographic, Driving exposure variables and Self-
regulation. Only hypothesis 18 found support within the current study: participants’
levels of driving confidence significantly (partial) mediated the relationship between
gender and self-regulation. This finding is consistent with that suggested in the
current literature reviewed in Chapter 3. However, as stated in Chapter 3, this is the
first study that formally tested this mediating hypothesis. The other three mediating
hypotheses did not find support mainly due to the lack of strong correlation between
socio-demographic variables and self-regulation within the current data.

5.7.2. Considerations of Research findings

In sum, the overall structure of the MOTRS model and variables of the model
found support within the current study. With the exception of cues to self-regulation
and employment status, all of the hypotheses regarding the bivariate relationships
between socio-demographic, driving exposure, psychosocial variables and self-
regulation were supported. Due to the non-significant relationships between self-
regulation and number of reported health conditions, cognitive impairment, and
remoteness of residential location, only the mediating hypothesis of gender-driving
confidence-self-regulation found support within the current study. Several potential
explanations may account for these findings.

The use of self-report self-regulation may account for the generally low
driving avoidance ratings across the current sample. While the low levels of self-
regulation was similar to that reported by previous studies (e.g. Horswill et al., 2011;
Molnar & Eby, 2008; Sullivan et al., 2009), a restriction in range in the dependent
variable (i.e. self-regulation) may reduce the correlations within the model pathways.
Similarly, both perception and usage of alternative transport were low across
participants, regardless of residential location. The restriction in range in these
mediating variables may lead to underestimating the correlations of the model pathways, accounting for the non-significant mediating hypothesis of residential location – alternative transportation – self-regulation.

Second, in regards to cues to self-regulation and employment status, very few participants reported receiving suggestions that they should limit or stop driving or being employed full-time. While non-parametric tests were employed to limit the effects of unequal sample sizes, such a small number of cases (cues to self-regulation, \( n = 21 \); full time employment, \( n = 6 \)) reduce the ability to conclusively affirm any statistical inferences made regarding these variables.

In regards to the three meditational hypotheses that were not supported within the current study, all were due to non-significant relationships between Socio-demographic variables and self-regulation. The non-significant relationships between these Socio-demographic variables (i.e. health conditions, cognitive impairment and residential locations) contradicted previous research findings discussed in Chapter 3 (Braitman & Williams, 2011; Kostyniuk & Molnar, 2008; Siren & Meng, 2012; Tuokko et al., 2012). The issue of inaccurate reporting is especially prevalent in assessing the health conditions and cognitive impairment of older adults. Indeed, as discussed in Chapter 3, previous research has demonstrated that a noted proportion of older drivers who experience significant cognitive impairments and other health impairments lack awareness of their conditions (e.g. Okonkwo et al., 2008; Ross et al., 2009).

5.7.3. Theoretical and practical implications

The results demonstrated encouraging findings for both the structure and content of the proposed MOTRS model. As discussed above, the overall structure of the MOTRS model found support within the current study. Importantly, the identified potential psychosocial factors revealed to contribute substantially to older adults’ driving self-regulation, and accounted for the influence of a number of salient socio-demographic factors in previous studies, such as age, and health conditions. The current findings also demonstrated the Socio-demographic, Driving-specific and Psychosocial factors interact with each other to influence older adults’ driving self-regulation, improving our understanding of the self-regulatory processes.
Further, the Socio-Demographic, Driving exposure and Psychosocial variables examined accounted for a significant amount of variance in participants’ levels of self-regulation. Collectively, these results indicate older driver theories need to consider a wide range of factors, particularly latent psychosocial factors, which have been shown in the current study to be crucial factors in predicting older adults’ driving self-regulation.

In addition, the current study demonstrates the need to consider environmental factors such as *dependency on other drivers* in predicting older adults’ driving self-regulation. This is consistent with the prediction of the MOTRS model that environmental factors could influence older adults’ self-regulation. On an experimental level, the current study reflected the need of the MOTRS model to be validated against objective measures of self-regulation and applied to a sample where more alternative transportation options are available.

In regards to *driving exposure*, the commonly used index of average hours driven per week was not predictive of older adults’ level of driving self-regulation. However, this study also adopted a second, novel, measure of driving exposure: *driving space* (frequency of various travel distances from home). *Driving space* was demonstrated to be a significant predictor of older adults’ levels of self-regulation, even after psychosocial variables were considered. These findings suggest *driving space* may better characterise the driving exposure of older adults than average hours driven per week. It is also possible, that the nature of older adults’ practice of self-regulation may be based on *driving space* (i.e. location of their driving trips), rather than total frequency, duration or distance of driving. In other words, self-regulating older adults may be driving just as much as their non self-regulating counterparts but may restrict their driving locations closer to home. This possibility could not be directly tested due to the lack of driving trip information. Future research should explore this potential distinction within self-regulation through the use of driving trip information; specifically, information regarding driving locations and distances driven by trip locations.

On the theoretical level, the results of Study Two provide support for the application of psychosocial variables in predicting older adults’ driving self-regulation. This is evident in the strong correlations between *affective* and
instrumental attitude, perceived behavioural norm and levels of self-regulation. However, intention towards driving and subjective norms were no longer significant predictors in the overall model of self-regulation, suggesting that the application of the Theory of Planned Behaviour (TPB) on older adults’ driving self-regulation requires caution. Further, the mediating nature of the Psychosocial variables indicates usage of self-regulation may be modified through focusing on older adults’ confidence, attitudes and beliefs towards driving.

5.7.4. Limitations and future suggestions

A main limitation of the current study is the reliance on self-report self-regulation information. As discussed in Chapter 3, despite the obvious advantages of assessing participants’ characteristics through self-report questionnaires, its vulnerability to inaccurate report and response biases (e.g. social desirability bias) may reduce the validity and reliability of the results. While the current study attempted to limit social desirability bias through emphasising the anonymity and confidentiality of responses during participants’ correspondence (Lajunen & Summala 2003), other biases such as inaccurate reporting could not be controlled. Study 4 of the current research program addressed this methodological limitation through cross validating the current findings against objectively measured older adults’ driving behaviours to ensure inter-method reliability and ecological validity of findings. Future research that measures participants’ health conditions using other methods, such as individual’s hospital records and physician’s referrals, may also provide a more accurate and reliable estimate of older adults’ health conditions and their relationships with driving self-regulation. This limitation is addressed in the final study of this research program by using objectively measured driving behaviours as outcome measures.

As discussed in section 5.7.2., to reduce the restriction in range, future research with larger sample sizes is required to investigate the relationships between these variables (e.g. health conditions, cues to self-regulation) with older adults’ driving self-regulation. Future research should also explore the self-regulatory driving behaviours of older adults who reside in locations where alternative transportations are more accessible and better received from older drivers. This limitation will be
addressed in Study Three through using a cohort of older adults from the Australian Capital Territory.

While the Clock Drawing Test (CDT) is a measure of cognitive ability that is sensitive to cognitive impairment (Sunderland et al., 1989; Wolf-Klein, Silverstone, Levy, Brod & Breuer, 1989), and a significant predictor of older adults’ performance on simulated driving task (Mathias & Lucas, 2009), this test is not a comprehensive measure of cognitive ability. A recent literature review indicates that while the CDT can accurately screen for moderate and severe dementia, its sensitivity is considerably lower when applied to patients with mild or questionable dementia (Pinto & Peters, 2009). While the CDT was used due to the requirement of a self-administered cognitive screening test to increase the representative and generalizability of the sample, other tests of cognitive abilities (such as test battery of the Mattis Organic Mental Status Syndrome Examination (MOMSSE), Trail Making Test, the Rivermead Behavioral Memory Test (RBMT)) should be used to further investigate the potentially mediating relationship between cognitive abilities, driving confidence and self-regulation.

A further limitation is the measurement of some of the psychosocial factors, specifically, participants’ attitudes and beliefs towards driving.

Finally the sampling strategies that were used (advertising for volunteer participants, and snowball sampling) may have resulted in the sampling of keen and active drivers. Various older adults’ community organizations (e.g. University of 3rd Age, Country Womens’ Associations) assisted in the participant recruitment process. Participants recruited through these organizations may be more active and of better health than other older adults. A qualitative study by Adler and Rottunda (2006) identified a group of older drivers who they called “resisters” (drivers who have unrealistic perceptions about their driving skills and continue to drive until they are forced to stop). Older adults of this group were unlikely to participate in studies. Nevertheless, the present sample shares similar demographic characteristics with other, larger sample, older driver studies (e.g. Freund et al., 2005; Ross et al., 2009).
5.8. Chapter Summary

This study was the first to simultaneously test the relationships between the Socio-demographic, Driving exposure, Psychosocial variables drawn from Chapter 3 and the driving self-regulation among older adults. An additional aim of the study was to test specific pathways of the proposed Multilevel Older Person’s Transportation and Road Safety (MOTRS) model proposed in Chapter 4.

The current findings are important in several aspects. First, it would appear from the self-report information that self-regulatory driving behaviours are not commonly practiced among these older adults. This outcome does not necessarily mean that older adults do not practice driving self-regulation. This finding could be due to the way self-regulation was measured. As revealed by the significant correlation between driving space and self-regulation, older adults who practice driving self-regulation may restrict their driving based on proximity of driving locations from home. That is, with increased sensory and functional declines, they may choose to restrict their driving trips to locations closer to their home and immediate neighbourhoods. Nevertheless, other measures of self-regulation (e.g. objective measure) may be needed to further investigate the relationship between these variables. In addition, the present study demonstrates that the relationships between older adults’ driving self-regulation, Socio-demographic and Driving exposure variables to be mediated by Psychosocial factors. This finding provides support for the structure and content of the proposed MOTRS model. The next chapter continues the quantitative examination of the MOTRS model through investigating the specific pathways and the overall structure of the theory.
Chapter 6: Structural analysis of the MOTRS model

6.1. Introductory comments

The study presented in the previous chapter provided an in-depth examination of the Socio-demographic, Driving-specific and Psychosocial factors relating to the driving self-regulation of older adults. This chapter continues the presentation of results from the second study. The aim of this chapter is to continue the examination of the MOTRS model. Specifically, the current chapter investigates how the salient factors identified in the previous chapters fit within the proposed MOTRS model, the relative importance and the pathways between these variable.

6.2. Method

The data used in this chapter is the same data presented in Chapter 5. Thus, information regarding participant recruitment, data collection procedures, data treatment and sample characteristics can be found in sections 5.5 and 5.6.

6.3. Structural analysis of the MOTRS model

In order to test the relationships between variables that significantly contributed to participants’ self-regulation (detailed in section 5.6), Structural Equation Modelling (SEM, AMOS version 20) was performed to further investigate the significant variables identified from the Hierarchical Multiple Regression in section 5.6.4.4. SEM was used instead of other multivariate statistical techniques because of its ability to 1) test the overall structure of the MOTRS model rather than coefficients or pathways individually, and 2) model mediating variables through enabling measurement of both direct and indirect effects of multiple variables. Further, SEM allows the reduction of measurement error through the use of Confirmatory Factor Analysis (CFA).

6.3.1. Model Conceptualisation

The Structural Equation Modelling (SEM) testing process followed the overarching process described by Byrne (2001) and others (e.g. Diamantopoulos &
The first step of the Structural Equation Modelling (SEM) process is model conceptualisation. Due to the design of the study (between subjects cross-sectional survey), not all variables within the MOTRS model could be tested. While variables within the SEM models are generally selected a-priori, the limited sample size ($N = 273$) prevents testing all of the variables in the model. Through focusing on the prominent variables identified through HMR in section 5.6.4.4, this model development approach allows a more in-depth investigation of the overall structure of the model, as well as the direct, indirect and total effects of the major variables on older drivers’ use of self-regulation. Compared to the strictly confirmatory approach of SEM, this model development approach reduces the stability of the model as it was developed based on the uniqueness of the current data set. However, this limitation is addressed through the use of a cross-validation strategy, whereby the model will be calibrated and confirmed using an independent validation sample in Chapter 7 (see Anderson & Gerbing, 1998, for further discussion of this issue).

Specifically, based on the bivariate correlations between all variables, variables that have been demonstrated to provide notable direct contribution to the DV (i.e. self-reported self-regulation), and variables that provide notable indirect contribution to the DV via these variables were selected. This systematic process moves from the broader conceptual model to a more specified measurement model. This selection process resulted in thirteen variables: seven demographic and driving exposure factors (driving space, advanced driver training, dependency on others, likelihood to pass up on opportunities, self-reported driving performance, self-reported health rating, and gender), five psychosocial factors (driving confidence, affective attitude, instrumental attitude, subjective norm, and perceived behavioural control about driving), and self-regulation. Likelihood to pass up on opportunities was excluded because this is likely to be an outcome of restrictive driving behaviours, rather than a presumed causal factor.

SEM assumes that the observed variables are drawn from a continuous population. Thus, the parameter estimates and standard errors obtained from ordinal and nominal variables will be biased (Kaplan, 2000). As a result, the direct and indirect effects of nominal variables (i.e. gender and advanced driving training) on
self-regulation were examined via Hierarchical Multiple Regression (see section 5.6.4.4.).

A prediction of the MOTRS model is that Socio-demographic and Driving-specific factors provide the individual and environmental context in which older adults process stimuli through their psychosocial filters, and make decisions regarding driving self-regulation. Specifically, socio-demographic and driving exposure factors were hypothesised to influence older adults’ self-regulatory driving behaviours by modifying how confident they are about their driving abilities (driving confidence), how much they take pleasure out of the driving task (affective attitude), how important they think driving is to their wellbeing (instrumental attitude), how much social pressure they feel regarding driving (subjective norm), and how much control they feel over the driving task (perceived behavioural control). To reflect this hypothesis, the MOTRS model outlined in Chapter 3 was presented below (see Figure 11) as a fully mediated structural model.

![Figure 11: A fully mediated model of self-regulation](image)

As this is the first study that focused on the psychosocial factors involved in the self-regulation process of older adults, it is likely that the current MOTRS model has not identified all important psychosocial variables in the process of self-regulation.
As such, an alternative model (Model 2) was developed to account for the condition that Socio-demographic and Driving exposure variables may indirectly influence self-regulation via other Psychosocial filters that were not examined within the current study. This partially mediating model is represented below in Figure 12.

![Figure 12: Model 2 – a partial mediated model of self-regulation](image)

**6.3.2. Construction and testing of measurement model**

The next step of the Structural Equation Modelling process was to construct and test the measurement model, a process of refining each of the constructs for inclusion in the final structural model. Testing the measurement model typically follows a two-stage process. First, the latent variables (*driving avoidance, driving confidence, driving space and attitudes and beliefs towards driving*) were considered in isolation as one-factor co-generic models to allow assessment of discriminant validity through a series of Confirmatory Factor Analysis (CFA). This step examines how well each scale item contributed to measuring the corresponding constructs under investigation, and reduce the measurement error through only retaining the significant indicators of the constructs (Byrne, 2001). This step would also allow single indicator latent variables to be established in which measurement error of the latent variables is specified as part of the final model (Marsh, Wen & Hau, 2004). After the properties of
each latent variable were examined, the full measurement model was constructed by combining all of the examined individual variables within the model using the conceptualised structural models (Model 1 and 2 above). This full measurement model was then respecified to provide to most parsimonious representation of the data.

6.3.2.1. Driving Space

Five items were used to measure participants’ averaged Driving Space (i.e. how far from home do they usually drive?). Results indicated the one factor cogenetic model structure with all five items provided a poor fit of the data, $\chi^2 (5) = 118.8$, $p<.001$, RMSEA = .29, CFI = .80. Inspection of the fit indices revealed that item one (driving within the immediate neighbourhood) to be a poor predictor of Driving Space, with low correlations with the other four items. This is not surprising given most participants reported that they “always” drive within the immediate neighbourhood. This item was not retained.

Item four and five (frequency of driving to more distant cities and outside the state) correlated highly, and that covariance was not explained by driving space alone. A two factor structure of short distance driving and long distance driving was specified and tested. This strategy was chosen to reflect the different nature of the driving trips between these two factors. That is, while some older drivers may prefer to restrict their driving trips to locations closer to home, some may prefer to reduce daily driving activities, but still carry necessary long distance trips (e.g. to visit families who are out of town). Results revealed the two factor structure of short and long distance driving represented a good fit, $\chi^2 (1) = .69$, $p = .41$, RMSEA = .00 (LO 90 = .00, PCLOSE=.55 suggesting that even the test of exact fit is supported), CFI = 1. Short distance driving was significantly positively correlated with long distance ($r = .69$). Therefore, the driving space variable in the measurement model is a combination of the frequency in which participants engage in short distance driving and long distance driving.

---

20 SEM fit indices: RMSEA <.05 suggests good fit, RMSEA <.08 suggests acceptable fit. CFI >.95 indicate parsimony
21 LO 90 and PCLOSE are presented when RMSEAs <.05. LO 90 (lower 90%) = 0 suggest even the test of exact fit is supported. PCLOSE is a p-value for testing the hypothesis that RMSEA that RMSEA <.05.
6.3.2.2. Attitudes and Beliefs about Driving

As mentioned in section 5.5.3.2, 12 items were used to measure the affective attitude, instrumental attitude, subjective norm, and perceived behavioural control of driving using four separate subscales, each with three items. These items were developed to capture the attitudes and beliefs of older adults towards driving (Lindstrom-Forneri et al., 2007). The full set of 12 items represented a poor fit of the data, $\chi^2 (48) = 159.36$, p <.001, RMSEA = .09, CFI = .92. Examination of factor loadings revealed the item “I am becoming more concerned about the unsafe behaviour of other drivers” and “My friends drive their vehicles regularly” revealed these items to be poor indicators of their respective factors. The inter-item correlations of these factors were also low. These items were therefore sequentially deleted. Items from the Subjective Norm subscale were statistically problematic. Inspection of the factor pattern and structure coefficients revealed poor discriminate validity of this factor. Further, the Eigenvalues indicated a four-factor solution to be inappropriate, and that a three-factor structure should be used. Inspection of items of the other three subscales demonstrated high factor loadings and discriminant validity. Thus, the subjective norm subscale was not retained. While the removal of the subjective norm factor deviates from the original scale by Lindstrom-Forneri et al., (2007), the factor structure of the attitudes and beliefs scale was never validated. Further, the findings discussed in the previous chapter indicated the majority of older drivers are not particularly concerned about peer’s assessment of their driving. The resulting two higher-order model of participants’ attitudes and beliefs towards driving was an acceptable fit, $\chi^2 (16) = 35.74$, p =.003, RMSEA = .067 (LO 90 = .038, PCLOSE =.15), CFI = .98

6.3.2.3. Driving confidence

Participants’ driving confidence was measured using 21 items (section 5.5.3.2), representing 21 driving situations that older adults’ reported in previous studies as risky (Owsley et al., 1999; Sullivan et al., 2011). The full set of 21 items represented a poor fit of the data, $\chi^2 (189) = 2164.29$, p <.001, RMSEA = .16, CFI = .74. While factor loadings were all significant, sample correlations demonstrated very high correlations between the items (> .8), indicating item redundancy. Using standardised residuals covariance matrix and modification indices, redundant items were
sequentially discarded. This item deletion process continued until all items remained demonstrated reasonable inter-item correlation (.4-.7; Kline, 2005), resulting in five items: in the rain, at night, with passengers (children), unfamiliar roads, and high traffic roads.

The standardised residuals covariance matrix and modification indices indicate driving confidence alone is not accounting well for the covariance between in the rain and at night. This is not surprising given previous literature (e.g. Baldock et al., 2006), which consistently reported that older adults commonly avoid these two situations. However, rather than discarding one of the items as measure of driving confidence, a two-factor model of driving confidence was specified and tested. Both of these items were retained to allow comparison with previous quantitative and qualitative studies. Further, the two factor structure reflects two qualitatively different types of driving situations: 1) visually demanding (at night, in the rain), and 2) cognitively demanding (with children, unfamiliar roads, and high traffic roads). This two factor structure of driving confidence was a good fit of the data, $\chi^2 (4) = 5.63$, $p = .41$, RMSEA = .04 (LO 90 = .00, PCLOSE=.52), suggesting that even the test of exact fit is supported, (CFI = >.99).

6.3.2.4. Driving Avoidance

As previously stated, the same driving situations were used to measure participants’ levels of driving avoidance. The full set of 21 items represented a poor fit of the data, $\chi^2 (189) = 1650.41$, $p < .001$, RMSEA = .17, CFI = .72, similar to the driving confidence scale. Using standardised residuals covariance matrix and modification indices, redundant items were sequentially discarded. This item deletion process continued until all items remained demonstrated reasonable inter-item correlation (.4-.7; Kline, 2005), resulting in five items: in the rain, at night, in foggy conditions, Freeways, and high traffic roads. Similar to driving confidence, a two-factor model of visual (in the rain, at night and in foggy conditions) and cognitively demanding (freeways and high traffic roads) driving situations represented a good fit of the model, $\chi^2 (4) = 8.88$, $p = .6$, RMSEA = .06 (LO 90 = .00, PCLOSE=.26), CFI = .995. Given that the same driving situations were used to measure driving confidence and avoidance, the similarity between the factor structure and items retained in the scales was expected. Driving with passengers (children) was not a
predictor of driving avoidance, potentially because older adults who are with child passengers may find it difficult to avoid such situations (i.e. lack of alternative options).

Once the properties of each latent variables have been established as acceptable in measuring the full structural MOTRS model, the three conceptual models presented in section 6.3.1 were specified and tested. The relationship pathways between socio-demographic, driving exposure, psychosocial variables, and self-reported self-regulation were examined through identifying the model fit of these three structural modes.

6.3.3. Structural Model identification

Single indicator latent variables were constructed for latent variables within the model using the factor structure discussed above. This method accounts for measurement error on parameter estimates through specifying the measurement error based on Cronbach’s alpha (Kline, 2005). Further, Bollen-Stine bootstrap p was used as a post-hoc adjustment to account for the small sample size and multivariate non-normality (Bollen & Stine, 1992). In line with SEM models, observed variables are represented by rectangles, while latent variables are represented by eclipse. The measurement models that determined each latent variable are not reproduced in the structural models, as they have already been discussed in the measurement model section of this chapter (see section 6.3.2). Significant pathways are represented by a solid line, whereas non-significant pathways are represented by a dotted line. The numbers of these pathways are standardised path coefficients.

6.3.3.1. Model 1 – fully mediating model

Model, 1, in which driving confidence, attitudes and beliefs towards driving were hypothesised to completely mediate the effect of socio-demographic and driving exposure variables on self-reported self-regulatory driving behaviours, was specified and tested (see Figure 13; for ease of interpretation, Socio-demographic and Driving-specific variables were represented by grey boxes). The fit indices revealed the

---

22 The respective regression coefficient loadings and measurement error variances were calculated using Munck’s simplified formulae of $SD \cdot \sqrt{\alpha}$ and $SD^2 \cdot (1-\alpha)$ (1979)
hypothesised fully mediating model to be a poor fit of the overall data, $\chi^2 (23) = 56.66$, $p < .001$, Bollen-Stine Bootstrap $p < .001$, RMSEA = .07, CFI = .95, AIC = 120.67. Overall, the socio-demographic, driving exposure and psychosocial variables were able to account for 69% of the variance in self-regulation (self-reported).

Regression weights of the pathways demonstrated that when all other variables were controlled for, *self-reported health* and *driving performance*, and *driving space* (but not *dependency on others*) significantly predicted *driving confidence*. Similarly, *dependency on others*, *self-reported health performance* and *driving space* (but not *self-reported driving performance*) significantly predicted *attitudes towards driving*. In turn, both *attitudes towards driving* and *driving confidence* were significant predictors of *self-regulation*. However, standardised regression coefficients demonstrated *beliefs towards driving* did not significantly predict *self-regulation* ($b = .07$). With the exception of the *self-reported health performance - driving space* and *self-reported health - dependency on others* covariance pathways, significant covariance between socio-demographic and driving exposure variables were all significant at $p < .05$.

![Figure 13: Structural model of Model 1- fully mediating model of self-regulation](image-url)

Figure 13: Structural model of Model 1- fully mediating model of self-regulation
6.3.3.2. Model re-specification

Modifications were made to the MOTRS model to improve the model fit. The model re-specification process was conducted through examining the standardised regression weights of variables, the standardised residual covariance matrix, as well as formal modification indices provided by AMOS. In order to guard against making changes solely based on data-driven grounds, re-specification of the models also had to meet the assumptions of the MOTRS model (see Chapter 4) and overall findings of the existing literature discussed in Chapter 3.

First, non-significant pathways between socio-demographic and driving exposure variables and psychosocial variables (discussed above in model 1) were deleted. This is in line with the MOTRS model’s assumption and the health behaviour literature that different psychosocial factors are influenced by different socio-demographic variables. Second, the standardised residual covariance matrix and modification indices demonstrated that the association between self-reported health rating, driving space and self-regulation was not being accounted for sufficiently by model 1. The association between these socio-demographic variables and self-regulation was hypothesised in the partially mediating MOTRS model (hypothesised model 2 in Figure 12, section 6.3.1). Therefore, pathways between self-reported health performance and self-regulation, driving space and self-regulation were specified. Finally, the standardised residual covariance matrix indicated association between driving confidence and attitudes toward driving was not being accounted for sufficiently in model 1. This is consistent with the MOTRS model (and connectionist models in general) that variables within each level share activation. Thus, a pathway between driving confidence and attitude towards driving was specified. While the pathway between beliefs towards driving and self-regulation was not significant (B = .07, p = .50), belief towards driving was hypothesised to predict self-regulation. Thus, this pathway was retained in the final model (see Figure 14). The resulting re-specified model resulted in a close fit of the data, \( \chi^2 (22) = 37.18, p = .023, \) Bollen-Stine Bootstrap \( p = .04, \) RMSEA = .05 (LO 90 = .02, PCLOSE = .46), CFI = .98, AIC = 103.18.
Figure 14: Re-specified partially mediating model of self-regulation (Model 2)

Overall, 75% of variance in self-regulation (self-reported) was accounted for by the model. Attitudes towards driving was the strongest predictor of self-regulation ($B = -.76, p < .001$). Psychosocial variables of driving confidence and attitudes toward driving partially mediated the effects of socio-demographic and driving exposure variables on self-regulation, suggesting the current study did not capture all the psychosocial factors involved in the self-regulation process.

6.3.3.3. Model comparison

As noted above, the partially mediating model 2 accounted for 75% variance in self-regulation, representing an increase of 6% variance accounted for over model 1. For ease of comparison, the fit indices of the two models were summarised below in Table 18. As can be seen in the difference in AIC, model 2 is the most parsimonious fitting model. This finding is supported by other indices.
Table 18: Comparative fit measures for both MOTRS models

<table>
<thead>
<tr>
<th>Model</th>
<th>$\chi^2$</th>
<th>df</th>
<th>$\chi^2$/df</th>
<th>CFI</th>
<th>RMSEA</th>
<th>AIC</th>
<th>Bollen-Stine p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Full mediation</td>
<td>56.66</td>
<td>23</td>
<td>2.46</td>
<td>.95</td>
<td>.07</td>
<td>120.67</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>2. Re-specified</td>
<td>37.18</td>
<td>22</td>
<td>1.69</td>
<td>.98</td>
<td>.05</td>
<td>103.18</td>
<td>p &lt; .04</td>
</tr>
</tbody>
</table>

Further, with difference in 1 degree of freedom, the difference of the 2 models was greater than the critical value of 3.84, $\Delta \chi^2 = 10.52$, p < .05. Therefore, model 2 represents a significant improvement in fit to the data.

6.4. Discussion

The present study serves as an extension of the previous chapter, and aimed to further investigate the structural pathways of the proposed Multilevel Older Person’s Transportation and Road Safety Model. The current study is the first to formally test the predictions of a proposed theoretical model on the self-regulatory behaviours of older adults. Overall, the results confirm that socio-demographic and driving exposure factors influence older adults’ self-regulatory driving behaviours through psychosocial variables. Encouragingly, the proposed partially mediating MOTRS model accounts for a significant proportion of variance in self-regulation (self-reported) within the current study.

6.4.1. Support for hypotheses

Using Structural Equation Modelling, this study re-examined the first research hypothesis outlined in Chapter 5 (see below). Specifically, the present study examines how psychosocial factors mediate the effects of Socio-demographic and Driving-specific variables on self-regulation.

There was strong support for this mediating hypothesis in the structural model examined. Overall, the Socio-demographic, driving-specific and Psychosocial factors included in the final model accounted for 75% of variance in self-regulation. The present study demonstrated the psychosocial variables (i.e. driving confidence,
attitudes and beliefs towards driving) significantly mediated the effects of socio-demographic and driving specific variables on older adults’ self-regulation. The significance of driving confidence in predicting older adults’ self-regulation is consistent with the existing literature discussed in Chapter 3. The significance of attitudes towards driving in predicting older adults’ self-regulation is consistent with the findings of Gwyther and Holland (2003).

No existing studies have examined the effects of perceived behavioural control (PBC) on older adult’s self-regulation. The non-significant relationship between PBC and self-regulation, when other variables are considered within the model, contrasted the expectation from the Theory of Planned Behaviour.

6.4.2. Limitations of research findings

There are several limitations that underlie the current research. First, as data from the current study are the same as that reported in Chapter 5, methodological limitations identified in the previous chapter also applied to the current study. As highlighted in section 5.7.2, these limitations are grounded in the following: the self-report nature of measurement of self-regulation and independent variables such as health and driving performance, and potential restriction in the range of variables.

A further limitation is the categorical (nominal) nature of the variables gender and advanced driver training. As SEM assumes that the observed variables are drawn from a continuous population (Kaplan, 2000), these variables were excluded from the structural analysis of the MOTRS model. The Hierarchical Multiple regression in section 5.6.4.4 demonstrated that both of these variables appear to provide significant indirect contribution to older adult’s self-regulation. However, the relative contribution, and the pathways of how these two variables influence self-regulation when other variables are considered, could not be tested through the structural analysis of the MOTRS model. It is plausible that these variables could provide indirect contribution to older drivers’ self-regulation through psychosocial factors. Indeed, support was found for the mediating hypothesis of gender-driving confidence – self-regulation (see section 5.6.5). Future research could consider testing the MOTRS model across different populations of older adults to determine model fit across these factors.
As previously discussed, while connectionist models, such as the proposed MOTRS model, are traditionally tested using computational modeling, the current study adopted a more regression-based approach to initially test the model with Structural Equation Modeling. This regression-based approach is more conventional within the domain of health psychology. Eventually, a computational approach in testing the MOTRS model will be required to model outcomes from different legal or social interventions.

A final limitation is the measurement of some of the psychosocial factors, specifically, participants’ attitudes and beliefs towards driving. Informed by the structural analysis, items that were intended to measure subjective norm towards driving were excluded in the final measurement model of attitudes and beliefs towards driving (see section 6.3.2.2). The exclusion of the subjective norm variable warrants attention of future researchers. The operationalisation of the attitudes and beliefs towards driving constructs (including the subjective norm variable) stem from Lindstrom-Forneri et al’s (2007) development of the attitudes and beliefs towards driving questionnaire in predicting older adults’ intention to continue driving. No existing research has examined whether (and to what extent) perceived behavioural control and subjective norm predicts older adults’ driving behaviours, including self-regulation. As evidenced by both the low factor loadings and the unclear factor structure of the subjective norm items, future research is needed to validate the content and structure of the attitudes and beliefs towards driving questionnaire.

### 6.4.3. Implications for the literature

Chapter 5 identified the mediating ability of psychosocial variables on the widely reported effects of socio-demographic and driving-exposure factors on older adults’ self-regulatory driving behaviours. The current study provided a more in-depth examination of the underlying mechanism (or pathways) these factors interact to influence older adults’ self-regulation (self-reported). The overall structure of the MOTRS model was supported, accounting for 75% of the variance in (self-reported) self-regulation.

In addition to the overall structure, the current study provided support for several assumptions of the MOTRS model discussed in section 4.5. First, in contrast
to the sequential processing of traditional older driver models, the MOTRS model assumes that factors operate in parallel, interactive ways. The parallel excitatory and inhibitory effects of self-reported health performance on older adults’ self-regulation support this assumption. As model 2 suggests, increase of self-reported health rating would increase driving confidence, which in turn would decrease the levels of self-regulation. However, the positive correlation between self-reported health performance and self-regulation suggests there is also a direct (or indirect through other variables) excitatory effect on self-regulation.

In addition, unlike traditional older driver models, the MOTRS model also explicitly assumes intra-level variables to interact with one another. Support for this assumption is evident in the significant covariance between socio-demographic and driving exposure variables and between attitudes towards driving and driving confidence. The MOTRS model represents a significant improvement over previous older driver behaviour models (section 4.2) in both its ability to generate testable hypotheses, and the amount of variance in self-regulatory driving behaviours explained.

The findings from the current study also inform the older driver safety literature. First, the simultaneous excitatory and inhibitory activation of factors may assist in explaining, at least in part, the inconsistent findings within the current literature. Specifically, without identifying the mediating or moderating factors involved, different studies that used different samples may produce contrasting results. As an illustration, a relatively healthy sample with high levels of driving confidence, may report relatively low levels of self-regulation; whereas another similarly healthy sample with low levels of driving confidence due another confounding factor (e.g. health conditions), may report higher levels of self-regulations. Thus, through formally testing pathways between a range of Socio-demographic, Driving-exposure and Psychosocial variables on self-regulation, the current study provided an opportunity to reconcile the conflicting findings discussed in Chapter 3.

As discussed in Chapter 3, most existing studies on the psychosocial variables of self-regulation emphasised the significance of driving confidence. However, the present study showed that when all other variables are considered, attitudes towards driving provided the largest single contribution towards older adults’ self-regulation.
This finding highlights the importance to further examine the effects of attitudes and beliefs towards driving on older adults’ self-regulation.

Examination of the measurement models of driving space, driving confidence and driving avoidance revealed the underlying factor structure of these latent variables may be different to their original intentions/development. Specifically, the identified two-factor structure of driving space (short and long-distance driving) reflects the two aspects of transportation needs of older adults. Similarly, the two-factor structure of driving confidence and avoidance represent the different types of driving situations (visually demanding and cognitive demanding) that older drivers feel confident about or prefer to avoid. To the author’s knowledge, this is the first study that subjected these scales to confirmatory factor analyses. Taken together, the factor structure of these supposedly one-factor structured variables reflects the need for these scales to go through more rigorous psychometric testing, and that item-level interpretation approach may be misleading.

The current findings provided explicit pathways in which socio-demographic and driving exposure variables influence older adults’ decisions to self-regulate. This finding is of practical importance as it allows researchers to potentially modify older adults’ self-regulation through targeting these latent psychosocial factors. Further, it highlights the need for effective interventions that consider the necessary variables involved in the process of older adults’ decision to self-regulate. To illustrate, an older driver program that aimed to increase the driving skills of older drivers may also increase their perceived driving performance, thereby increasing their driving confidence, in turn, resulting in a reduced level of self-regulation.

6.4.5. Chapter Summary

This chapter examined the underlying pathways in which socio-demographic, driving exposure and psychosocial factors interact to influence older adults’ self-regulation. Using the assumptions of the MOTRS model discussed in Chapter 4 as a foundation, the pathways of selected variables were specified and tested using structural equation modelling. These structural analyses provided information about the interactive relationships between the variables and self-regulation. Furthermore, they supported a partially mediating model. Several assumptions consistent with the
computational-modelling approach adopted in the conceptualisation of the MOTRS model, including parallel excitatory and inhibition of stimuli were supported. The final step of the structural analysis approach requires that the re-specified MOTRS model be subjected to a cross-validation in an independent sample, using a more objective measure of self-regulation. This is addressed in the following chapter.
Chapter 7: Study 3 – Cross validating the MOTRS model

7.1. Introductory comments

Through sampling a relatively large cohort of Australian older drivers, the study in the previous chapters provided an in-depth understanding of older adults’ practice of self-regulation, and the factors that underlie this practice. Building on that foundation, Study Three was a quantitative re-examination on how these socio-demographics and psychosocial factors are associated with older adults’ self-regulatory behaviours using a naturalistic observational study of older drivers recruited from the Australian Capital Territory, Australia. A mixed-method approach allowed for the comparison between existing findings of older adults’ self-regulation against their actual driving behaviours, thereby increasing the reliability and validity of the current program of research.

The results of this study are presented across two chapters. This chapter contains the results retesting significant pathways of the re-specified Multilevel Older Person’s Transportation and Road Safety (MOTRS) model discussed in the previous chapter. The next chapter describes the travel patterns of the older drivers recorded by Driving Diaries and Global Positioning System (GPS) tracking units over two weeks, and compared these prospectively measured driving parameters with that obtained via self-report questionnaires.

7.2. Purpose of the Study

The proposed Multilevel Older Person’s Transportation and Road Safety (MOTRS) model was formally tested using Structural Equation Modelling (AMOS) in Chapter 6 and re-specified via formal criteria to produce a final ‘best fit’ model. To validate the final model, the current study cross-validated specific pathways in an independent sample of older drivers. Cross-validation provide a mechanism for testing how well the re-specified MOTRS model from Chapter 6 fit an independent older driver sample, thereby guarding against the possibility that the SEM analysis, a sample-based solution, has capitalised on chance relationships within the sample that are not present in the older driver population (MacCallum, Roonzowski, Mar & Reith,
1994; Holmes-Smith, 2010). Despite its importance, none of the existing older driver models have been cross-validated using multiple samples of older drivers.

In addition, the re-specified MOTRS model was based on findings from self-reported information of self-regulation. The findings from the previous study provided important insight into the underlying factors and the process in which these factors contribute to self-regulation. However, this information still needs to be validated against measures of objectively measured driving behaviours to ensure inter-method reliability, convergent and ecological validity. This is particularly important if the ultimate outcomes are objectively measured (e.g. morbidity and mortality associated with road crashes).

Over the past decade, there have been substantial advances in travel data collection methods, especially through the progression of Global Positioning System (GPS) and Geographic Information System (GIS) technology. GPS and GIS can allow researchers to accurately pinpoint and record older drivers’ travel information. Further, this technology allows the use of naturalistic observational studies involving instrumenting older adults’ own vehicles. It provides the potential to monitor their driving behaviours in their normal driving conditions, representing a significant methodological advantage over studies that are based on self-reported behaviours, and laboratory based driving simulation studies.

Studies that used GPS and GIS technology have reported discrepancies between self-reported travel data and objective measures of driving exposure (Staplin et al. 2008; Stopher et al., 2007; Blackchard et al., 2010) across a range of age cohorts. To date, only a few researchers have examined the relationship between self-reported and objectively measured driving behaviours specifically with older adults (Huebner et al., 2006; Marshall et al., 2007; Blacnchard et al., 2010, Crizzle et al., 2013). However, GPS studies are generally expensive and time-consuming to conduct, leading to the small and potentially underpowered sample size utilised (N > 20; Huebner et al., 2006; Marshall et al., 2007, Crizzle et al., 2013), lack of trip details provided, and limited number of predictor variables included in these studies.

While Blanchard et al. (2010) had a larger sample size of older adults (N = 61) and provided detailed trip details in the analyses, only one-week driving information was recorded. Analyses of GPS travel patterns over a 28-day period by Stopher et al.
(2012) found Halo effects in the first three or four days of participants’ travel data, whereby driving behaviours during that period differed significantly from subsequent periods. Thus, short duration travel pattern analyses may lead to inflated estimates of average daily travel. Considering the 1) reliability of travel data, 2) GPS devices limitations (in regards to recording and battery life), and 3) the compliance of participants, Stopher et al (2012) concluded that about 15 days of measurement may represent the optimum length of GPS based studies. As a result, the current study sampled participants’ driving behaviours using GPS waypoints over a 2-week period.

Besides safety of older drivers (and other road users), the maintenance of mobility and independence of older adults also represents an important part of the overall research problem. The functional mobility of older adults has to be considered and maintained in order to mitigate potential negative consequences commonly associated with cessation of driving (e.g. Edwards et al., 2009). To date, little empirical attention has been directed towards identifying the transportation needs of older adults. Thus, an additional focus of the current study was to investigate the driving purposes of older adults using prospective driving diaries.

Accelerometry is another emerging ambulatory assessment being used to identify driving characteristics. An accelerometer is a device that measures both magnitude and rate of acceleration and deceleration. Kinematics measures produced by the accelerometers such as longitudinal and lateral accelerations and decelerations have been used to determine safe driving performance (e.g. Classen et al., 2007). However, traditional accelerometry devices are typically large and non-portable (see Figure 15 for an example), thereby requiring participants to drive along a pre-determined track using an instrumented vehicle. With the rapid advances in technology, recording accelerometry devices have greatly improved in affordability, portability and reliability (see Figure 16 for the recording accelerometers used in the current study). These improvements represent a significant methodological advantage in the current study, as it allows participants to use their own vehicles, in their normal driving environments, thereby increasing the ecological validity of findings. To the author’s knowledge, the potential benefits of using accelerometry to measure driving performance of older adults in their own driving environments has not been determined. Thus, an additional aim of the current study was to serve as a pilot
methodological study to explore the utility of accelerometer in determining older adults’ safe driving performance.

Figure 15: Recording accelerometry devices in the trunk of the instrumented vehicle in Classen et al. (2006)

Figure 16: Recording accelerometry device used in the current study

7.3. Study aims and hypotheses

Extending upon the findings of the MOTRS model in the previous studies, this study aimed to:
1) Cross-validate the respecified MOTRS model discussed in Chapter 6 using a different sample of older drivers

2) Investigate the relationship between self-reported and objectively measured driving behaviours

3) Explore older adults’ transportation needs

4) Determine the utility of recording accelerometer in measuring the safe driving performances of older drivers

In regards to the first study aim, five meditational hypotheses were derived from the findings of Study Two. The first four hypotheses were drawn from the respecified MOTRS model using Structural Equation Modelling (detailed in Chapter 6). The fifth hypothesis was based on the meditational analyses detailed in Chapter 5. These hypotheses are presented graphically below: For ease of interpretation, the respecified MOTRS model is presented with each hypothesis to illustrate how each hypothesised pathway fits within the overall model.

Hypothesis 1: driving confidence (MV) and attitude towards driving (MV) would \textit{partially mediate} the relationship between driving space (IV) and self-regulation (DV) (Figure 17)

![Figure 17: Hypothesis 1 - partial mediation between driving space and self-regulation](image)

Hypothesis 2: driving confidence (MV) and attitude towards driving (MV) would \textit{partially mediate} the relationship between health (IV) and self-regulation (DV) (Figure 18)
Figure 18: Hypothesis 2 - partial mediation between health and self-regulation

Hypothesis 3: driving confidence (MV) would completely mediate the relationship between driving performance (IV) and self-regulation (DV) (Figure 19).

Figure 19: Hypothesis 3 - complete mediation between driving performance and self-regulation

Hypothesis 4: Attitude towards driving (MV) would completely mediate the relationship between dependency on other drivers (IV) and self-regulation (DV) (Figure 20).
Chapter 7: Study 3 177

Figure 20: Hypothesis 4 - complete mediation between dependency on other driver and attitudes towards driving

Hypothesis 5 - Driving confidence (IV) would partially mediate the relationship between attitudes towards driving (IV) and self-regulation (DV) (Figure 21)

Figure 21: Hypothesis 5 - partial mediation between attitude towards driving and driving confidence

In addition to the above hypotheses that are drawn from the respecified MOTRS model, the current study was also intended to cross-validate the gender – driving confidence – self-regulation meditational hypothesis that found support in Study Two. Attitudes towards driving was also included as a mediating variable to
examine the potential mediating effect of attitudes towards driving on the relationship between gender and self-regulation.

**Hypothesis 6:** Driving confidence (MV) would partially mediate the relationship between gender (IV) and self-regulation (DV) Figure 22

![Figure 22: Hypothesis 6 - partial mediation between gender and self-regulation](image)

**Hypothesis 7:** Attitudes towards driving (MV) will partially mediate the relationship between alternative transport usage (IV) and self-regulation (DV)

To test the incremental learning properties of the MOTRS model, the current study also tested whether the availability of alternative transportation alters the pathways of the MOTRS model. As noted, based on the incremental nature of the learning process, the MOTRS model predicts that the recency and frequency with which a pattern has been activated influence the strength of the corresponding pathways (see section 4.5.3). Using the example provided in 4.5.3, it is anticipated that the increased accessibility of alternative transportation with the Australian Capital Territory would strengthen the pathway between usages of alternative transportation – attitudes towards driving – self-regulation pathway (Figure 23).

![Figure 23: Hypothesis 7 - complete mediation between alternative transportation usage and self-regulation](image)

**Due to the exploratory nature of the remaining research aims, a correlational approach was used to examine associations between driving purposes, transportation needs and objectively measured driving behaviours of older adults.**
7.4. Method

7.4.1. Participants.

Participants were a sample of 78 Australian drivers (55.1% female) aged 65 years or over \((M = 72.36, SD = 5.53,\) range = 65-87). They were recruited from the community in response to newspaper, magazine, radio and email advertisements, fliers distributed via a range of organisations (e.g. Meals on Wheels Volunteer cars, University of the 3rd Age, Council On the Aging, various health clinics, and aged care activity centres). As equipment had to be fitted into participants’ own vehicles, and to control for extraneous variables such as availability of public transport, all the participants were recruited within the same state of Australia, the Australian Capital Territory. Participants were required to have a private vehicle, be over the age of 65, and reside in the Australian Capital Territory, Australia.

One hundred and fifty interested participants provided initial contact to the research team. Table 19 detailed the reasons for withdrawal provided by the 72 non-participants.

Table 19: Reasons for withdrawal from study

<table>
<thead>
<tr>
<th>Reasons</th>
<th>n</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change of mind (no further reason)</td>
<td>43</td>
<td>(59.7%)</td>
</tr>
<tr>
<td>Concerns that information required was too sensitive</td>
<td>7</td>
<td>(12.5%)</td>
</tr>
<tr>
<td>Could not attend testing session (could not re-schedule for another time)</td>
<td>8</td>
<td>(11.1%)</td>
</tr>
<tr>
<td>Too far to travel to the university</td>
<td>5</td>
<td>(6.9%)</td>
</tr>
<tr>
<td>Health issues (e.g. surgery)</td>
<td>5</td>
<td>(6.9%)</td>
</tr>
<tr>
<td>Provided incorrect contact information</td>
<td>2</td>
<td>(2.7%)</td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
<td>(100%)</td>
</tr>
</tbody>
</table>

Comparison of age and gender between the study’s participants and those who hold an active driver’s license within the Australian Capital Territory are presented below in Table 20. As demonstrated in the table below, the sample of the current
study shared similar age and gender characteristics compared to the population of licence holders within the ACT region.

Table 20: Comparison of age and gender between sampled participants and active license holders of the Australian Capital Territory of the year 2012

<table>
<thead>
<tr>
<th>ACT licence holders</th>
<th>Study participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>( M_{\text{age}} )</td>
<td>72.54</td>
</tr>
<tr>
<td>Gender (% / n)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>46.74% (13892)</td>
</tr>
<tr>
<td>Female</td>
<td>53.26% (15830)</td>
</tr>
</tbody>
</table>

7.4.2. Design

This study adopted a prospective naturalistic observation design, using a combination of retrospective and prospective, self-report, and objective measurements. These include a (retrospective) self-reported questionnaire, prospective (self-report) driving diaries, and unobtrusive ambulatory assessments (GPS and recording accelerometer). A correlational design was used to examine the pathways specified in the previous chapter, and the relationship between self-reported and objectively measured driving behaviours. Anonymity and confidentiality was emphasised to participants to reduce response biases and privacy concerns. Due to the highly involved nature of the study, the use of the ambulatory assessment and the de-identified nature of driving parameters extracted from the instrument were also explained in detail to the participants.

7.4.3. Materials

7.4.3.1. Self-report questionnaire

For ease of comparison and interpretation, the questionnaire used in Study Two (detailed in section 5.5.3) was adopted for this study. In addition, participants were asked to list the number and type of any medications that they used at the time of the testing period. As with Study Two, clarification regarding the confidentiality and anonymity of the information obtained from the study was emphasised on the
questionnaire, Participant Information Sheet and fliers. Following previous experience with the older driver population and HREC feedback, the de-identified nature of the driving parameters extracted from the ambulatory assessments was also highlighted on these materials.

7.4.3.2. Prospective driving diaries

Participants were required to mark their driving trips (time of day and duration of driving trips) after each trip using a brief driving diary over a two-week period (Smith and Doyle 2009; Livingstone, Armstrong et al. 2010). Participants were also encouraged to state the purposes for taking the trip (e.g. grocery shopping). In addition, they were asked to rate their driving performance of each driving trip along a scale from 1 (very poor) to 9 (very well). Finally, participants were asked to record any driving incidents (e.g. near misses) in the driving diary. See appendix D for the driving diary specifically developed for this study. To reduce attrition and encourage prompt recall of driving trips, a message informing participants about their progress was included in the middle of the 2-week driving diary (i.e. after one-week). An example of the information required in the driving diary was also included in the first page in the driving diary to ensure consistent reporting among participants. Finally, verbal instructions of how to complete the driving diary were also provided while the ambulatory assessments were fitted into participants’ vehicles.

The driving behavioural measures (self-reported) extracted from the prospective driving diaries over the two-week driving period are: driving purposes, total driving duration, and driving (duration) under peak hours (i.e. 8-9am, 5-6pm), mid-afternoon high-risk fatigue times (i.e. 2-4pm), and during night time (sunset to sunrise).

---

23 Peak hours were based on analysis of peak hour travel using the Sydney Household Travel Survey Data (Corpuz, 2012)
24 While the period between 10pm to 6am is also identified as high risk fatigue times, this period is already included in night time driving. Thus only the mid-afternoon fatigue hours (i.e. 2-4pm) are identified as fatigue hours to avoid redundancy
25 Sunrise and sunset times of driving days were calculated using records provided by the Bureau of Meteorology, Australia.
7.4.3.3. GPS driving data

Objective measures of driving times and durations were provided by mapping data extracted from small passive global positioning systems (GPS; ProTrackStick and MiniTrackStick, Telespatial Systems; Figure 24)\(^{26}\). The GPS trackstick is a small GPS location recorder, which uses the vehicle’s power source by plugging into the vehicle’s cigarette lighter\(^{27}\). This method of measuring participants’ driving activity has been demonstrated to possess acceptable test-retest reliability (Duncan et al., 2007; 2009). The GPS trackstick allows continuously updated record of driving information such as driving times and locations. It can record over 4 weeks of travel data at a 5 second sampling rate.

The driving parameters (objectively measured) extracted from this instrument were overall driving duration and distance, and driving (duration) under *peak hours* (i.e. 8-9am, 5-6pm)\(^{28}\), *mid-afternoon high-risk fatigue times* (i.e. 2-4pm)\(^{29}\), and during *night time* (sunset to sunrise)\(^{30}\).

---

\(^{26}\) To protect participants’ privacy, and as per Human Research Ethics’ protocol, the nature of locations at the drive destination will not be extracted from the GPS data.

\(^{27}\) The equivalent pre-charged USB Trackstick Mini were used for participants where the cigarette lighter was used for other devices (e.g. GPS navigators, mobile phone chargers). The only difference between the MiniTrackstick and the ProTrackstick is that the alternative, Trackstick Mini has a limited (80 hours in-motion) battery life. This represents approximately 6 hours per day of non-stop driving, and was deemed adequate.

\(^{28}\) Peak hours were based on analysis of peak hour travel using the Sydney Household Travel Survey Data (Corpuz, 2012)

\(^{29}\) While the period between 10pm to 6am is also identified as high risk fatigue times, this period is already included in nighttime driving. Thus only the mid-afternoon fatigue hours (i.e. 2-4pm) are identified as fatigue hours to avoid redundancy

\(^{30}\) Sunrise and sunset times of driving days were calculated using records provided by the Bureau of Meteorology, Australia.
7.4.3.4. Accelerometer

Proxy measures of safe driving performance were provided by kinematics data extracted from small, sensitive, MEMS (Micro-Electro Mechanical System) based Tri-axial recording accelerometers (GP1 recording accelerometers, SENSIR Inc.). These devices can record movement (specifically, acceleration and deceleration) continuously for a period of up to a month, with a sampling rate of 100 samples per second. To ensure adequate battery lives of the accelerometers for the duration of the experiment (i.e. 2-weeks), the reporting intervals of the accelerometers was set at a 30 second epoch. This means the units still sampled at 100 samples per second, but only report the single highest sample within the 30-second period.

Similar to the approach described by Classen et al. (2007), specific performance parameters extracted from this data included lateral accelerations and decelerations (gravitational forces; $g$) and longitudinal accelerations and decelerations ($g$). Longitudinal accelerations are caused by change of velocity of the vehicle during both acceleration (e.g. through pressing the accelerator pedal) and deceleration (e.g. through pressing the brake pedal), whereas lateral accelerations are caused by lateral motion (through turning the steering wheel) of the vehicle (Klauer et al., 2008).

Hard braking events were operationally defined by longitudinal deceleration that exceeded 0.45g. This cut-off point was chosen to allow comparison with previous research and represented relatively rare events (Cheng et al., 2011; Klauer et al., 2008; Simons-Morton et al., 2011; Nobuyuki et al., 2011). In addition, previous
research by Klauer et al. (2008) demonstrated that unsafe drivers engaged in longitudinal accelerations at >0.35g levels more frequently than safe or moderately safe drivers. Thus, longitudinal accelerations at 0.35g -0.45g were extracted and indexed as *abrupt braking* situations. Figure 25 below presents the time required to brake (to a complete stop, not accounting for reaction time, in normal dry weather condition) at various speeds at 0.45g and 0.35g. In addition, as per Klauer et al. and Nobuyuki et al. (2011), lateral accelerations >0.4g were also extracted as potential driving incidents. Figure 25 demonstrates the braking time under various speeds at longitudinal acceleration of 0.45g and 0.35g.

Figure 25: Braking time under various speeds at 0.45g and 0.35g

7.4.4. Procedure

Ethical clearance for this project was provided by the institutional review board of Queensland University of Technology (HREC #100000460). Cross Institutional approval was also provided by the University of Canberra Human Research Ethics Committee. Under the approved protocol, informed consent was collected through an informed consent form with the questionnaire package. Funding was granted from the NRMA-ACT Road Safety Trust to purchase the materials required for this study. Infrastructural assistance to conduct testing (e.g. testing site
and contact) was provided by the Discipline of Pharmacy, University of Canberra.

Potential participants were told that the research was interested in their opinions on the driving experience and the transportation needs of older drivers, that the questionnaire would take approximately 30 minutes to complete, that the equipment-fitting session would take approximately 30 minutes, and that they would have to be aged 65 years or over and current drivers to take part. No other inclusion criteria was applied.

Information about the study was provided through an informed consent package. Each package contained the Participant Information Sheet, Informed Consent Form, contact information of the research team, the driver questionnaire (detailed in section 5.5.3) and a reply paid envelope. While participants were encouraged to return their completed questionnaire using the reply-paid envelope in the information package, some participants preferred to bring the completed questionnaires with them to the vehicle-fitting session and return it directly to the research team.

Once the questionnaires were completed, participants were encouraged to contact the research team to organize a time for the ambulatory assessment (GPS and accelerometer) to be fitted into their vehicles. These fitting sessions were conducted at the University of Canberra campus, an accessible location with ample free parking facilities. This meeting would also allow the research team to show the participants how to complete the driving diaries, and answer any queries they might have about the study. Participants were also fitted with Actiwatches as part of a broader study on activity and sleep. However, these data will not be reported within the current study.

The researcher first ensured that all instruments had the adequate battery life and memory capacity for the 2-week duration. The researcher would then meet with the participants at the designated carpark, explain the overall aim of the research project, and answer any questions in regards to the overall project. The researcher would then demonstrate the use of the driving diary, and answer any questions in regards to the use of the driving diary. Following the diary, the researcher would show the participants the ambulatory assessments (GPS and accelerometer), their use, and the location they will be placed within the vehicle. The researcher would also show an
example of the data extracted from these instruments to ensure participants understand their involvement of the study.

Once participants were satisfied with their understanding of the instruments, and agreed to have them fitted into their vehicles, the researcher then plugged the GPS TrackStick into the participant’s vehicles. If the cigarette lighter was not available in the vehicle (broken, required for other devices such as GPS navigation or mobile phone charger), then the pre-charged GPS TrackStick Mini would be fitted into the participants’ central console. The researcher then would wait until the LED light on the Trackstick showed a blinking green light, indicating that the GPS location was established, and that locations were being recorded. Following that, the researcher would then move to the back of the vehicle and fit the accelerometer onto the back of the backseat. This location was chosen because it is most stable for the magnetic mount regardless of vehicle types (e.g. sedan, hatchback or station wagon). The orientation (X, Y and Z axes) of the recording accelerometers had to be consistent across participants to allow reliable and accurate measurements of longitudinal and lateral accelerations. Further as per ethics protocol, all instruments had to be out of sight to reduce the likelihood of theft, and the potential that these instruments may cause harm to the participants in the event of a crash.

The researcher then emphasised that these instruments should not be moved during the testing period to allow for accurate measurements. The researcher further highlighted the anonymity and confidentiality of these data, and instructed the participants to drive as they normally would for the next two-weeks. See Appendix E for a checklist developed for the equipment fitting session. At the completion of the two-week testing period, participants had to come to the University of Canberra to return the equipment, and collect $50 (AUD) in return for participation.

31 Because the TrackStick Mini used 360° GPS antenna, no sight of sky is necessary to detect GPS waypoints.
7.5. Results

7.5.1. Data cleaning and assumption testing

As the focus of the current chapter is to cross-validate the respecified MOTRS model, the data treatment and analyses of prospective data (i.e. driving diaries, GPS and accelerometer) will be discussed in the following Chapter. Data was initially screened for accuracy of data entry, missing values outliers and the assumptions of univariate and multivariate through visual inspection of data and descriptives. Twelve participants did not provide answers for all the items on the questionnaire. A Missing Value Analysis using SPSS was conducted, with Little’s MCAR test revealed to be non significant, $\chi^2 (1097) = 1033.99, p = .76$, indicating that the data were missing completely at random.

In regards to outliers, visual inspection of histograms did not identify any univariate outlier. Mahalanobis distances of key variables were examined, and revealed thirteen multivariate outliers using Bartlett and Lewis’ (1978) recommended critical values. Regression analyses were performed with and without these cases resulting in no notable difference in the results. These multivariate outliers were subsequently retained.

With the exception of estimated travel duration (skewness = 5.71; kurtosis = 38.49), all variables satisfied the normality assumption as recommended by West, Finch and Curran (1995). Square root transformation of the skewed variable was performed and revealed notable changes in the regression when using transformed and non-transformed data. Thus, the square-root transformed data was used for subsequent analyses.

7.5.2. Equivalence testing

Equivalence testing was conducted to determine whether sample characteristics of participants in Study Two ($N = 273$) and Three ($N = 78$) were comparable. Details of this statistical technique were discussed in detail in section 5.6.2. Similar to Study Two, a more stringent criterion (+/- 10%) was used due to the leptokurtic distribution of some of the key variables, and the small range of the Likert scales used. The current study utilised the Study Two sample as the reference group
as 1) it was collected first; and 2) it was the data that the respecified MOTRS model pathways was based upon.

In addition to the variables in the respecified MOTRS model, other key variables including *age*, *hours driven per week*, and *financial confidence* were selected for equivalence testing to provide a thorough investigation. Table 21 presents the means, standard deviations, and equivalency test results for each of the selected variables. As indicated by the non-significant results of *driving space* and *driving confidence*, criterion for equivalency was not met across these two variables. That is, participant in each groups differed significantly in their responses to these items. The study two and study three samples are comparable on the remaining eight variables. Thus, the regression weights of the pathways involving driving space and driving confidence are expected to differ from that of Study Two.
Table 21: Equivalence tests and mean differences statistics for the Study Two and Study Three sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>M (SD) Study Two</th>
<th>M (SD) Study Three</th>
<th>MDiff</th>
<th>SE</th>
<th>Criterion</th>
<th>Z</th>
<th>p^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>71.29</td>
<td>72.36</td>
<td>5.53</td>
<td>-1.07</td>
<td>.39</td>
<td>-15.54</td>
<td>.0001</td>
</tr>
<tr>
<td>Hrs driven/wk</td>
<td>9.02</td>
<td>10.99</td>
<td>17.80</td>
<td>-1.97</td>
<td>.50</td>
<td>2.14</td>
<td>.016</td>
</tr>
<tr>
<td>Financial confidence</td>
<td>2.80</td>
<td>3.82</td>
<td>.72</td>
<td>-1.02</td>
<td>.07</td>
<td>10.57</td>
<td>.0001</td>
</tr>
<tr>
<td>Health rating</td>
<td>3.06</td>
<td>3.83</td>
<td>.75</td>
<td>-0.77</td>
<td>.04</td>
<td>11.5</td>
<td>.0001</td>
</tr>
<tr>
<td>Driving performance</td>
<td>3.92</td>
<td>3.83</td>
<td>.67</td>
<td>0.09</td>
<td>.04</td>
<td>-7.5</td>
<td>.0001</td>
</tr>
<tr>
<td>Affective Attitude</td>
<td>3.38</td>
<td>3.44</td>
<td>.63</td>
<td>-0.06</td>
<td>.05</td>
<td>-5.6</td>
<td>.0001</td>
</tr>
<tr>
<td>Instrumental Attitude</td>
<td>4.39</td>
<td>4.37</td>
<td>.63</td>
<td>0.02</td>
<td>.05</td>
<td>-8.4</td>
<td>.0001</td>
</tr>
<tr>
<td>Perceived Behavioural Control</td>
<td>3.68</td>
<td>3.52</td>
<td>.81</td>
<td>0.16</td>
<td>.06</td>
<td>-3.5</td>
<td>.0009</td>
</tr>
<tr>
<td>Driving space Confidence</td>
<td>3.25</td>
<td>3.47</td>
<td>.96</td>
<td>-0.22</td>
<td>.05</td>
<td>.52</td>
<td>.30</td>
</tr>
<tr>
<td>Confidence</td>
<td>3.87</td>
<td>4.25</td>
<td>.67</td>
<td>-0.38</td>
<td>.06</td>
<td>-1.7</td>
<td>.43</td>
</tr>
</tbody>
</table>

^a Equivalence criterion equals +/- 10% for all variables, with the Study One sample as the reference group
^b As per Rogers et al. (1993), the greater of the two p values (calculated from the smaller z values) are shown here
^c Significant p values indicates the means of the two groups are determined to be equivalent

7.5.2. Sample characteristics

Participants’ demographic information is shown in Table 22. This table presents the age, gender, remoteness of residential locations, employment status and
health conditions of the sample. The majority of participants resided in major cities, and were confident that their income would satisfy their current and future needs. Participants also rated themselves to be of good health, and reported relatively few medical conditions. Chi-Square tests and independent-sample t-tests revealed no significant gender differences at p<.05.

Table 22: Participants' sample characteristics

<table>
<thead>
<tr>
<th>Sample characteristic</th>
<th>N = 78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (M/SD)</td>
<td>72.36 (5.53)</td>
</tr>
<tr>
<td>Employment (n /%)</td>
<td></td>
</tr>
<tr>
<td>Not employed/ no voluntary work</td>
<td>1 (1.3%)</td>
</tr>
<tr>
<td>Not employed/ voluntary work</td>
<td>12 (15.4%)</td>
</tr>
<tr>
<td>Retired</td>
<td>54 (69.2%)</td>
</tr>
<tr>
<td>Part time</td>
<td>9 (11.5%)</td>
</tr>
<tr>
<td>Full time</td>
<td>2 (2.6%)</td>
</tr>
<tr>
<td>Residential location (n /%)</td>
<td></td>
</tr>
<tr>
<td>Major city</td>
<td>70 (89.7%)</td>
</tr>
<tr>
<td>Inner Regional</td>
<td>8 (10.3%)</td>
</tr>
<tr>
<td>Outer Regional</td>
<td>- -</td>
</tr>
<tr>
<td>Remote</td>
<td>- -</td>
</tr>
<tr>
<td>Very remote</td>
<td>- -</td>
</tr>
<tr>
<td>Financial confidence (current) (M/SD)</td>
<td>3.82 (.72)</td>
</tr>
<tr>
<td>Financial confidence (future) (M/SD)</td>
<td>3.88 (.85)</td>
</tr>
<tr>
<td>Health rating (M/SD)</td>
<td>3.83 (.75)</td>
</tr>
<tr>
<td>Medical conditions (n/ %)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>26 (33.3%)</td>
</tr>
<tr>
<td>1</td>
<td>30 (38.5%)</td>
</tr>
<tr>
<td>&gt;2</td>
<td>22 (28.2%)</td>
</tr>
</tbody>
</table>

The driving characteristics of participants are presented in Table 23. Chi-square and independent t-tests showed no significant gender differences at p <.05. On average, participants estimated they drove approximately 1.57 hours per day. They
rated their overall driving performance to be *good*. While most participants preferred to drive themselves, most rated the alternative transportation options within their areas to be *fair*, and have reported usage of these options. Their dependence on other drivers were relatively high, indicating most participants have driving partners (e.g. friends, family) to share their driving tasks. Chi-square and independent t-tests revealed no significant gender differences in participants’ driving-related characteristics (p< .05).
Table 23: Participants' driving-related characteristics

<table>
<thead>
<tr>
<th>Driving characteristic</th>
<th>N = 78</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Years licensed driving (M/SD)</td>
<td>52.67</td>
<td>(6.48)</td>
</tr>
<tr>
<td>Advanced driver training (n/%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>17</td>
<td>(21.8%)</td>
</tr>
<tr>
<td>No</td>
<td>61</td>
<td>(78.2%)</td>
</tr>
<tr>
<td>Hrs/wk driving (M/SD)</td>
<td>10.99</td>
<td>(17.8)</td>
</tr>
<tr>
<td>Driving quality (M/SD)</td>
<td>3.83</td>
<td>(.67)</td>
</tr>
<tr>
<td>Driving speed (M/SD)</td>
<td>2.86</td>
<td>(.49)</td>
</tr>
<tr>
<td>Transport preference (n/%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use public transport/taxi</td>
<td>3</td>
<td>(3.8%)</td>
</tr>
<tr>
<td>Have someone drive you</td>
<td>3</td>
<td>(3.8%)</td>
</tr>
<tr>
<td>Drive yourself</td>
<td>72</td>
<td>(92.3%)</td>
</tr>
<tr>
<td>Rate alternative transport (M/SD)</td>
<td>3.17</td>
<td>(1.23)</td>
</tr>
<tr>
<td>Use alternative transport (M/SD)</td>
<td>2.25</td>
<td>(1.09)</td>
</tr>
<tr>
<td>Dependency of driving partners (M/SD)</td>
<td>2.68</td>
<td>(.96)</td>
</tr>
<tr>
<td>Preferred person to discuss driving changes (n/%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Person of authority</td>
<td>4</td>
<td>(5.1%)</td>
</tr>
<tr>
<td>Medical Practitioner</td>
<td>39</td>
<td>(50.0%)</td>
</tr>
<tr>
<td>Family member</td>
<td>23</td>
<td>(29.5%)</td>
</tr>
<tr>
<td>Partner</td>
<td>10</td>
<td>(12.8%)</td>
</tr>
<tr>
<td>Need of programs (M/SD)</td>
<td>3.84</td>
<td>(.93)</td>
</tr>
<tr>
<td>Likelihood to attend programs (M/SD)</td>
<td>3.80</td>
<td>(1.26)</td>
</tr>
<tr>
<td>Preference of session’s delivery (n/%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>(6.4%)</td>
</tr>
<tr>
<td>Mail-out materials</td>
<td>17</td>
<td>(21.8%)</td>
</tr>
<tr>
<td>In groups</td>
<td>33</td>
<td>(42.3%)</td>
</tr>
<tr>
<td>Internet modules</td>
<td>20</td>
<td>(25.6%)</td>
</tr>
</tbody>
</table>

7.5.4. Driving confidence and avoidance

With the exception of driving at night in the rain (M = 3.81, SD = 1.17), in foggy conditions (M = 3.71, SD = 1.11), and driving other people’s car (M = 3.58, SD = 1.24), participants rated themselves to feel “confident” driving in all remaining 18
driving situations. The three conditions that participants reporting to be least confident are similar to that reported in Study One.

In regards to driving avoidance (i.e. self-regulation), with the exception of driving at night in the rain and in other people’s car, all of the remaining 19 items were rated by participants as driving situations that they would “least avoid”. The three situations that participants reported the highest ratings (i.e. more likely to restrict from driving) were at night in the rain (M = 2.19, SD = 1.16), other people’s car (M = 2.06, SD = 1.22), and during peak hour (M = 1.95, SD = 1.01).

7.5.5. Mediation analyses of pathways

The sample size (N <200) was deemed to be inadequate for a full cross-validation, i.e. re-testing the MOTRS model in its entirety using Structural Equation Modelling. Therefore, a partial cross-validation approach was undertaken. Specifically, individual pathways of the MOTRS model would be tested separately through mediation analyses that essentially parallel the mediation pathway analyses conducted in Study two (section 5.6.5).

The direct and indirect effects of Driving Space, Driving performance, Health, Dependency on other drivers, Driving confidence, and attitudes towards driving on participants’ levels of self-regulation (self-reported) were examined. Similar to Study Two, meditational analyses were conducted using the bootstrapping method developed by Preacher and Hayes (2004; Shrout & Bougler, 2002), with 5000 bootstrapped resamples. For ease of interpretation, each mediation analysis is illustrated graphically in the following. Significance of the indirect effect is shown if zero is not contained within the 95% CIs for the indirect path of the two variables (path a*b) (Baron & Kenny, 1986; Roelofs et al., 2008).

Hypothesis 1: driving confidence (MV) and attitude towards driving (MV) will partially mediate the relationship between driving space (IV) and self-regulation (DV)

Figure 26

The proposed mediation model accounted for 64% of variance in self-regulation (adjusted r² = .63, F = 43.67, p <.001). Driving space was significantly correlated with self-regulation (B = .29, SE = .07, p <.001) and attitudes towards
driving (B = .14, SE = .05, p < .01) (“a” paths). Driving confidence was significantly related to (self-report) self-regulation (B = -.71, SE = .07, p < .001) (“b” path). While bivariate regression revealed attitudes towards driving to be significantly correlated with self-regulation (r = .39, p < .001), its influence on self-regulation was no longer significant after controlling for driving confidence (B = -.04, SE = .11, p > .71) (“b” path). The total effect of driving space on self-regulation (without driving confidence and attitudes towards driving) was significant (B = -.24, SE = .06, p < .001) (“c” path). Thus, this proposed model met all the criteria for mediation according to Baron and Kenny (1986). The total indirect effect of the proposed mediators was significant (Boot = -.21, SE = .05, 95% CI = -.31 to -.12). However, only driving confidence mediated the effects of driving space on self-regulation (Boot = -.21, SE = .05, 95% CI = -.30 to -.12). After controlling for the effects of driving confidence and attitude towards driving, the direct effect of driving space on self-regulation was non-significant (B = -.04, SE = .05, p = .45) (“c’’ path), indicating driving confidence completely mediated the effects of driving space on (self-report) self-regulation.

Figure 26: Hypothesis 1 - partial mediation between driving space and self-regulation

Hypothesis 2: driving confidence (MV) and attitude towards driving (MV) will partially mediate the relationship between health (IV) and self-regulation (DV) Figure 27

Health was not significantly correlated with driving confidence (B = .16, SE = .11, p = .17) and attitudes towards driving (B = -.04, SE = .08, p = .67) (“a” paths). Further, the relationship between health and self-regulation was non-significant (B = -.04, SE = .11, p = .74). Thus, no significant mediation effect was found.
Figure 27: Hypothesis 2 - partial mediation between health and self-regulation

Hypothesis 3: driving confidence (MV) will completely mediate the relationship between driving performance (IV) and self-regulation (DV)

Driving performance was significant correlated with driving confidence (B = .34, SE = .12, p <.01) (“a” path), and self-regulation (B = -.25, SE = .12, p <.05) (“c” path). Driving confidence was significant correlated with self-regulation (B = -.75, SE = .07, p <0001). The indirect effect of driving performance on self-regulation through driving confidence was significant (Boot = -.25, SE = .08, 95% CI = -.42 to -.09).

After controlling for driving confidence, the direct effect of driving performance on self-regulation was non-significant (B = .007, SE = .08, p =.92) (“c” path), indicating a complete mediation (Figure 28).

Figure 28: Hypothesis 3 - complete mediation between driving performance and self-regulation
Hypothesis 4: Attitude towards driving (MV) will completely mediate the relationship between dependency on other drivers (IV) and self-regulation Figure 29

Dependency on other drivers was not significantly correlated with attitude towards driving (B = -.03, SE = .06, p = .61) ("a" path), and self-regulation (B = .04, SE = .08, p = .64) ("c" path). Attitudes towards driving was significantly correlated with self-regulation (B = -.54, SE = .15, p <.001) ("b" path). Overall, no significant mediation effect was found.

![Figure 29: Hypothesis 4 - complete mediation between dependency on other driver and attitudes towards driving](image)

Hypothesis 5: Driving confidence (IV) will partially mediate the relationship between attitudes towards driving (IV) and self-regulation (DV)Figure 30

Attitudes towards driving was significantly correlate with driving confidence (B = .47, SE = .15, p <.001) ("a" path), and self-regulation (B = -.54. SE = .15, p <.001) ("c" path). Driver confidence was significantly correlated with self-regulation (B = .73, SE = 07, p <.001). The indirect effect of attitudes towards driving on self-regulation through driving confidence was also significant (Boot = .49, SE = .12, 95% CI = -.75 to -.27) ("ab" path). After controlling for driver confidence, the direct effects of attitudes towards driving was no longer significant (B = -.05, SE = .11, p = .63). Overall, these findings suggest driver confidence completely mediated the effects of attitudes towards driving on self-regulation.
Figure 30: Hypothesis 5 - partial mediation between driving confidence and self-regulation

Hypothesis 6: Driving confidence (MV) will partially mediate the relationship between gender (IV) and self-regulation (DV)

Gender was not significantly correlated with confidence (B = -.09, SE = .17, p = .61), and attitude towards driving (B = -.04, SE = .12, p = .76) (“a” path). Further, gender was not significantly related to self-regulation (B = .07, SE = .11, p = .64) (“c” path). No significant mediation effect was found.

Figure 31: Hypothesis 6 - mediation of gender and self-regulation

Hypothesis 7: Attitudes towards driving (MV) will partially mediate the relationship between alternative transport usage (IV) and self-regulation (DV)

Usage of alternative transportations was significantly correlated with attitudes towards driving (B = -.23, SE = .05, p < .001) (“a” path), and self-regulation (B = .16, SE = .07, p < .05) (“c” path). As noted, attitude towards driving was
significantly correlated with self-regulation. The indirect effect of alternative transportation usage on self-regulation through attitude towards driving was significant (Boot = .11, SE = .04, 95% CI = .05 to .21) (“ab” path). After controlling for attitude towards driving, the effect of alternative transportation usage on self-regulation was no longer significant (B = .05, SE = .08, p = .54) (“c’” path), indicating a complete mediation.

Figure 32: Hypothesis 7 - complete mediation between alternative transportation usage and self-regulation

7.6. Discussion

This third study presents a quantitative cross-validation of the pathways of the respecified MOTRS model detailed in Chapter 6. The current study is, to the author’s knowledge, the first to cross-validate an older adults’ self-regulatory driving behaviour model using an independent sample of older adults. The following section presents a summary of results and conclusions drawn from this study.

7.6.1. Research findings

This section discusses the research findings in relation to the research hypotheses.

H1: Driving space – Driving confidence X Attitudes towards driving – Self-regulation

Partial support was obtained for this hypothesis. Specifically, driving confidence completely mediated the effects of driving space on self-regulation. While as predicted, attitudes towards driving was correlated with self-regulation, this effect was no longer significant once driving confidence was entered into the model. This finding indicates the effects of attitudes towards driving on self-regulation were accounted for by driver confidence (see hypothesis 5). This finding contradicts the
respecified MOTRS model, because the respecified MOTRS model demonstrated attitudes towards driving provided distinct contribution towards self-regulation, independent of driver confidence.

**H2: Health – Driving confidence X Attitudes towards driving – Self-regulation**

This hypothesis did not find support within the current study due to the non-significant correlation between health and other variables within the proposed mediating model. This could potentially be due to the sample being a relatively healthy cohort, reporting high ratings of self-rated health performance and few number of health conditions. This results in a restriction in range of the IV (i.e. Health), and subsequently reduces the correlation with other variables.

**H3: Driving performance – Driving confidence –Self-regulation**

This hypothesis was supported within the current study. Specifically, driving confidence completely mediated the effects of driving performance on self-regulation. This finding provides support for the MOTRS model pathways regarding the effects of driving performance on self-regulation.

**H4: Dependency on other drivers – Attitudes towards driving –Self-regulation**

This hypothesis did not find support within the current study due to the non-significant relationship between dependency on other drivers and attitudes towards driving and self-regulation.

**H5: Attitudes towards driving –Driving confidence –Self-regulation**

This hypothesis was partially supported within the current study. Specifically, while driving confidence mediated the effects of attitudes towards driving on self-regulation, the mediating effect was complete. This finding indicates that attitudes towards driving was no longer a significant contributor of self-regulation once driving confidence was controlled for.

**H6: Gender – Driving confidence X Attitudes towards driving – Self-regulation**

This hypothesis did not find support within the current study. Specifically, gender was not significantly correlated with driving confidence, attitudes towards driving...
driving and self-regulation. This contradicts findings of study Two regarding the effects of gender on Psychosocial variables and self-regulation. This also contradicts the findings of existing literature that demonstrates gender to be a significant contributor of older adults’ self-regulatory driving behaviours.

_H7: Alternative transportation usage –Attitudes towards driving –Self-regulation_

This hypothesis was supported within the current study. Specifically, attitudes towards driving completely mediated the effects of alternative transportation usage and self-regulation

7.6.2. Considerations of research findings

The over-arching structure of the MOTRS model (Socio-demographic and Driving specific variables influence self-regulation through Psychosocial variables) found support within the study (from hypothesis 1, 3, and 6). However, some specific pathways of the respecified MOTRS model that included the variables of health, dependency on other drivers and attitudes towards driving did not find support within the current study. Several potential explanations may account for these findings.

First, as noted in section 4.5.3, in a connectionist network, the recency and frequency with which a pattern has been activated influence subsequent strength of the pathways. Thus, when a stimulus is introduced (e.g. alternative transportation options), learning changes weight of related activation pathways, making the current and similar pathways easier to reproduce in the future, sometimes at the expense of other, less-used, pathways. The significant mediating effect of the alternative transportation usage –attitudes towards driving – self-regulation pathway provides support for this incremental learning assumption, and provides a potential explanation towards the non-significant effects of other pathways, such as dependency on other drivers. As previously discussed in section 4.5, dependency on other drivers may no longer be predictive of older adults’ self-regulatory behaviours if they have regular access to alternative transportation options.
7.6.3. Limitations and future suggestions

The non-significant pathways of health, dependency on other drivers, and attitudes towards driving may also be due to methodological limitations of this study. A main limitation that applies to these variables was restriction in range. Visual inspection of histograms and descriptives of these variables demonstrated participants consistently reported to be of “good” health, hold positive affective and instrumental attitudes towards driving, and have shared driving partners. The restricted ranges of these variables have likely deflated the correlation of their corresponding pathways. As meditational analysis is a regression-based approach, deflated correlation of these pathways would contribute to the non-significant direct and indirect effects found within the current study (Preacher and Hayes, 2013).

While efforts were made to recruit participants through a diverse range of media (e.g. local and state newspapers and magazines), the sampling strategies that were used (advertising for volunteer participants) may have resulted in the sampling of more active drivers. In addition, the current study required participants to travel to the university in order for the equipment to be fitted into their vehicles. This requirement likely resulted in the sampling of drivers who are more willing to travel to unfamiliar places, and prevented drivers who are of poorer health and more dependent on others for transportation from taking part. Further, the complexity and the highly involved nature of this study (e.g. filling in the driving diaries and the use of ambulatory assessments) may have deterred drivers who are less confident about their driving, hold negative attitudes towards driving, and are of poorer health from participating. This is evident in the significantly higher driving space, driving confidence and lower driving avoidance (i.e. self-regulation) findings reported in the equivalence testing of Study Two and Study Three samples. Taken together, the volunteer-based sampling strategy and the high-involved nature of this study may have contributed to the restricted ranges of these variables.

A further limitation is related to the relatively small sample size of the current study. As discussed, the sample size prevented a full-cross-validation of the MOTRS model using Structural Equation Modelling. While pathways of the MOTRS model were individually tested, future studies should re-test the MOTRS model in its entirety using larger sample sizes.
Finally, the reliance on self-report information may account for the inconsistent findings between the current study, and that of Study two. As noted, self-report information is prone to responding biases, and the study methodology may have promoted one source of responding, resulting in mono-method bias (Christensen, 2006). Specifically, the detailed driving-related information both directly required from participants (from driving diaries) and extracted from the ambulatory assessments (GPS and accelerometer) may have lead to an increase of demand characteristics of the participants.

Due to the use of cross-sectional survey, the current study cannot discern whether the non-significance of the selected pathways was due to incremental learning through the introduction of new stimulus (such as increased accessibility of alternative transportations), or methodological limitations (restriction in range, sampling biases and self-report information), or a combination of these explanations. Future studies should use longitudinal methodologies to rigorously test the assumption of incremental learning in a larger, more diverse, sample.

7.6.4. Theoretical and practical implications

Overall, the results demonstrated strong support for the overall structure and the underlying assumptions of the MOTRS model. The overall structure of Socio-demographic, Driving-specific factors influencing self-regulation via the effects of Psychosocial variables also received support within the current study.

On an experimental level, the current study reflected the need to utilise prospective methodology to investigate the learning process and the effects this has on older adults’ self-regulatory behaviours. The significant pathways between alternative transportation usage and self-regulation, and the non-significant pathways between health and dependency on self-regulation, provide support for this theoretical assumption. However, as noted, these findings may also be an artefact of potential methodological limitations. In order to experimentally test this assumption and to rigorously cross-validate the MOTRS mode, large sampled prospective studies that simultaneously consider the diverse range of factors involved in the self-regulatory process are needed.
Further, the effects of alternative transportation options on older adult’s self-regulation highlight the importance of environmental factors on individual’s self-regulatory behaviours. These environmental factors include the availability of alternative transportation options, urban density and road conditions. Although the importance of environmental factors has been suggested by previous researchers such as Linstrom-Forneri et al. (2007), it has not been explicitly tested within the current older driver literature.

Finally, the differences in pathways weightings illustrate the importance of cross-validation of behavioural models, especially those that have gone through a re-specification process using Structural Equation Modelling techniques. SEM is an increasingly common statistical technique used by researchers to refine and respecify behavioural models. However, SEM analysis is a sample-based solution, prone to the influence of chance relationships within the sample that are not present in the wider population (MacCallum, Roznowski, Mar & Reith, 1994; Holmes-Smith, 2010). The different strength, and potentially structure, of pathways across Study Two and Three is consistent with this possibility.

7.7. Chapter 7 Summary

Study Three aimed to cross-validate the MOTRS model using a new sample of Australian older drivers. An additional aim of the study was to test one specific assumption of the MOTRS model – incremental learning, proposed in Chapter 4. While not all hypothesised pathways were supported in the second sample, theoretical and experimental explanations were offered to account for these findings.

The current findings are important in several aspects. First, the potential that the introduction of a new stimulus may promote the strength of new pathways, at the expense of other existing pathways, has important implications for existing older driver behaviour models. Most of the older driver behaviour models reviewed in Chapter 3 assume static relationships between factors. However, findings from the current study, in comparison of findings from Study Two, suggest that pathways between factors may be dynamic and subject to change, depending on environmental factors, such as availability of alternative transportations. As noted, the changes of strengths of pathways within the MOTRS model may be due to sampling biases and restriction in range. Nevertheless, this finding indicates that prospectively measured
driving behaviours are needed to further examine the process of self-regulation. Further, this finding also highlights that changes in environmental factors may influence older adults’ self-regulatory behaviours, which have not been explicitly tested within the current literature.

The next chapter continues the quantitative examination of older adult’s self-regulatory driving behaviours and transportation needs through prospectively assessing their driving behaviours.
Chapter 8: Naturalistic driving study to understand the transportation needs and driving behaviours of older adults

8.1. Introductory comments

The study presented in the previous chapter provided a cross examination of the MOTRS model pathways and its assumptions. This chapter continues the presentation of results from the third and final study of the current research program. The aim of this chapter is to examine the transportation needs and driving behaviours of older adults through a prospective naturalistic driving study. Specifically, the current chapter investigates the driving behaviours (time of day, duration and distance of trips) of older adults, and investigates the relationship between self-reported and objectively measured driving information (e.g. estimated driving distance and self-regulatory behaviours). A secondary aim of the study was to determine the utility of ambulatory assessments, such as GPS and recording accelerometer, in determining older adults’ driving behaviours.

The current chapter presents the findings of a combination of prospective measures of older adults’ driving behaviours in three sections. First, the driving behaviours and purposes and the self-evaluated driving performance extracted from the driving diaries over the two-week testing period are discussed. This is followed by the discussion of the objectively measured driving behaviours extracted through GPS units. Finally, the results obtained from the accelerometers are presented.

8.2. Study aims and hypotheses

This study explores the driving behaviours of older adults using objectively measured driving behaviours. In addition, the current study extends the prediction of the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model, to explore the application of the MOTRS model in predicting objectively measured driving behaviours of older adults. Using objectively measured driving behaviours, the current study addressed the third question of the current research program (detailed in section 2.5), “how do older drivers self-regulate?”, by understanding the transportation needs and actual driving behaviours of older adults. The current study also addressed the fourth, and final, research question, “how can we improve older
adults’ practice of driving related self-regulation?”, through exploring the relationship between their self-report driving self-regulation and their driving behaviours and patterns.

As detailed in section 7.3, this study aimed to: 1) Investigate the relationship between self-reported and objectively measured driving behaviours; 2) explore older adults’ transportation needs; and 3) determine the utility of recording accelerometer in measuring the safe driving performances of older drivers.

8.3. Method

The data used in this study was collected in conjunction with the data described in Chapter 6. Thus, information regarding participant recruitment, data collection procedures and sample characteristics can be found in section 7.4 and 7.5.

8.4. Results

8.4.1. Driving diaries

8.4.1.1. Data treatment

Two of the 78 participants in the sample did not complete the driving diaries, and are subsequently excluded in the analysis of this section. All remaining 76 participants completed the entire two-week driving diaries.

8.4.1.2. Overall driving exposure and performance

Participants noted the purpose of each driving trip in their driving diaries. On average, they reported driving 22.32 trips (range from 3 trips to 49 trips, SD = 8.48, skewness = .46, kurtosis = .27) over the two-week period. Besides affective attitude (r = .27, p <.05) and driving avoidance (r = -.31, p <.05), none of the key variables examined within the MOTRS model significantly predicted number of trips taken as reported in the driving diaries.

Participants spent driving an average of 22.12 hours over the two weeks (range 2.75 to 47 hours, SD = 9.65, skewness = .63, kurtosis = -.26). None of the key variables within the MOTRS model significantly predicted total driving duration. No significant gender difference in number of trips or total driving duration was found.
Participants were asked to rate their driving performance after each driving trip (1 = very poor to 9 = very well). On average, they rated their driving performance of these trips to be very well (M = 8.31, SD = .90, skewness = -2.02, kurtosis = 4.50). Driving confidence (Spearman’s rho = .24, p < .05), driving avoidance (Spearman’s rho = -.26, p < .05), and questionnaire self-reported driving performance (Spearman’s rho = .28, p < .05) significantly predicted participants’ mean driving performance ratings from driving diaries. None of the other key variables within the MOTRS model significantly predicted driving performance as reported in the driving diaries.

8.4.1.3. Time of day of driving trips

Participants were also asked to provide the time of day of their driving trips. The number and time of trips they spent driving in peak hours, at night and during afternoon fatigue times were extracted, and are presented in Table 24.

**Peak hours** were defined by periods of high traffic volume using ACT traffic data (Bureau of Infrastructure, Transport and Regional Economics, 2012), that is 8-9am in the morning and 5-6pm in the afternoon. Sunrise and sunset times over the testing periods were assessed from Geoscience Australia astronomical records. **Night-time** driving was defined as driving within the hours between sunset and sunrise of that particular day. Daytime driving in the hours of circadian rhythm low-points (between 2pm to 4pm) were extracted as fatigue times driving. While midnight to 6am also fall within the low-points of the circadian rhythm and vehicle crashes within these hours are typically coded as fatigue-related crashes, driving within these hours were already coded as night-time driving. Thus, fatigue hours only include driving within the hours from 2pm to 4pm. The averaged self-rated performance of their driving trips under these times is also presented in Table 24.

One way repeated-measures ANOVA revealed significant differences in self-rated driving performance across time of day of driving, Pillai’s trace = .34, F (2, 74) = 18.94, p < .001. Post Hoc analysis revealed participants rated their driving performance on trips during the hours associated with increased fatigue or sleepiness (2-4pm) to be significantly higher than during peak hours (p < .001, Mdiff = 1.79, 95% CI = .91 to 2.68) and night-time (p < .001, Mdiff = 2.75, 95% CI = 1.79 to 3.70).
Furthermore, one way repeated-measures ANOVA revealed a significant effect for time of day on driving duration, Wilk’s Lambda = .45, F (2, 74) = 44.78, p <.001. Participants drove significantly longer hours during fatigue times than peak hours (p <.001, M_diff = 4.06, 95% CI = 3.05 to 5.07) and night-time (p < .001, M_diff = 3.95, 95% CI = 3.09 to 4.80).

Table 24: Time of day of driving trips

<table>
<thead>
<tr>
<th></th>
<th>% of total driving duration</th>
<th>hr (M/SD)</th>
<th>Self-rated Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak hours (8-9am; 5-6pm)</td>
<td>9.76%</td>
<td>2.15 (2.28)</td>
<td>6.34 (3.65)</td>
</tr>
<tr>
<td>Fatigue (2-4pm)</td>
<td>28.36%</td>
<td>6.21 (3.76)</td>
<td>8.13 (1.35)</td>
</tr>
<tr>
<td>Night-time (sunset-sunrise)</td>
<td>9.65%</td>
<td>2.27 (2.77)</td>
<td>5.38 (3.90)</td>
</tr>
</tbody>
</table>

Finally, participants had to report if they had any driving incidents (e.g. near misses) over the two-week driving period. In total, they reported 55 incidents (M = .072, SD = 1.11) over the two-week period. Despite reporting relatively high performance during fatigue times, most of these driving incidents occurred between 2pm - 4pm in the afternoon (n = 27, 49%). Five of these incidents occurred during peak hours (9.1%), and seven incidents (12.7%) occurred during the night. Sixteen incidents (29.1%) occurred during other times of the day.

8.4.1.4. Driving trip purposes

Participants also reported the purpose of each driving trip. These trips were then coded into one of seven purposes: 1) **Shopping** was defined as trips to grocery shopping, shopping malls, produce markets and other stores; 2) **Sports and recreation** was defined as trips for exercises (e.g. gym, swimming and golf) and social/recreational purposes (e.g. church, night classes), sports and recreation was coded as one group because of the large degree of overlap between these two purposes (e.g. walking clubs, tennis, swimming and yoga classes); 3) **Appointment** was defined by trips to a pre-scheduled appointment (e.g. doctor, tests at the hospital, chiropractor); 4) **Pick-up/drop-off** was defined as trips to pick-up or drop off for friends and family (e.g. driving friends to airport/doctor, pick-up/drop-off grandchildren to school and extra-curricular activities; 5) **Visiting friends and family** was defined as trips to visit family members or friends at places outside of shops and
recreational trips. These include visits to babysit grandchildren, visiting friends and family members at their house and hospitals; 6) *Work* was defined as any work-related trips (both paid and voluntary work); 7) *Leisure* was defined by any trips for leisure activities (mostly solitary activities), including scenic drives, going to museum, gallery and beach. The percentages of total driving duration by driving purposes are presented in Table 25.

Table 25: Percentages of driving duration by driving purpose

<table>
<thead>
<tr>
<th>Purpose of trips</th>
<th>% of total driving duration</th>
<th>Hr (M/SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shopping</td>
<td>31.52%</td>
<td>6.90 (4.57)</td>
</tr>
<tr>
<td>2. Sports and recreation</td>
<td>27.20%</td>
<td>2.72 (4.99)</td>
</tr>
<tr>
<td>3. Appointment</td>
<td>10.45%</td>
<td>2.24 (1.96)</td>
</tr>
<tr>
<td>4. Pick-up/drop-off</td>
<td>9.46%</td>
<td>2.04 (3.19)</td>
</tr>
<tr>
<td>5. Visiting friends and family</td>
<td>8.43%</td>
<td>1.82 (2.49)</td>
</tr>
<tr>
<td>6. Work</td>
<td>8.06%</td>
<td>2.23 (5.87)</td>
</tr>
<tr>
<td>7. Leisure</td>
<td>6.19%</td>
<td>1.28 (2.16)</td>
</tr>
</tbody>
</table>

8.4.2. GPS

8.4.2.1. Data treatment

Driving trips data including distance (km) and duration (mins) were downloaded from each unit to a personal computer, using Trackstick Manager (Trackstick™, 2012; Google™ Earth, 2013). This allowed for visual inspection of signal dropouts and data recording errors. Data were then exported from Trackstick Manager to SPSS v20 for statistical analysis.

First, the UTC date/time recorded was converted to the local time/date; adjustment for daylight saving time was also undertaken. The collection of data by GPS waypoints yielded very large volume of data. As an illustration, at 5s sampling rate, a 30 min driving trip would yield a minimum of 360 data points. Thus, automated procedures were developed to analyse the data and convert it to trip-based information. Similar to the trip identification algorithm used by Stopher et al. (2008),
a trip end was assumed if the elapsed time between two successive in-motion GPS waypoints was >120s (>2 mins). This algorithm was suitable because most traffic signals in Australia have a red-light cycle of less than 1.5 minutes. Thus, traffic light stops should not be identified as trip ends using this trip identification algorithm. Further, signalised turn (right turns, in Australia) across oncoming traffic generally results in delay much less than 2 minutes.

Visual inspection of the data and mapped tracks identified that not all recorded tracks were valid. Driving trips that yielded unrealistic driving information is typically due to equipment errors (e.g. signal dropouts) (Duncan et al., 2007; Stopher, 2008). As per Stopher et al. (2008), the following parameters were used to guide the data cleaning process. Trip data was rejected for any trip:

- Where minimum to no movement was recorded (< 0.25km driving distance, less than a 15m change in either latitude or longitude, or <1 min duration); or
- That have driving speed that were considered as suspect (>300km/h)

A total of 89 driving trips (out of the total of 1043 trips recorded) met the above exclusion parameters, and were subsequently deleted.

Of the 78 participants in this study, GPS data was not collected from 16 participants due to equipment failure. A further 18 participants yielded incomplete GPS data (either disconnected prior to end of experiment/during the experiment or equipment out of battery/memory), and were excluded from subsequent analyses. Thus, this following section presents the complete GPS data collected from 44 participants within the current study.

8.4.2.2. Overall driving exposure

On average, participants took 24.48 trips (SD =14.70, skewness = 1.17, kurtosis = 1.09) over the two-week period, approximating two driving trips per day. The number of trips across the two-week period ranged from a minimum of 4 trips to a maximum of 66 trips. In regards to driving times, participants, on averaged, spent 217.62 minutes (3.63 hours; SD = 180.84 min, range = 43.4 to 972, skewness = 2.34,
kurtosis = 6.70) driving over the two-week period. Finally, they travelled an average of 198.09km (SD = 180.52, range = 37.47 to 981.50, skewness = 2.71, kurtosis = 8.99). Taking into account their averaged total driving duration and driving distance, on average, they travelled at 54.57 km/hr.

Bivariate correlations between the driving exposure parameter as measured by GPS and key variables of the MOTRS model (self-report) are presented in Table 26. Self-reported driving avoidance significantly predicted all three GPS measured driving parameters. Overall, psychosocial variables also demonstrated higher correlations than socio-demographic variables with GPS measured driving parameters.

Table 26: Bivariate correlations between GPS measured driving parameters and key variables of the MOTRS model

<table>
<thead>
<tr>
<th>Key variables (self-reported)</th>
<th>No. of trips (Pearson’s r)</th>
<th>Driving duration (Spearman’s rho)</th>
<th>Driving distance (Spearman’s rho)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-.17</td>
<td>-.32*</td>
<td>-.26</td>
</tr>
<tr>
<td>Health</td>
<td>.26</td>
<td>.11</td>
<td>.11</td>
</tr>
<tr>
<td>Driving performance</td>
<td>.06</td>
<td>.28</td>
<td>.27</td>
</tr>
<tr>
<td>Dependency on other drivers</td>
<td>-.05</td>
<td>-.14</td>
<td>-.08</td>
</tr>
<tr>
<td>Usage of alternative transport</td>
<td>-.24</td>
<td>-.02</td>
<td>-.04</td>
</tr>
<tr>
<td>Affective attitude</td>
<td>.28</td>
<td>.31*</td>
<td>.30*</td>
</tr>
<tr>
<td>Instrumental attitude</td>
<td>.42**</td>
<td>.26</td>
<td>.25</td>
</tr>
<tr>
<td>Subjective norm</td>
<td>.25</td>
<td>.21</td>
<td>.24</td>
</tr>
<tr>
<td>Perceived behavioural control</td>
<td>.32*</td>
<td>.36*</td>
<td>.36*</td>
</tr>
<tr>
<td>Driving confidence</td>
<td>.40**</td>
<td>.16</td>
<td>.15</td>
</tr>
<tr>
<td>Driving avoidance</td>
<td>-.44**</td>
<td>-.30*</td>
<td>-.30*</td>
</tr>
</tbody>
</table>

*p <.05, **p <.01

8.4.3. Comparison of driving exposure measures

8.4.3.1. Comparison of overall driving exposure

Bivariate correlations between participants’ estimated travel time (self-reported questionnaire), and driving duration as measured by the driving diaries and GPS are presented in Table 27. GPS estimates demonstrated a strong positive
correlation with driving diaries. However, while estimated travel time obtained from retrospective questionnaires demonstrated a moderate correlation with prospective diaries, it was not significantly correlated with that obtained from the prospective GPS units.

Table 27 Correlations of travel time obtained from questionnaires, diaries and GPS units

<table>
<thead>
<tr>
<th></th>
<th>GPS</th>
<th>Diaries</th>
<th>Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diaries</td>
<td>.52**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Questionnaire</td>
<td>.23</td>
<td>.37*</td>
<td>1</td>
</tr>
</tbody>
</table>

**p <.001, *p < .01

In order to test for equivalence of methods, the difference in travel duration (self-reported minus GPS) was plotted against each individual’s mean of self-reported and GPS travel duration using difference plots (often referred as Bland Altman plots; Bland and Altman, 1986) using SPSS v21. In Figure 33, the solid line is the line of equality, the dashed line represents the mean difference between the two measures and the dotted line marks the 95% confidence interval.

As can be seen in Figure 33, participants tend to subjectively overestimate their travel duration. Only one participant underestimated his/her travel duration ($M_{diff} = 2.1$ hrs). The majority ($n = 30, 70\%$) of participants’ estimates of travel duration were within the overall mean difference of 6.37 hours. One sample t-test demonstrated the mean difference deviated significantly from 0, indicating the presence of a fixed bias for driving duration. One sample t-test demonstrated a significant difference between self-reported and GPS recorded total driving duration, $t(2, 42) = 6.86, p <.001$ ($M_{diff} = 6.37$, SD = 6.09), with a large effect size, $r = .73$. Finally, the general positive slope of the Bland-Altman plot demonstrates that the difference between two measurements tend to increase with increased (averaged) driving exposure. In other words, participants increased their overestimation of driving exposure with increased driving duration.
Figure 33: Bland-Altman plot of self-reported and GPS duration (hr) travelled.

Difference in travel duration (diary minus GPS) was plotted against each individual's mean of diary and GPS recorded duration. The solid line is the line of equality, the dashed line represents the mean difference between the two measures and the dotted line represents the marks the 95% confidence interval. As can be seen in Figure 34, participants’ reported travel duration in the driving diary are consistently over that obtained from GPS measures. 60% participants’ diary recorded driving duration was within the overall mean difference of 8.42 hours. One sample t-test demonstrated the mean difference deviated significantly from 0, indicating the presence of fixed bias of driving duration, \( t(2, 43) = 12.69, p < .001 \) (M_{diff} = 8.42, SD = 4.40), with a large effect size, \( r = .88 \).
Figure 34: Bland-Altman plot of GPS and diary recorded duration (hr) travelled.

The number of trips reported using driving diaries and GPS were also compared (Figure 35). Participants’ reported no. of trips on the driving diaries demonstrated a significant moderate correlation with information obtained from the GPS units ($r = .41$, $p = .007$). Difference in the number of trips recorded (diary minus GPS) was then plotted against each individual's mean number of trips recorded by both measures. The solid line is the line of equality, the dashed line represents the mean difference between the two measures and the dotted line marks the 95% confidence interval. Compared to the driving diaries reported, GPS recorded a greater number of driving trips in 22 participants, and fewer driving trips in 20 participants. The reporting between two modalities was an exact match for 3 participants. One sample t-test demonstrated the mean difference did not differ significantly from 0, indicating the absence of a fixed bias, $t (44) = -1.36$, $p = .18$. It should be noted that
the number of trips recorded by these two measures were in agreement within 10 trips for the majority of participants (n = 33, 73.3%).

Figure 35: Bland-Altman plot of GPS and diary recorded number of trips

8.4.3.2. Comparison of time of day driving

GPS measured information demonstrated participants drove, on average, 32.84 minutes (SD = 84.74) during peak hours, 45.66 minutes (SD = 52.39) during fatigue hours, and 13.16 minutes (SD = 23.71) during night time. Bivariate correlations between diary and GPS measured information demonstrated significant correlations of driving during peak time (Spearman’s rho = .41, p <.001) and night time (Spearman’s rho = .58, p <.001), but not during fatigue hours (Spearman’s rho = .17, p =.19). One-way repeated-measures ANOVA demonstrated a significant main effect of time of day on driving duration, Pillai’s trace = .35, F (2, 58) = 15.81, p <.001. Post Hoc analysis revealed participants recorded significantly less driving during night time than during fatigue hours (p <.001, M_diff = 32.51, 95% CI = 20.38 to 44.64).
8.4.3.3. Comparison of self-regulatory driving behaviours

Participants’ scores of several driving avoidance items (at night and during peak hour) were compared against the amount of time they drove under these situations as recorded by the driving diaries and GPS. Table 28 demonstrate that participants seldom drove in the situations that they nominated they would avoid as per the Driving Avoidance Questionnaire. However, the cell sizes were too small to examine statistical significance.

In regards to driving in peak hour, self-reported questionnaire driving avoidance scores moderately correlated with that reported through driving diaries (Spearman’s rho = -.29, p < .05), but were not significantly correlated with that recorded by the GPS (Spearman’s rho = -.10, p = .47). GPS recorded peak hour driving demonstrated moderate correlations with that reported using driving diaries (Spearman’s rho = .41, p < .01).

In regards to driving at night time, self-reported questionnaire driving avoidance scores significantly correlated with that reported in driving diaries (Spearman’s rho = -.33, p < .05) and GPS (Spearman’s rho = -.44, p < .01). There was also a large correlation between GPS and driving diary recorded night-time driving (Spearman’s rho = .74, p < .001).

Table 28: Time of day of driving: self-report versus objective record

<table>
<thead>
<tr>
<th>Self-report avoidance</th>
<th>Times actually drove</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Peak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>11</td>
<td>28</td>
</tr>
<tr>
<td>Night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>No</td>
<td>20</td>
<td>22</td>
</tr>
</tbody>
</table>

Self-report avoidance groups were based on scores of the corresponding driving situations: “often” and “always avoid” = Yes; “never” and “sometimes” avoid = No.
Bold font indicate participants who drove in the situations that they indicate would avoid as per GPS records

**8.4.4. Driving performance measures**

**8.4.4.1. Data treatment**

Driving trips data including longitudinal and lateral accelerations (including decelerations) were downloaded from each unit to a personal computer, using Sensware v1.2.0, for visual inspection of errors. Data were then exported from Sensware to SPSS v20 for statistical analysis.

The collection of data by accelerometer records yielded very large volumes of data. As an illustration, at a 0sec epoch, each participant yielded, on average, above 40,000 records of vehicle kinematics data for each of the three axes. Thus, automated procedures were developed to analyse the data and convert it to driving performance information. As detailed in section 7.4.3.4, the following three categories of events were extracted from the vehicle kinematics data:

- Hard braking = longitudinal deceleration that exceeded 0.45g
- Abrupt braking = longitudinal deceleration between 0.35g to 0.45g
- Fast turning = Lateral accelerations exceeding 0.4g

This algorithm was based on previous research using accelerometers in investigating driver performance (Klauer et al., 2008; Simons-Morton et al., 2008; Uchida et al., 2011). All vehicle kinematics data were inspected for validity. For example, some records demonstrated that an accelerometer was removed/dropped, and then moved to a different orientation during the 2-week driving period. These invalid records were identified by either longitudinal or lateral axes showing above 1.5g, or either one of the axes demonstrating negative g for significant periods of time (beyond normal vehicle performance). These invalid records were screened and deleted from subsequent analyses.
Of the 78 participants in this study, 31 (39.7%) participants’ vehicles did not allow secure attachment of the magnetic mount of the recording accelerometers. A further 35 participants yielded incomplete data from insecure installation, dislodged or removal of accelerometers, or equipment out of battery/memory. Eighteen of these participants provided data for at least 7 days of driving, and were included in subsequent analyses. To compensate the missing data, inferential statistics were based on averaged longitudinal and latitudinal acceleration events per week. This following section presents the accelerometry data collected from 30 participants within the current study.

8.4.4.2. Overall driving performance

Over the two-week driving period, participants recorded a total of 143 (M = 4.77, range = 2-8) abrupt braking events (longitudinal acceleration .35-.45g), 36 (M = 1.27, range = 0-3) hard braking events (longitudinal acceleration >.45g), and 60 (M = 2, range = 0-4) fast turning events (lateral acceleration >.4g).

8.4.4.3. Predictors of driving performance

As can be seen in Table 29, bivariate correlations revealed strong correlations between longitudinal and lateral acceleration variables. While self-reported driving performance ratings from the diaries significantly correlated with the self-reported driving performance from the retrospective surveys, neither self-reported driving performance measures correlated significantly with longitudinal and lateral acceleration variables.

---

32 While the recording accelerometers could be manually attached to the underside of the vehicle, or electronically wired to the dashboard of the vehicle, these options were outside of the approved ethics protocol. Further, under the approved protocol, the accelerometers had to be mounted out of sight of, and would not be in contact with vehicle’s passengers in the event of a crash. The only place that fulfills these criteria was within the trunk of the vehicle. This prevented the installation inside many vehicles, especially hatchback and some 4WD models. Subsequently, this resulted in loss of data and a reduced final sample size.
Table 29: Bivariate correlations (Pearson’s r) between longitudinal and lateral accelerations

<table>
<thead>
<tr>
<th>Safe driving performance indicators</th>
<th>1.</th>
<th>2.</th>
<th>3.</th>
<th>4.</th>
<th>5.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Longitudinal .35-.45g</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Longitudinal &gt;.45g</td>
<td>.79***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Lateral &gt;.4g</td>
<td>.46*</td>
<td>.39*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Self-report (survey) driving performance</td>
<td>.13</td>
<td>.04</td>
<td>.13</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>5. Diary reported driving performance</td>
<td>-.23</td>
<td>-.26</td>
<td>-.20</td>
<td>.33**</td>
<td>1</td>
</tr>
</tbody>
</table>

*p< .05, ** p<.01, ***p<.001
Table 30 below shows the bivariate correlations between longitudinal and lateral accelerations and various measures of driving exposure. While GPS measured driving exposure variables generally demonstrated stronger correlations with longitudinal accelerations (hard braking and abrupt braking events), only the relationship between travel duration (GPS measured) and abrupt braking events (longitudinal acceleration .35-.45g) reached statistical significants at p <.05.

Table 30: Bivariate correlations (Pearson's r) between accelerations and driving exposure variables

<table>
<thead>
<tr>
<th>Driving performance indicators</th>
<th>Diary (n = 30)</th>
<th>GPS (n = 26)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of trips</td>
<td>Travel duration</td>
</tr>
<tr>
<td>Longitudinal .35-.45g</td>
<td>-.02</td>
<td>.03</td>
</tr>
<tr>
<td>Longitudinal &gt;.45g</td>
<td>.06</td>
<td>.07</td>
</tr>
<tr>
<td>Lateral &gt;.4g</td>
<td>.08</td>
<td>.23</td>
</tr>
</tbody>
</table>

* p< .05

Table 31 demonstrates the bivariate correlations between longitudinal and lateral accelerations and participants’ socio-demographic and driving exposure variables (self-reported survey). Significant negative correlations between dependency on other others, usage of alternative transport, driving confidence, avoidance, and acceleration events were observed at p <.05. Significant positive correlations between driving confidence levels and braking events were also observed. That is, participants who reported greater levels of confidence driving in various situations were also more likely to experience these braking events.
Table 31: Bivariate correlations (Pearson's r) between accelerations and self-reported socio-demographic and driving exposure variables (n = 30)

<table>
<thead>
<tr>
<th>Key variables (self-reported)</th>
<th>Longitudinal (.35-.45g)</th>
<th>Longitudinal (&gt; .45g)</th>
<th>Lateral (&gt; .4g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>.05</td>
<td>.09</td>
<td>.04</td>
</tr>
<tr>
<td>Health</td>
<td>.22</td>
<td>.21</td>
<td>.09</td>
</tr>
<tr>
<td>Driving Space</td>
<td>.11</td>
<td>-.18</td>
<td>.35</td>
</tr>
<tr>
<td>Dependency on other drivers</td>
<td>-.44*</td>
<td>-.23</td>
<td>-.38</td>
</tr>
<tr>
<td>Usage of alternative transport</td>
<td>-.33</td>
<td>-.03</td>
<td>-.51**</td>
</tr>
<tr>
<td>Affective attitude</td>
<td>-.26</td>
<td>-.01</td>
<td>-.05</td>
</tr>
<tr>
<td>Instrumental attitude</td>
<td>-.15</td>
<td>-.15</td>
<td>.16</td>
</tr>
<tr>
<td>Subjective norm</td>
<td>.10</td>
<td>-.19</td>
<td>-.08</td>
</tr>
<tr>
<td>Perceived behavioural control</td>
<td>.05</td>
<td>.07</td>
<td>-.11</td>
</tr>
<tr>
<td>Driving confidence</td>
<td>.32</td>
<td>.15</td>
<td>.42*</td>
</tr>
<tr>
<td>Driving avoidance</td>
<td>-.43*</td>
<td>-.22</td>
<td>-.39*</td>
</tr>
</tbody>
</table>

P < .05; ** p < .001

8.5. Discussion

The present study serves as an extension of the previous chapter. It aimed to investigate older adults’ driving behaviours and transportation using a combination of retrospective and prospective methodology. The present study is the first naturalistic driving study to simultaneously examine the transportation needs and the self-regulatory driving behaviours (self-reported vs. objectively measured) of older adults. Further, the current study is the first to explore the use of accelerometers in measuring the safe driving performance of older drivers in a naturalistic driving study. Overall, the results indicate 1) a diverse range overall driving exposure among older adults, 2) some common driving behaviours among older adults, 3) discrepancy between retrospective and prospectively measured driving information, and 4) correlation between self-reported self-regulation and objectively measured driving behaviours.

The discussion of the current findings follows the structure discussed in turn: first, the four overarching themes emerged from the combination of the driving diaries, GPS and accelerometers are discussed, followed by the findings specific to each
methodology. Finally, the strengths, limitations and implications of the current study are presented.

8.5.1. Overarching findings from the mixed-method approach

8.5.1.1. Diverse range of driving exposure

A wide range of driving behaviours among older drivers was evident from participants’ records of driving diaries and GPS measured driving behaviours. Specifically, while some participants recorded little driving over the two-week period, some participants recorded very frequent use of the vehicle over the study. This difference in driving behaviours may be prompted by work-related activities (both voluntary and paid work, such as Meals On Wheels and COMCAR\textsuperscript{33}) required by some participants. The heterogeneity of overall driving exposure is consistent with that reported within the older driver literature (based on self-report information).

8.5.1.2. Common driving practices

Despite the wide range in driving exposure (both in terms of overall travel distance and number of trips), information obtained from both the diaries and GPS demonstrated some common driving practices among older adults. Specifically, participants generally recorded little driving during peak hours and during the night time hours. With the exception of fatigue hours, both modalities demonstrated significantly less night time driving, than other times of day (e.g. peak traffic and fatigue hours). Further, both modalities recorded that on average, participants’ driving trips were short in both duration and distance.

8.5.1.3. Incongruence between self-report and objectively measured driving behaviours

Prospective measures of driving exposures (diary and GPS) have demonstrated convergent validity in terms of overall driving duration. Nevertheless, compared to GPS measured driving parameters, both diary and survey (both self-report) demonstrated that participants tend to overestimate their overall driving

\textsuperscript{33} COMCAR: common casual (paid) driving work within the Australian Capital territory; part of the car-with-driver Ministerial and Parliamentary Services for parliamentarians and guests of the Australian government.
exposure. Further, this discord between self-report and objectively measured driving exposure was more pronounced with increased (averaged) driving exposure. These findings are consistent with that of Blanchard et al., (2010). In addition, the retrospective self-report (survey) driving exposure demonstrated a significant positive skew, whereas both the prospective driving exposure measures (diary and GPS) were normally distributed. These finding suggests that the majority of participants self-reported a high amount of driving exposure, but the actual driving exposure of older adults were indeed more evenly distributed. The lack of correlation between self-rated driving performance and number of hard braking, abrupt braking, and fast turning events further highlights the lack of convergent validity of self-report data.

8.5.1.4. Correlation of self-regulation and driving behaviours (objectively measured)

Chapter 7 reported no significant correlations between participants’ levels of self-regulation (self-report driving avoidance) and retrospective self-report driving exposure (estimated hours of driving per week). Nevertheless, moderate negative correlations were observed between self-regulation and prospectively measured driving exposure items, including number of trips (both diary and GPS), driving duration and distance (GPS). The finding that self-regulation was related to prospectively measured, but not retrospectively measured, driving exposure, is consistent with the overestimation of driving exposure obtained from retrospective surveys (Blanchard & Myers, 2010). Further, there appeared to be general agreement between reported avoidance of driving situations, and the amount of driving recorded under these situations. The agreement between self-reported self-regulation and objectively measured behaviours are consistent with that reported by Blanchard et al. (2010).

Finally, the significant negative correlation between acceleration events and driving avoidance scores suggests that safe driving performance may be a contributor of older adults’ self-regulatory driving behaviours.

8.5.2. Findings specific to each measure

The following section discusses the findings, and considerations of these findings, specific to each measure of older adult’s driving behaviours.
8.5.2.1. Transportation needs

Driving purposes recorded from the driving diaries demonstrated that besides basic physical needs (such as shops and appointments), a substantial proportion of older adults’ driving needs were based on social and high-order (e.g. church) needs. Further, a significant proportion of driving trips were for health and fitness related purposes (e.g. gym, swimming, fitness classes). These findings may explain, at least in part, the significant decline in physical and social functioning following driving cessation (Edwards et al., 2009).

A notable proportion of participants’ driving trips were for work (both paid and voluntary) and assisting other family members in needs (e.g. babysitting, pick-up/drop-off). The potential social and economic consequences of withdrawing from these duties as a result of driving cessation have not been explored in the current literature.

8.5.2.2. Time of day performance

The finding that participants reported greater number of driving incidents during afternoon fatigue hours (2-4pm) than other times of day is consistent with the importance of circadian rhythm on cognitive and simulated driving performance reported in previous literature (Tassi & Muzet, 2004; Valdez, Ramirez & Garcia, 2012). While driving within peak hours and night time has been previously identified to be potentially risky driving situations, particularly for older adults who have declined cognitive and/or visual abilities, the number of driving incidents reported within these times were relatively low. However, this finding is likely confounded by the lack of driving exposure experienced during these hours.

Further, both peak hours and night-time driving have been reported by participants to be events during which they feel less confident and are more likely to avoid. Thus, older adults may be more cautious when driving in these situations than driving within afternoon fatigue hours.
8.5.2.3. Mismatch between diary and GPS driving exposure

Participants generally reported greater travel duration in their driving diaries than was recorded by the GPS units. Several explanations are provided for this. First, while the driving diaries provided line markings for participants to indicate the duration of each driving trip (line markings at every 30 minutes), it is difficult to discern whether a driving trip only lasted for a proportion of the marked time (e.g. 5 minutes versus 30 minutes). Some participants marked the entire round trip as one single driving trip (e.g. homes-shop-home as a single trip), whereas GPS units only record travel duration when vehicles are in motion. Finally, GPS units can have a ‘cold start’ start-up time (a maximum 50 seconds). Thus, the first minute (typically less than one minute) of some driving trips may not be recorded, deflating the GPS based estimate of overall travel duration. Nevertheless, the moderate correlation observed between GPS and diary reported driving exposure is consistent with Blanchard et al. (2010).

Mismatch of the number of trips (both under and over-reporting) between driving diaries and GPS was also observed. Each GPS was installed onto the vehicle and participants were instructed to leave the GPS units within the vehicle for the two-week testing period. If the vehicle was a shared vehicle within the household, it is impossible to discern whether trips, which were recorded on the GPS units, but not the diaries, were actual “missed” trips, or if the vehicle was driven by another family member. These trips (missed or otherwise) would contribute to the underestimated driving trips (i.e. less trips on the diaries than on the GPS records). On the other hand, due to the (max) 50 sec cold start of the GPS units, some short trips (within one minute duration) could be missed. As shown by the overall driving exposure data, most of the driving trips by older adults were short in duration. Thus, it is possible that the GPS may have missed some short trips made by the participants (e.g. to the corner shop).

8.5.2.4. The effects of psychosocial variables on objectively measured driving exposure

Psychosocial variables within the MOTRS model (i.e. affective attitude, instrumental attitude, perceived behavioural control, and driving confidence) demonstrated moderate correlations with objectively measured driving exposure
Together with the moderate correlation observed between self-reported and objectively measured self-regulation, these findings provide support for the application of the MOTRS model in predicting older adults’ actual self-regulatory driving behaviours.

8.5.2.5. Safe driving performance

In general, the current sample recorded relatively few acceleration related events (hard braking, abrupt braking and fast turning). In a naturalistic study of teenage drivers (N = 42), Simons-Morton et al (2008) reported 1721 hard braking events (longitudinal acceleration >.45g) over a 6 month period. The current sample registered approximately 1.2 hard braking events per participant over the two-week period, markedly less than the 3.05 per person over two-week average reported by Simons-Morton et al. (2008). Similarly, compared to another naturalistic driving study that compared drivers with high versus low rates of crashes (N = 78, Klauer et al., 2009), participants from the current studies, on average, would be classified as “safe” and “moderately safe” drivers based on the number of longitudinal and lateral acceleration events recorded.

8.5.2.6. Predictors of safe driving performance

Participants’ self-rated driving performance (both survey and driving diary) was not correlated with the number of acceleration events recorded in their vehicles. However, moderate correlations were observed between objectively measured driving exposure and number of acceleration events recorded. Participants who reported greater dependence on other drivers, usage on alternative transport and higher levels of self-regulation, were less likely to experience acceleration related events. However, the causation of these variables cannot be established within the current study. It is likely that these observed relationships were mediated, at least in part, by their levels of driving exposure.

Finally, participants who demonstrated greater levels of driving confidence also experienced greater number of braking related events. This finding is consistent with the hypothesis that without accurate insight of their driving performance and appropriate self-regulation, older drivers may drive in situations that are beyond their
abilities. However, due to inadequate power, this hypothesis could not be inferentially tested within the current study.

### 8.5.3. Limitations and future suggestions

A main limitation of this study is the data attrition from the technologies used for the prospective assessments. This methodological limitation resulted in a small sample size, and inadequate power to examine the statistical significance of some driving-related variables (e.g. self-reported versus objectively measured time-of-day self-regulation). Further, the small sample size may have prevented some observed relationships from reaching statistical significants (e.g. correlation between driving exposure and driving performance, i.e. Type 2 error). However, it must be noted that both GPS and accelerometer generated large quantities of data per person (approximately 6000 GPS waypoints and 40000 accelerometry records per participant over two weeks). Thus, the complexity of data handling increases greatly with increased sample size.

In regards to the GPS, there was no screen display that alerted of low memory or battery capacity. Some vehicles’ design prevented secure attachment of the accelerometers’ magnetic mounts. The accelerometers could be dislodged if participants readjusted the backseats where the accelerometers were mounted. These equipment issues could be rectified through hard-wiring these instruments directly to the participants’ vehicles; however, the current ethics protocol prevented this procedure from taking place. Further, it was anticipated that some participants (especially older adults who are less confident with their driving abilities) might not be comfortable with these instruments being directly connected to their vehicles. Newer models of GPS and accelerometers have longer battery and memory capacity, some with display screens that alert users regarding it battery and memory levels. The use of accelerometers in naturalistic driving studies has increased in recent years. Increased usage of these instruments may also improve to usability of this equipment. Future research that utilises these technologies, especially on smart-phone platforms, may experience less data attrition issues.

Another limitation related to the GPS is the inability to identify the driver of the driving trips. This is a major limitation in the accurate identification of missed
trips when compared to the driving diaries. Future potential solutions including key fobs or password entry should be explored. Wearable GPS devices (e.g. pocket GPS) are increasingly popular. However, the current wearable GPS devices generally have short battery capacity (less than one week).

Another major limitation of the current study is the potential sampling bias detailed in section 7.6.2. As discussed, the highly involved and complex nature of this study, and the requirement to travel to university, may have resulted in the sampling of more active drivers. While both self-report and objectively measured driving exposure demonstrated a diverse range of driving behaviours and practices within the current sample, future research should consider other recruitment strategies (e.g. through specific organisations) to further investigate the driving behaviours of different subgroups of older drivers.

Finally, the requirement that participants’ had to complete the driving diary after each driving trip may have added to the effort in participation, and subsequently promoted participants’ reactivity to the experimental situation and the potential of disruption effects (Christensen, 2006). In other words, the driving diaries may serve as a reminder to participants that their driving behaviours were being observed, and that the disruption of having to complete the driving diaries may have inadvertently altered their travel practices over the study period, thereby decreasing its construct validity.

8.5.4. Implications for research

Notwithstanding these limitations, one important outcome from this study is that self-reported self-regulation (as measured by the revised DAQ, Sullivan et al., 2011) is generally consistent with the objectively measured driving behaviours of older adults through the use of GPS. As discussed in Chapter 3, the current knowledge of older adult’s driving behaviour, including self-regulation, is based almost solely on self-reported information, mostly on retrospective surveys. Driving diaries are onerous to complete and can lead to non-compliance over a long study period (Wolf et al., 2007). As stated, the requirement of completing the driving diary may also promote disruption effects, thereby altering the observed travel pattern of older adults. While previous research have questioned the validity of driving diaries
compared to objectively measured driving parameters in measuring older adults’
driving behaviours (e.g. GPS) (Huebner et al., 2006; Marshall et al., 2007), these
studies only examine overall driving exposure, rather than self-regulatory behaviours.
The current study demonstrated that while older adults typically overestimate their
overall driving exposure, their self-report self-regulatory information is generally
consistent with specific objectively measured driving behaviours.

Another important outcome of this study is the low convergent validity
between retrospective self-report and prospectively measured driving exposure. Many
existing older driver studies (reviewed in Chapter 3) use retrospective self-report (e.g.
survey) driving exposure as a key variable. The current findings, in combination of
the findings from previous naturalistic driving studies (e.g. Blanchard et al., 2010;
Huebner et al., 2006; Marshall et al., 2007), suggest a lack of correspondence between
self-report and objectively measured overall driving exposure. The inaccuracy of self-
report driving exposure has also been found to apply to drivers of other age groups
(Staplin et al., 2008), but suggests that more accurate and reliable measures of overall
driving exposure are needed.

The current study also demonstrated the importance of psychosocial variables
in predicting objectively measured driving behaviours. This finding provides support
for the proposed MOTRS model, and the overall importance of these variables in
understanding older adults’ driving behaviours.

Finally, an additional aim of the current study was to explore the utility of
accelerometers in assessing older drivers’ safe driving performance in a naturalistic
driving setting. Compared to more traditional methods of measuring older adults’
driving performances, such as instructor ratings and simulated driving performance,
the lack of artificiality of the situation allow older adults to be left in their natural
driving environment (instrumenting their own vehicles), thereby eliminating any
artificial influence that might be caused by bringing them out of their natural driving
environment (Christensen, 2006). More importantly, naturalistic driving studies allow
researchers to consider the effects of driving exposure, self-regulation and other
compensatory strategies on older adults’ overall driving performances. Longitudinal
and lateral acceleration events extracted from the current study was consistent with
previous accelerometer studies (Klauer et al., 2009; Simons-Morton et al., 2008),
providing support for the use of accelerometers in older adults’ driving behaviours. Nevertheless, a normative approach to establish ‘normal’ ranges of acceleration forces may be required to further contextualise this data.

8.6. Chapter summary

This chapter examined the self-report and objectively measured driving behaviours of older adults through the use of retrospective self-report survey, prospective self-report diary, GPS and accelerometer. The current study demonstrated a wide range of transportation needs, driving behaviours and driving performances among older adults. Further, the current study provided empirical support for the use of the Driving Avoidance Questionnaire in assessing older adults’ self-regulatory driving behaviours, and the potential application of the MOTRS model in accounting for older adults’ actual driving behaviours. Finally, the current study provided empirical support for using GPS and accelerometers in assessing older adults’ driving behaviours and performances in a naturalistic driving setting. The chapter concluded with the discussion of the study’s findings and the implications of the results for the older driver literature.
Chapter 9: Discussion

9.1. Introductory comments

The previous chapters have presented a program of research studies that investigated a range of socio-demographic and psychosocial factors that influence older adults’ self-regulatory driving behaviours, and examined the relationship between self-report and objectively measured driving behaviours. This final chapter demonstrates how these studies inform our current understanding of older adults’ self-regulatory driving behaviours through providing a synthesis of the research findings, structured around the research questions. Theoretical contributions to the current body of research are presented, followed by the practical implications for programs aimed at improving older driver safety and mobility. Finally, a summary of the strengths and limitations of the overall program of research, as well as suggestions for further research, are presented.

9.2. Overall research findings

This section discusses the findings of the overall program of research through addressing each research question separately.

9.2.1. Research Question 1: What do we know about older adults’ driving behaviours, in particular, self-regulation?

This research question was based on the need to provide an explicit integrated understanding of the current knowledge on older adult’s self-regulatory driving behaviours. To address this need, a systematic review of the literature on older drivers’ adoption of self-regulation was conducted to identify the current state of knowledge, as well as to identify some of the methodological and theoretical gaps in this literature.

The systematic review demonstrated inconsistent empirical findings in regards to older adults’ self-regulatory behaviours across 29 studies. Specifically, the proportion of older adults who self-regulate (self-report) their driving behaviours remains unclear. While some studies reported self-regulatory driving behaviours to be common practice among older adults, other studies found that only a subset of older adults reported such behaviours.
In addition, the factors, and the relative importance of these factors, that influence older adults’ self-regulatory driving behaviours were inconsistent. The factors that received most consensus were largely Socio-demographic and Driving-specific factors: age, gender, overall driving exposure (mileage driven), visual impairments, number of medical conditions and driving confidence. However, due to the diversity of data collection and analysis methods, the relative importance of these factors on older adults’ driving self-regulation was unclear. For instance, while some studies report age to be a strong predictor of older adults’ driving self-regulation, other studies indicated that its influence on self-regulation was, at least partially, medicated by health conditions (Braitman & McCartt, 2008; Ragland et al., 2004). These findings indicate that age may be acting as a proxy for health-related abilities in older adults’ self-regulatory driving behaviours.

Further, little research could be identified that addressed the psychosocial influences on older adults’ adoption of self-regulation. Thus, the underlying process that the identified Socio-demographic and Driving-specific influence older adults’ self-regulatory behaviours remained unexplored.

Using the factors identified through the systematic review, and after examining current models of older driver behaviours and self-regulation, the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model was proposed. This model differs from existing older driver behaviours models because it 1) systematically incorporates the major known factors and assumptions older drivers’ behaviours, 2) expands upon existing older driver models through assessing the influence of psychosocial variables on older drivers’ self-regulatory behaviours, and 3) allows the generation of specific and testable pathways about the dynamic interactions of factors.

9.2.2. Research Question 2: What are the factors that contribute to self-regulation of older adults?

Attempts to improve the use of self-regulation may rely on an accurate understanding of the factors that influence self-regulation, especially those that are potentially modifiable. Knowledge of these factors, and the relative importance of these factors, also provides a foundation for developing and testing a comprehensive
theoretical model that accounts for older adults’ self-regulation. With this in mind, using the proposed MOTRS model as a foundation, the factors drawn from the systematic review were tested simultaneously in Study Two on a representative sample of older Australian drivers.

Overall, psychosocial factors (i.e. driving confidence, affective attitude, instrumental attitude and perceived behavioural control towards driving) demonstrated the strongest influence on older adults’ driving self-regulation (self-report). Out of all the Socio-demographic, Driving-specific and Psychosocial factors tested, attitude towards behaviour was the single largest contributor of self-regulation. Socio-demographic and driving-exposure factors that provided notable contribution to self-regulation were: age, gender, driving space, health, driving speed and performance, dependence on other drivers, usage and rating of alternative transportation. Importantly, gender, health, dependency on other drivers and driving speed were not significant predictors of self-regulation after considering the effects of psychosocial factors. Nevertheless, the importance of Socio-demographic and Driving-specific factors on self-regulation is generally consistent with the current body of literature reviewed in Chapter 3. The results regarding the interrelationship with these variables, and their influences on self-regulation demonstrated that older adults’ self-regulation is a complex process, influenced by many personal and environmental factors.

As predicted by the MOTRS model, the influence of Socio-demographic and Driving-specific factors on older adults’ self-regulation is simultaneously mediated by a number of psychosocial factors. Using Structural Equation Modelling (SEM, detailed in Chapter 6), Study Two demonstrated the specific pathways through which some of these factors could influence older adults’ self-regulatory driving behaviours. Additional meditational analyses of pathways not included in the Structural Equation Model (mainly due to insufficient sample size) also provided support for the general structure of the MOTRS model, and helped to explain how these factors interact with each other to influence older adults’ self-regulation.

Finally, although less strongly predictive of self-regulation, environmental factors, such as usage and perception of alternative transportsations, and dependence on other drivers, were also found to be important predictors within the MOTRS
model. This result suggests that the older adults’ social and environmental context also significantly influence their use of self-regulation.

Overall, Study Two demonstrated that the Socio-demographic and Driving-specific variables (age, gender, driving space, health, driving speed and performance, dependence on other drivers, usage and rating of alternative transportation) influence older adults’ self-regulation through specific psychosocial factors (driving confidence, affective and instrumental attitudes, and perceived behavioural control).

9.2.3. Research Question 3: How do older adults self-regulate?

Study Two and Three were designed to provide an in-depth examination of the practice of self-regulation among older drivers. Importantly, these studies allow for an assessment of the consistency across self-report and objectively measured driving behaviours, including behaviours associated with self-regulation. This approach was adopted because the knowledge of older driver behaviours, especially those associated with self-regulation, is based almost entirely on self-report information.

Consistent with previous naturalistic driving studies of older adults, older drivers generally overestimated their driving exposure, in terms of overall travel distance, travel duration, and number of trips in both prospective driving diaries and surveys (Stopher et al., 2008; Blanchard et al., 2010). This general inaccurate estimation of driving exposure has lead some researchers to conclude that older drivers’ self-report driving behaviours are inaccurate and unreliable (Crizzle et al., 2013; Hueber et al., 2006). However, consistent with Blanchard and Myers (2010), the current study found general agreement between drivers who reported avoidance of driving situations, and the amount of driving recorded under these driving situations. This finding suggests that the accuracy of older drivers’ report of driving related self-regulation may be improved by increasing the specificity of questions, such as focusing on specific driving situations instead of overall driving exposure.

Study Two demonstrated that older drivers generally avoid driving under conditions that are either visually demanding (e.g. at night, in the rain) or cognitively demanding (e.g. peak hour, high traffic roads). Study Three tested the agreement of self-report and objectively measured driving exposure under each of these driving-avoidance categories: driving during night-time (visually demanding) and under peak
hour (cognitively challenging). Under these two driving situations, examination of older adults’ driving avoidance scores against objectively measured driving exposure revealed general agreement between these two variables. This finding indicates that while older adults may not be accurate in self-report overall driving exposure, their self-report self-regulation is generally in agreement with their objectively measured driving behaviours. Further, older drivers who reported greater levels of self-regulation also recorded less overall driving exposure.

Previous studies that focused on the driving capacities of older adults reported that their self-regulatory driving behaviours (self-report) are not based on driving performance (expert rated on-road course or simulated driving performance (e.g. Baldock et al., 2006). However, through studying the naturalistic driving behaviours of older adults over a two-week period, older adults who reported greater levels of self-regulation demonstrated fewer longitudinal and lateral acceleration events. In other words, older adults who reported greater self-regulation were less likely to demonstrate hard braking, abrupt braking and fast turning events. This finding is encouraging for the use of self-regulation in managing older driver safety. It is encouraging because the central premise of self-regulation is to preserve functional mobility through reduced exposure to potentially risky driving situations, in light of progressive functional declines. Therefore, the effectiveness of self-regulation in maintaining older driver safety would be supported if the reduced number of acceleration events among self-regulating older adults were due to their decreased driving exposure. While a longitudinal prospective study (beyond the current two-week testing period) is needed to establish the causality of driving capacities, self-regulation and driving exposure, findings from the current study provided preliminary empirical support to this hypothesis.

9.2.4. Research Question 4: How can we improve older adults’ practice of driving-related self-regulation?

This final research question is based on the need to improve older driver safety and mobility through promoting more widespread, as well as more appropriate, use of self-regulation. This section provides a summary of the avenues to improve the appropriate use of self-regulation
Study Two demonstrated that the psychosocial variables examined (driving confidence, perceived behavioural control, affective and instrumental attitudes), mediated the effects of major socio-demographic variables (e.g. gender, health and driving performance), and provided substantial contribution to variation in older adults’ practice of self-regulation. This finding is encouraging for future programs that might aim to improve older drivers’ self-regulation. This is because unlike Socio-demographic and Driving-specific variables, Psychosocial variables are potentially modifiable factors. Previous studies have demonstrated programs that successfully modified older drivers’ levels of driving confidence through providing them accurate feedback about their driving performance (Molnar & Eby, 2010; Ackerman et al., 2011). The strong correlation between psychosocial variables and self-regulatory driving behaviours (both self-report and objectively measured) suggests that future programs intended to improve older drivers’ self-regulatory behaviours could focus on modifying their driving confidence, attitudes towards driving and the perceived behavioural control of the vehicle.

Using a combination of prospectively measured driving information (driving diaries and GPS), Study Three demonstrated that older adults drove significantly more (number of trips, travel distance and duration) and reported better driving performance under afternoon post-lunch fatigue hours (2-4pm), than during other potentially at-risk driving times (e.g. peak hour and night-time hours). This was associated with greater number of driving incidents (e.g. near-misses) recorded under the post-lunch fatigue times than other times of day. In a previous study of older adults’ perception of various driving situations, older adults nominated road conditions that they perceived as unsafe (Sullivan et al., 2011). While various ‘unsafe’ driving conditions were mentioned (e.g. driving at night, through heavy traffic, poor road conditions), driving during times of day where fatigue are most likely to occur was identified as a “safe” driving situation (Sullivan et al., 2011). This suggests that the lack of understanding about the risks associated with fatigue while driving may contribute to increased driving exposure under these situations, thereby increasing the likelihood of driving incidents under these potentially risky driving situations.

While it can be argued that older drivers’ avoidance of driving during nighttime is indicative of their risk perception of fatigue driving, previous studies suggest that their self-restriction from night-time driving is likely due to their concern of
decreased visual abilities (e.g. Braitman & Williams, 2011; Charlton et al., 2006; Molnar & Eby, 2008; Kostyniuk & Molnar, 2008; Loftipour et al., 2010; Ruechel & Mann, 2005), rather than awareness of fatigue. This finding indicates that increasing older adults’ knowledge and risk perception of driving under various potentially risky driving situations (e.g. driving when fatigued) may improve more appropriate use of self-regulation. Potential strategies to improve older adult’s self-regulation in regards to fatigue driving may be to encourage them to reduce their driving between post-lunch fatigue hours (2-4pm). However, the increased driving exposure during these times may also be due to lifestyle choices, that driving during these times may better suit their transportation needs. Therefore, alternative strategies such as increased education about fatigue management (e.g. detection of fatigue driving, use of rest breaks), and increased access to alternative transportation during these times may be required to limit the restriction on their functional mobility. This is consistent with previous qualitative research that suggests flexible and person-centred public transportation systems are needed to encourage active aging (Michael, Green & Farquhar, 2006).

Provision of safe travel options that satisfy older adults’ transportation needs would allow older drivers to practice self-regulation without compromising their mobility. With this in mind, the results of the two quantitative studies (Study Two and Three) also investigated the transportation needs of older adults. Study three demonstrated that besides basic services and amenities (e.g. shop, doctors appointments = 41.67%), a substantial proportion of older adults’ driving trips were for high-order social and recreational purposes (e.g. gathering with friends, recreational and spiritual purposes = 60.74%). Some of these driving trips were made outside the normal operating hours (e.g. during night-time hours) of traditional alternative transportation options. Thus, more flexible alternative transportation options may be required to satisfy the transportation needs of older drivers.

Study Two and Three demonstrated that older drivers who reported greater levels of self-regulation were also more likely to report greater levels of dependency on other drivers. In other words, older adults who have another driver to share the driving duties are more likely to practice self-regulation. This finding suggests that use of shared-driving (peer based and/or family based) maybe an avenue to promote the adoption of self-regulation among older adults. The use of peer-based shared
driving may also have the additional benefits in assisting older adults to maintain some form of social engagement at a time of driving restriction.

9.3. Contributions to research

This section summarises the key contributions to the current body of transportation and aging literature. First, the development and testing of the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model represents an advancement in both the transportation and aging literature. The MOTRS model is the first theoretical model that considers the driver, the environment, and the interaction between the two, and allows the generation of specific and testable pathways about the dynamic interactions between its variables. Recent research has demonstrated that the practice of self-regulation is not limited to the older driver cohort (Naumann, Dellinger & Kresnow, 2011). Indeed, the practice of self-imposed restrictions from high-risk driving conditions may improve the safety of other vulnerable road user groups, such as novice drivers and drivers with medical conditions that impair driving performance. Self-regulation may more broadly be considered as an adaptive and continuous assessment of driving conditions and individual state. The MOTRS model provides a dynamic, testable, theoretical framework to investigate the application of driving-related self-regulation in these contexts.

While the MOTRS model was developed specifically to predict older adults’ practice of driving-related self-regulation, many of the model constructs and assumptions stem from a broader literature on older adults’ health behaviours. The adoption of self-regulation may also be extended as a general risk reduction strategy, protecting older adults from common non-driving related injuries due to increased functional declines, such as slips and falls. The MOTRS model provides a theoretical framework for future injury prevention research to investigate the practice of self-imposed restrictions from high-risk situations among older adults.

This research examined the psychometric properties of some of the commonly used scales (e.g. Driving Avoidance Questionnaire, Driving Confidence Questionnaire, and Driving Space) within the older driver safety literature, and demonstrated that the factor structures of these scales differed from their proposed
factor structure. At the time of writing this dissertation, no existing studies have examined the factor structure of these scales. The factor structure of these supposedly one-factor structured variables reflects the need for these scales to undergo more rigorous psychometric examination, and that the current one-factor interpretation of these scales may not be appropriate in all populations.

At the time of writing this dissertation, there is only one published study that has examined the influence of attitudes towards driving on older adults’ self-regulation (Gwyther & Holland, 2012); whereas no existing study has examined the effects of perceived behavioural control of the vehicle, not the subjective norms about driving on older adults’ self-regulation. The current research program also demonstrated a role for these more novel psychosocial variables in predicting older adults’ driving behaviours, including (self-report and objectively measured) self-regulation.

The Multilevel Older Person’s Transportation and Road Safety was intended to reconcile some aspects of the existing transportation and aging literature. The model was formally tested for fit against data, and then cross-validated using an independent sample of older drivers. Findings from both Study Two (formal testing) and Study Three (cross-validation) provided empirical support for the MOTRS model. The MOTRS model may provide a framework for future studies intended to simultaneously test the constituent factors, the relative importance of these factors, and the interaction between these factors, on older adults’ driving self-regulation. The MOTRS model may also be extended to understanding the role for driving self-regulation in other populations, such as novice drivers.

Another contribution of this thesis is an improved understanding of the potential importance of knowledge and risk perception of driving under various potentially hazardous situations on older drivers’ practice of self-regulation. At the time of writing this thesis, no existing studies have examined older drivers’ understanding and perception of risk of driving under certain road conditions such as driving while fatigue. The current study suggests that accurate driving-related knowledge may be an important factor in older drivers’ practice of self-regulation, and that knowledge of specific risks may need to be a focus.
Previous naturalistic driving studies have demonstrated that older drivers, along with drivers of other age groups, can be inaccurate in their estimates of driving behaviours. This has led to the conclusion that older drivers may not be regulating as often as they report (Huebner et al., 2006; Staplin et al., 2006). However, the current study demonstrated a moderate relationship between the situations that older driver indicate they would avoid, and their objectively measured driving behaviours under those circumstances. This finding is broadly consistent with the findings from another naturalistic driving study by Blanchard et al. (2010). The general agreement between self-report self-regulation and objectively measured driving behaviour provides some support to the application of the MOTRS model (based on self-report) to older drivers’ objective driving behaviours.

Finally, the current study demonstrated a potential application of accelerometers in assessing older drivers’ driving performance in a naturalistic driving setting. As discussed in Chapter 8, the use of naturalistic setting has several advantages over traditional assessments of driving performance, such as on-road driving performance on a pre-determined road course and simulated driving performance. One such advantage is that the effects of driving exposure (both overall driving exposure, and driving exposure under specific, higher-risk, driving situations) can be accounted for. If self-regulation is effective in decreasing older adults’ crash risk through reducing their driving exposure under risky driving situations, as the results of this research program indicated, then driving exposure represents a significant confound in studies that assess older drivers’ crash risk based solely on their driving performance.

9.4. Practical implications of the research program

This research may have several practical implications for managing older driver safety. The first practical implication relates to the importance of psychosocial factors on older adults’ practice of self-regulation, and the mediating influence these factors have on the established relationship between socio-demographic factors and older adults’ self-regulatory behaviours. Unlike most socio-demographic factors, certain psychosocial factors are potentially amendable to change, either through individual, peer or family level behavioural interventions, or through community-level public health interventions. As noted, previous studies have successfully
modified older adults’ levels of driving confidence through providing them accurate feedback about their driving performance (Molnar & Eby, 2010; Ackerman et al., 2011). However, to date, no existing studies have documented the modification of older adults’ attitudes and beliefs about their driving. The MOTRS model could be used to develop targeted practical strategies to improve older drivers’ self-regulation through specifically focusing on these psychosocial factors.

The second practical implication for managing older driver safety is the potential importance of accurate driving-related knowledge for appropriate self-regulation. Circadian-rhythm studies consistently reported mid-afternoon fatigue times to be associated with reduced cognitive functioning and poorer simulated driving performance (Tassi & Muzet, 2005; Valdez, Ramirez & Garcia, 2012). However, participants of the current study drove more and reported a greater number of driving incidents during the afternoon hours than at other times of day. Further, previous studies on older adults’ driving-related risk perception did not identify mid-afternoon fatigue times to be perceived as potentially hazardous (e.g. Sullivan et al., 2011). These findings suggest that increased knowledge of the risk involved in driving under various situations, such as fatigue times, may also be useful in improving the appropriate use of self-regulation among older drivers. There are already strategies and technologies oriented to prevention, identification and warning about sleepiness while driving (e.g. MacLean, Davies & Thiele, 2003; Papadelis et al., 2007). However, these approaches have not been applied to non-clinical groups of older adult drivers.

The third practical implication is the importance of having some form of alternative transportation options. These alternative options may be formal ones through provision of public transport, but may also be informal ones through shared driving partners. The finding that shared driving partners increases the likelihood of self-regulation is of particular relevance to older adults who reside in less populated regions, where public transportation options are not readily available or accessible. The promotion of some form of shared driving programs (peer-based or volunteer-based) may be a strategy to be considered for maintaining the mobility of rural older adults.
Effective programs to manage older driver safety cannot be only about safety. The prolonged mobility of older adults must also be considered (Dickerson et al., 2007; Oxley & Whelan, 2008). The current research program demonstrates that the transportation needs among older adults are not restricted to basic services and amenities access. The social, recreational and spiritual needs also formed a substantial proportion of older adults’ driving trips, and will need to be considered in any programs that improve older driver safety. Loss of these social, recreational and spiritual opportunities may be reflected in previous reports of depression and functional decline after cessation of driving (e.g. Edwards et al., 2009; Freedman et al., 2006).

Finally, the findings that age per se was a non-significant predictor of older drivers’ safe driving performance as measured by the accelerometers challenges a fundamental assumption of Age-Based Testing (ABT) as a risk mitigation strategy for older adults. If age is not predictive of older adults’ driving performance in a naturalistic setting, as the current prospective study suggest, then reliance upon ABT to manage driver safety may be problematic. Further, the relationship between objective driving performance and crash risk remains unclear within the transportation literature.

9.5. Strengths of the research program

As described in Chapter 2, due to a combination of a rapidly aging population and their increased fragility, managing the travel needs of the older driver cohort has become an increasingly critical social and public health issue in most developed countries. Findings from the research program provided significant contribution to the current body of transportation and aging literature, through examining the driving behaviours, including self-regulation, of older adults. The main strengths of the research program are presented below, followed by a discussion of its key methodological and theoretical limitations.

A core strength of this research is the mixed-method approach. The current research program used simultaneous self-report and objective measurements in a prospective naturalistic setting, allowing a thorough investigation of the actual driving behaviours of older adults. It is noted that this study is not the first to utilise GPS and
driving diaries in assessing older drivers’ driving behaviours. This research, however, is the first to empirically examine the effectiveness of self-regulation through examining older drivers’ self-regulation scores (self-report) against their actual driving behaviours (GPS) and driving performance (accelerometer). Researchers and road safety authorities are increasingly promoting self-regulation as a compensatory strategy to maintain older driver safety and mobility; however, the effectiveness, and practice, of self-regulation has not been thoroughly investigated. The current research was intended to address this gap by testing the agreement between self-regulation, driving exposure under various driving situations, and driving performance.

The second strength of this research was the simultaneous testing of a broad range of factors thought to be involved in older drivers’ practice of self-regulation (drawn from a systematic review of the current literature detailed in Chapter 3). Using the Multilevel Older Person’s Transportation and Road Safety (MOTRS) model as a foundation, Study Two and Three demonstrated that relevant socio-demographic factors influenced self-regulation primarily through psychosocial variables, such as attitudes towards driving and driving confidence. As identified in Chapter 3, much of the existing literature was found to be inconsistent and lacking a congruent theoretical focus. The current work, particularly the development of the MOTRS model and direct comparison of predictive factors, contribute to a more concise understanding of these problems.

A final strength of the current work lies in the generalizability of the current findings, especially in regards to the MOTRS model, to the broader community (at least to the broad Australian population). This is evidenced by the wide range of organisations and avenues used to recruit sample participants for Study Two. As demonstrated in Chapter 3, many studies on older driver behaviour, in particular those studies assessing self-regulation, have utilised samples from specific senior community centres, clinics or existing older driver study registries. The current program’s recruitment strategy through recruiting older drivers from right across Australia (including both urban and rural communities; Study Two), and recruiting through a range of outlets and organisations (Study Two and Three), was intended to increase the generalizability of the studies’ findings.
9.6. Limitations of the current research program

Notwithstanding the above-mentioned strengths, the current research program also has several limitations. A limitation of the approach adopted in this study program relates to the use of self-report data on participants’ Socio-demographic and Driving-specific variables. In context, Socio-demographic variables such as age, gender and remoteness of residential locations are relatively stable factors and less prone to biases, and psychosocial factors can only be meaningfully assessed through self-report information. However, other factors, such as severity and impact of health conditions and dependency on other drivers may be more subject to personal interpretation, thereby increasing the likelihood of participant effects. The use of self-report information for the Socio-demographic and Driving-specific variables may have biased the findings, resulting in restriction of range in several variables, and reduced correlations between these variables and self-regulation. It should be noted though, that a number of previous studies which used objectively measured (e.g. hospital records, test performance) health and cognitive performance information, also demonstrated significant negative correlation with (self-report) self-regulation (e.g. Ball et al., 1998; Vance et al., 2006; Okonkwo et al., 2008).

Another methodological limitation relates to the inability to rigorously test the effects of cognitive performance on self-report and actual driving behaviours, including self-regulation and performance. Efforts were made to examine the relationship between cognitive performance and self-regulation and in Study Two and Three. However, due to the difficulty in recruiting a representative sample of older drivers across Australia, the inclusion of web-based questionnaire precluded the use of cognitive testing within Study Two. As a result, the effects of cognitive impairments on self-regulation, and its interaction with other socio-demographic variables, were excluded from the current MOTRS model. It should be noted, however, an attempt to estimate the effects of cognitive state on self-regulation was made in a sub-study of the current research program (not reported in thesis, see paper in Appendix F).

A third methodological limitation of the research relates to the generalizability of the results of Study Three. The attrition of data due to equipment issues, and the inability to safely and securely install the accelerometers onto some participants’
vehicles, resulted in the loss of data from approximately 50% of the sample. This data attrition resulted in reduction in power to detect differences, and prevented the use of multivariate tests to validate pathways of the MOTRS model on objectively measured driving parameters. The low power of Study Three also led to only partial validation of the model using meditational analyses, rather than full validation of the complete model through SEM. As mentioned in section 1.5, due to financial and other practical constraints, participants of Study Three were all recruited within one state of Australia (Australian Capital Territory). Future research is needed to validate whether the findings regarding objective driving behaviours (and their relationships with self-report information) could be applied to older adults from other geographical areas.

Psychosocial factors have been demonstrated to be important factors in predicting the self-regulation (self-report) of older drivers, as well as their objectively measured driving behaviours. However, structural analysis of the model constructs demonstrated the subjective norm variable requires further investigation into its psychometric properties. This operationalisation issue stems from the adoption of the attitudes and beliefs towards driving questionnaire developed by Lindstrom-Forneri et al. (2007) in predicting older adults’ intention to continue driving. No existing research has examined whether (and to what extent) subjective norm predicts older adults’ self-regulatory driving behaviours. Clearly, future research is needed to validate both the content and structure of the attitudes and beliefs towards driving questionnaire, and to further investigate the psychosocial factors that underlie older adults’ driving related self-regulation.

Another limitation relates to the appropriateness of using regression based methods, such as mediation analyses and structural equation modelling, to test the proposed MOTRS model, a connectionist model that is typically tested through computation modelling techniques. As stated, the current research program conducted the preliminary investigations of the MOTRS model using a regression-based approach, because it is more conventional within the domain of health psychology. Further, the use of SEM allows the identification of constructs within the model that requires further operationalisation. Eventually, a computational approach in testing the MOTRS model will be required to model outcomes from different behavioural, legal or social interventions.
A final limitation that applies to the overall program of research relates to the conceptualisation and measurement of “self-regulation”. Consistent with previous literature, the current research program defined self-regulation as ‘deliberate, a-priori self-restriction strategies in reducing exposure to potentially harmful driving conditions’ (detailed section 1.1). The strong positive correlation between Driving Space and self-regulation scores suggests older adults who practice driving self-regulation may restrict their driving based on proximity of driving locations from home. That is, with increased sensory and functional declines, they may choose to restrict their driving trips to locations closer to their home and immediate neighbourhoods, rather than restricting their driving trips to specific driving situations. This interpretation is consistent with findings that older drivers reported greater acceptance towards restrictions that provide them with greater flexibility in accessing services and amenities (Marshall et al, 2007). However, none of the existing measurements considers reduced driving distances as an index for older adults’ driving-related self-regulation.

9.7. Suggestions for future research

There are a number of directions which future research might follow to address the limitations highlighted above, and to extend the findings of the current research program. As described, future studies should consider using objective measures of Socio-demographic and Driving-specific variables where possible, such as hospital records and physician’s ratings, to gain a more accurate and reliable description of these variables.

The systematic review of the current literature demonstrated the need for more ecologically valid and reliable outcome measures when assessing older drivers’ driving behaviours, including behaviours related to self-regulation. Study Three endeavoured to progress in this direction through assessing older adults’ driving behaviours and driving exposure through driving diaries, GPS and accelerometers over a two-week period. This prospective methodology represents a significant improvement upon traditional studies of older drivers’ behaviours that may be confounded by participants’ biases, such as demand characteristics and inaccurate recall. However, both the GPS and accelerometers resulted in significant data attrition, making it difficult to accurately identify the relationships between various socio-
demographic, psychosocial variables and objectively measured driving parameters. Future studies should consider exploring other GPS and accelerometer instruments that are more user-friendly and suitable for a range of vehicle models.

Appropriate use of self-regulation is contingent upon having an accurate understanding of one’s driving abilities and driving behaviours. The cognitive deficits due to age-related neurological disorders, such as lack of insight and awareness, may impact upon older drivers’ ability to appropriately self-regulate. Future naturalistic driving studies are required to examine the effects of cognitive deficits on older adults’ driving behaviours, including those associated with self-regulation. Further, current knowledge on the effects of cognitive deficits on older adults’ driving performance are mostly based on laboratory based driving performance (such as expert rating using pre-determined track or simulator driving performance). As has been described, driving exposure (both overall driving exposure and exposure to specific risky situations) needs to be considered when assessing the safety of older drivers with cognitive impairment. Thus, additional investigation on cognitive impaired older drivers’ driving behaviours and performance using a naturalistic driving setting is required.

The role of psychosocial influences on older adults’ driving self-regulation has been largely ignored in the current literature. The current study demonstrated the importance of psychosocial factors, such as attitudes towards driving, on older adults’ practice of self-regulation. The finding that the psychosocial variables examined partially mediated, rather than fully mediated, the influence of Socio-demographic and Driving-specific variables on self-regulation, indicate that there may be other important Psychosocial variables not included in the present study. Research is needed to investigate the underlying psychosocial influence of older drivers’ self-regulatory practice. This may be achieved by examining mechanisms and pathways identified by other prominent models of health behaviour change in conjunction with the ones considered within the current research program.

Further, additional investigation is required on the psychometric properties of the driving scales used within the current study. The confirmatory factor analyses of these scales, detailed in section 6.3.2, showed the factor structures of these scales differed from their original intent. Continued use of these scales in its original format,
or using the item-level interpretation approach, may be problematic. Thus, future research is needed to rigorously examine the psychometric properties of these scales.

Most developed countries are experiencing a rapid expansion of the older driver cohort. To date, there has been scant research on older drivers’ practice of self-regulation in a cross-cultural context. Self-regulation may be a more commonly used driving strategy in countries that frequently experience prohibitive driving conditions (e.g. heavy snow, rarely experienced in Australia). Thus, more research on the self-regulatory driving behaviours of other drivers, in a cross-cultural context, may be required. Additional investigation is also needed to examine the application of the MOTRS model in a cross-cultural context.

Finally, while the MOTRS model was specifically developed to predict older adults’ use of driving-related self-regulation, the practice of self-imposed restrictions from high-risk situations could also be adopted and potentially applied to other road user groups, in other road-risk circumstances (e.g. acute change in road conditions such as roadworks or flooding) and in other injury prevention areas where risky activities may be involved (e.g. falls, drinking-related activities). Hence, further research is needed to investigate the relevance of the MOTRS model to understanding these domains.

9.8. Concluding comments

The present study is the first to simultaneously and systematically examine a range of Socio-demographic, Driving-specific and Psychosocial variables on older adults’ practice of driving self-regulation. An additional focus of the current study was to examine the actual driving behaviours and performance of older drivers to investigate the actual self-regulatory driving practice of this cohort.

The current findings are important in three ways. First, through systematically reviewing the current literature and prominent health behaviours models, a theoretical framework that incorporated the relevant assumptions and variables that underlie older drivers’ self-regulation was developed. The proposed Multilevel Older Person’s Transportation and Road Safety (MOTRS) model was formally tested, then cross-validated using an independent sample of older drivers. Findings from both the formal testing (Study Two) and the cross-validation process (Study Three) provided
encouraging support for major predictions of the model. Further work is required to explore in greater detail the psychosocial factors that underlie older drivers’ self-regulation, and whether the predictions of the MOTRS model can be applied to drivers across other contexts.

Second, the present research program demonstrated the important influence of psychosocial factors on older adults’ driving self-regulation. This finding provided significant contribution to the current body of knowledge, as well as important practical implications for future intervention programs that aim to improve older driver safety.

Finally, the current research demonstrated general agreement between older drivers’ self-report self-regulation and objectively measured driving behaviours, and that drivers with less (overall) driving exposure also recorded less acceleration-related events. Taken together, these findings provided encouraging support for the use of self-regulation. However, future longitudinal studies are required to determine the causality of these variables.

The current research program developed a theoretical framework to understand older adults’ practice of driving self-regulation. Encouraging empirical support was obtained for the proposed MOTRS model, as well as the potential effectiveness of self-regulation as a compensatory strategy to extend the safety and mobility of older individuals. This program of research has provided new insights into the driving behaviours of older drivers. Older individuals have made significant contributions to society over the course of their lives. It is hoped that the new knowledge contained in this work will contribute to maintaining the health and well being of older individuals within our society.
10. References


Allan, D.E., McGee, P.D. (2003). *Accessible transportation for all in the capital regional district: where are we now, where should we be going?* Retrieved 28 November 2005, from the University of Victoria, Centre on Aging Web site: [http://www.coag.uvic.ca/research reports.htm](http://www.coag.uvic.ca/research reports.htm).


48,167–171.


Department of Infrastructure, Energy and Resources (2011). *The alternative older driver licensing system for Tasmania: Final report*.


Dulisse, B. (1997). Older drivers and risk to other road users. Accident Analysis and Prevention, 29, 573-582.


Association for the Advancement of Automotive Medicine Course on the 
Biomechanics of Impact Trauma, Los Angeles, USA.

MacLean, A. W., Davies, D. R., Thiele, K. (2003). The hazards and preventin of 
driving while sleepy. Sleep Medicine Reviews, 7, 507-521.

Systematic review of driving risk and the efficacy of compensatory strategies 
in persons with dementia. Journal of the American Geriatrics Society, 55, 
878-884.

Risk factors of motor vehicle crashes in older men. Journals of Gerontology 
Series A, Biological Sciences and Medical Sciences, 57, M186-191.

Association of traffic sign recognition with other measures of cognitive 
function in a cohort of older drivers. Journal of the American Geriatrics 
Society, 53, S83-S83.

Marottoli, R., Mendes de Leon, C., Glass, T., Williams, C., Cooney, L., Berkman, L., 
& Tinetti, M. (1997). Driving cessation and increased depressive symptoms: 
prospective evidence from the New Haven EPESE. Journal of the American 
Geriatrics Society, 45, 202-206.

Marottoli, R.A., Mendes de Leon, C.F., Glass, T.A., Williams, C.S., Cooney Jr., L.M. 
& Berkman, L.F. (2000) Consequences of driving cessation: decreased out-of-
home activity levels. Journals of Gerontology Series B - Psychological 
Sciences and Social Sciences, 55, S334-S340

Marottoli, R. A. Mendes de Leon, C. F., Glass, T. A., Williams, C. S., Cooney, L. M., 
Jr., Berkman, L. F., et al. (2007). Driving cessation and increased depressive 
symptoms: prospective evidence from the New Haven EPESE. Established 
Populations for Epidemiologic Studies of the Elderly. Journal of the American 
Geriatrics Society, 45, 202-206.

Marottoli, R., & Richardson, E. (1998). Confidence in, and self-rating of, driving 
ability among older drivers. Accident Analysis and Prevention, 30, 331-336.

on hypothesis testing approaches to setting cut-off values for fit indexes and 
dangers in overgeneralizing Hu and Bentler’s (1999) Findings. Structural 
Equation Modelling, 11, 320-341.


Oxley, J., & Fildes, B. (2004). Retiring from driving: The process of reduction and cessation of driving and the role of a handbook to assist in this process. *Monograph 1, Road Safety Issues for Older Road Users*. Selection of papers from the Older Road User Safety Symposium, 26 November, Brisbane, Australia. Centre for Accident Research and Road Safety, Queensland.


Appendix A: Questionnaire for Study Two and Three
Questionnaire Booklet

This questionnaire booklet contains questions about you and your driving practices. Please write or select the answer most suitable to you. Please complete as many questions as possible and that there are no right or wrong answers.

1. Gender  □ Male  □ Female
2. Age ________ (years)
3. Postcode __________

4. Current employment status
   □ Full-time
   □ Part-time
   □ Retired
   □ Not currently employed but some voluntary work
   □ Not currently employed and no voluntary work

5. What is your average household income in relation to everyday needs?
   □ Very sufficient
   □ Sufficient
   □ Just sufficient
   □ Insufficient
   □ Very insufficient

6. How confident are you that your income will be able to meet your everyday needs in the future?
   □ Very confident
   □ Moderately confident
   □ Neutral
   □ Moderately unconfident
   □ Very unconfident

7. a. Do you hold a current Queensland Driver’s Licence?
   □ Yes  □ No

   7b. If NO, please give details of any driving licence you hold: __________________________

8. Are you a current driver?
   □ Yes  □ No

9. How many years have you had your open drivers’ licence? ____________ (years)

10. Have you had advanced driving training?
    □ Yes (please specify __________________________)  □ No

11. Where do you generally drive?
    □ City  □ Rural
    □ Suburb  □ Varies
12. Over the last 3 years, approximately how many hours per week do you estimate you would drive? ________________ hours per week

13. How do you prefer to get around?
   - Drive yourself
   - Have someone drive you
   - Use public transportation or a taxi

14. In general, how would you rate your health?
   - Excellent
   - Very good
   - Fair
   - Poor
   - Very poor

15. Have you ever experienced any of the following medical conditions?
   (You can tick more than one)
   - Eye condition (cataracts, glaucoma, or macular degeneration)
   - Stroke
   - Arthritis (including stiffness or joint pain severe enough to interfere with daily activities)
   - Heart condition  (please specify _____________________________)
   - Heart attack   (please specify _____________________________)
   - Neurological condition (e.g. Parkinson’s disease)
     (please specify _____________________________)

16. If you ticked any of the above conditions, do you think this condition(s) affects your driving ability?
   - Yes
   - No

17. a. Did a doctor provide advice relating to the potential effects of the condition on driving?
   - Yes
   - No

   b. Did you adapt your driving behaviour due to this condition?
      - Yes  (please specify _____________________________)
      - No

18. How fast do you usually drive compared to the general flow of traffic? Would you say:
   - Much faster
   - Somewhat faster
   - About the same
   - Somewhat slower
   - Much slower
19. How would you rate the quality of your driving? Would you say:

- Excellent
- Good
- Average
- Fair
- Poor

20. Please rate from 1 (Strongly Disagree) to 5 (Strongly Agree) for the following statements.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driving a vehicle is pleasurable</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I am experiencing increasing apprehension about driving</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I am becoming more concerned about the unsafe behaviour of other drivers</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Being able to drive is important to me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Driving is necessary to my life to give me the flexibility I desire</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Driving is central to my independence</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Some people think I should stop driving</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>People close to me disapprove of my driving</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>My friends drive their vehicles regularly</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The physical demands of driving a vehicle (e.g. turning my head to shoulder check) are becoming a challenge</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>The financial cost of driving and maintaining a vehicle is an increasing concern of mine</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Parking is becoming more difficult for me</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I plan to continue driving in the foreseeable future</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I intend to keep driving when I want to in the near future</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
21. How confident are you in your ability to drive under the following conditions?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>At night in the rain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>In the rain</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>When alone</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>With passengers (adult)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>With passengers (children)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Parallel parking</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Familiar Roads</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Unfamiliar Roads</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Freeways</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>High traffic roads</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Peak hour</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>At the start/end of school times</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>At night</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Roadworks</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Long distance driving</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Lane changes</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Right turns</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Other people’s car</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>In foggy conditions</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Tunnels</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Roundabouts</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
22. During the past year, how often did you drive to the following places?

<table>
<thead>
<tr>
<th>Location</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>Immediate neighbourhood (within 10km from home)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Places beyond your neighbourhood (within 40km from home)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neighbouring cities (within 100km from home)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>More distant cities (within 500km from home)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside the state</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

23. To what extent do you avoid driving under the following conditions?

<table>
<thead>
<tr>
<th>Condition</th>
<th>Never</th>
<th>Rarely</th>
<th>Sometimes</th>
<th>Often</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>At night in the rain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In the rain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>When alone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With passengers (adult)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With passengers (children)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parallel parking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Familiar Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unfamiliar Roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freeways</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High traffic roads</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At the start/end of school times</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At night</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roadworks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long distance driving</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lane changes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right turns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other people’s car</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In foggy conditions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tunnels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roundabouts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
24. The circle below represents the face of a clock.
   1. Please put in the numbers so that it looks like a clock.
   2. Then add arms so that the clock indicates the time “ten minutes after eleven”.

![Clock Diagram]

25. Please consider all the places you drive in a typical week. Select the places that you frequently drive to. (you can tick more than one)
   - Grocery store
   - Church
   - Work
   - Relative's House
   - Friend's House
   - Out to eat
   - Appointments (e.g., doctor, hair)
   - Shopping centre

26. Are there any other places you go in a typical week?
   - Yes  (please specify____________________________________)
   - No

27. If you had to go somewhere and didn't want to drive yourself. Would you:
   - Drive yourself regardless of how you feel
   - Ask a friend or relative to drive you
   - Call a taxi or take the bus
   - Cancel or postpone your plans and stay home
   - Other (specify): ________________________________________
28. How often do you pass up opportunities (e.g. go shopping or visit friends) due to driving-related concerns?

- Not at all
- Not often
- Reasonably often
- Very often
- All the time

29. a. Over the past year, have you regularly travelled by car with a friend or family member?

- Yes
- No

29 b. If yes, who was that person? ________________________________

29 c. Who was driving? ________________________________

30. How often do you use alternative transport (e.g. buses, trains) in your area?

- Not at all
- Not often
- Reasonably often
- Very often
- All the time

31. How do you rate the alternative transport other than your own vehicle available in your area?

- Excellent
- Good
- Average
- Fair
- Poor

32. How do you think alternative transport in your area can be improved?

- Number of stops
- Lighting
- Ease of use (e.g. boarding a bus)
- Frequency of routes
- Other (please specify: ________________________________)

33. a. Has anyone suggested over the past year that you should limit your driving or stop driving?

- Yes
- No

33b. If yes, who made this suggestion? (Please tick all that apply)

- Medical professional (e.g. Doctor)
- Family member (please specify relationship__________________________)
- Friend
- Other (please specify__________________________)
33c. What did you do in response to their suggestion?

- Ignored it
- Made own assessment of ability and decided no action was required
- Restricted my driving (please specify) ________________________________
- Other (please specify) ________________________________

34. If anyone ever suggested to you to stop or restrict your driving, how do you think you would respond to such a suggestion?

- Ignore it
- Make an assessment of my ability and make my own decision
- Restrict my driving (please specify) ________________________________
- Stop driving
- Other (please specify) ________________________________

35. Whose suggestion regarding change in driving status would you most likely to listen to?

- Family member
- Partner
- Medical Practitioner
- Friend
- Person of authority (e.g. police)
- Other (please specify) ________________________________

36. a. Do you have any health-related conditions (diagnosed or undiagnosed) that might affect your driving ability?

- Yes (please specify______________________)  
- No

36b. How concerned are you that this health-related condition(s) might affect your quality of life?

- Not at all concerned
- Slightly concerned
- Somewhat concerned
- Moderately concerned
- Extremely concerned

36c. How concerned are you that this condition(s) might affect your driving performance?

- Not at all concerned
- Slightly concerned
- Somewhat concerned
- Moderately concerned
- Extremely concerned

36d. How concerned are you that seeking diagnoses or treatment will have an impact on the renewal of your driver license?

- Not at all concerned
- Slightly concerned
- Somewhat concerned
- Moderately concerned
- Extremely concerned
36e. To what extent does this concern prevent you from seeking diagnoses or treatment?
- Never
- Rarely
- Occasionally
- A moderate amount
- A great deal

36f. Have you ever hidden symptoms from your doctor because you were worried about losing your licence?
- Yes
- No

37. Do you think there is a need for information sessions targeted for older drivers?
- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

38. What kind of information would you like to be included in these sessions?
(You can select more than one)
- Driver licence renewal procedures for older drivers
- Alternative transportation options in your area
- Age-related bodily changes and their implications for driving
- Strategies to cope with these changes
- Diagnoses and treatment options
- Other (please specify ______________________________)

39. How likely is it that you would attend these information sessions?
- Very likely
- Likely
- Neutral
- Unlikely
- Very unlikely

40. How would you like such information sessions to be delivered?
(You can select more than one)
- Internet modules
- In groups
- Mail-out materials
- Other (specify): ______________________________

Thank you very much for your participation in this study 😊
Appendix B: Participant Information Sheet for Study Three
### Description

This study is designed to give us a better idea of the driving practices of older Australian drivers. We want to find out more about travel speeds, driving purposes, motivation to drive, driving behaviours and patterns as well as factors such as sleep times and medication use. This study will contribute to our understanding of the needs of drivers aged 65 years or over.

### Participation

If you take part in this study, you will be asked to 1) complete a questionnaire which should take about 10 minutes, 2) drive with a GPS and accelerometer (i.e. devices that measure trip details) within your vehicle for 2 weeks, as well as 3) complete driving related information in the driving diary provided, and 4) wear an actigraphy, which is a simple watch band to measure your sleep times, for the 2 week period. These devices are compact in size and non-invasive.

1) The initial questionnaire will ask for your driving practices, as well as your interests, general health and well-being.

2) You will also be asked to complete your usual driving trips, in a way that you would normally drive. You will be asked to record all your driving trips in these 2 weeks using the accelerometer and GPS provided by the research team and track every driving trip you take using these devices (which records speed, time, distance and vehicle acceleration and deceleration). To protect your privacy, the nature of the driving locations will NOT be recorded.

3) Using a driving diary provided by the research team, you will also be asked to record driving related information after each driving trip for the 2 week testing period. You are also encouraged to make note about anything that might have affected your driving performance. You will only be required to keep a diary

4) You will also be asked to wear an actigraphy wristwatch for the 2 week testing period. This wristwatch will provide an indication of your sleep and wake times.

To assist installing the devices onto your vehicle, the research team require you to attend an installation session. This session should take no more than 45 minutes. In this session, you will be asked to complete the initial questionnaire. We will also install the GPS and accelerometer onto your vehicle, as well as explaining the use of the driving diary and actigraphy wristwatch. If travelling to the research team is impractical, it is possible for a research team member to travel to you for the session.
While you are requested to record all trips, please be advised of the following. Note that we have no interest in your individual driving performance and related information. As an individual, we are only interested in group results. Your driving record (including your current license) will not be affected by your participation in this research. There is no way in which your driving status can be affected by taking part in this study. All responses are completely anonymous and will be treated confidentially. Also, if you are involved in an accident, you are within your rights to withhold the data collected during the event from the researchers. If you withdraw at any time during the project without penalty, your decision to participate will in no way impact upon your current or future relationship with QUT or CARRS Q.!

Expected benefits

It is expected that this research will benefit you, the wider older drivers community, and the general public. Information gathered can help develop strategies to improve older drivers' safety and convenience through appropriate infrastructure and education.!

Risks

There are some potential risks associated with your participation. These are potential time loss (e.g., completing the driving diary) and potential inconvenience due to the travel required to have the devices installed in your vehicle. However, these risks are not beyond the risks associated with normal day-to-day living.!

And you are asked to only undertake activities you would normally do, at a level of risk you feel personally comfortable with.!

Confidentiality

All comments and responses are anonymous and will be treated confidentially. Names of individual persons are not required in any of the responses.!

Consent to Participate

We would like to ask you to sign the enclosed consent form to confirm your agreement to participate. If you can withdraw at any time of the study, you will have to send the equipment back to the research team upon withdrawal. A padded pre-stamped envelope will be provided to return the equipment.!

Questions (Further information about the project)

Please contact the research team members named above to have any questions answered or if you would like further information about the project.!

Concerns (Complaints regarding the conduct of the project)

QUT is committed to researcher integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project, you may contact the QUT Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au. The research ethics Unit is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.

Thank you for helping with his research project. Please keep this sheet for your information.
CONSENT FORM for QUT RESEARCH PROJECT

“Sustaining Safe Driving Among Older Drivers”

Research Team Contacts

<table>
<thead>
<tr>
<th>Centre for Accident Research and Road Safety–Queensland (CARRS-Q)</th>
<th>Griffith University</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ms Ides Wong (PhD Scholar)</td>
<td>Dr Kirsteen Titchener</td>
</tr>
<tr>
<td>07-3138 7698</td>
<td>(Associate Supervisor)</td>
</tr>
<tr>
<td><a href="mailto:ides.wong@qut.edu.au">ides.wong@qut.edu.au</a></td>
<td>07-3138 4660</td>
</tr>
<tr>
<td>Dr Simon Smith (Supervisor)</td>
<td>Dr Patricia Obst</td>
</tr>
<tr>
<td>07-3138 4908</td>
<td>(Associate Supervisor)</td>
</tr>
<tr>
<td><a href="mailto:simon.smith@qut.edu.au">simon.smith@qut.edu.au</a></td>
<td>07-3138 4660</td>
</tr>
<tr>
<td>Dr Patricia Obst</td>
<td><a href="mailto:p.obst@qut.edu.au">p.obst@qut.edu.au</a></td>
</tr>
</tbody>
</table>

Statement of consent

By signing below, you are indicating that you:

• have read and understood the information document regarding this project
• have had any questions answered to your satisfaction
• understand that if you have any additional questions you can contact the research team
• understand that you are free to withdraw at any time, without comment or penalty
• understand that you can contact the Research Ethics Unit on 3138 5123 or email ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project
• agree to participate in the project

Name

Signature

Date

Please return this sheet to the investigator.
Appendix C: Recruitment Flyer for Study Three

Participants Sought For OLDER DRIVER Study

University of Canberra is seeking Australian Drivers aged 65 years or over to take part in a driving study. All participants will get a $50.00 shopping voucher. To participate, you must be a current driver aged 65 years or over.

This project looks at the driving practices of older Australian drivers. First, you will be asked to complete a basic ‘about you’ questionnaire. Then, the researcher will meet you to set up a vibration sensor and GPS in your car to measure driving times and distance. You will then drive for 2 weeks with these devices in your vehicle. In these 2 weeks, you will also be asked to wear a wristwatch to measure sleep times and complete a driving diary.

Your participation will involve you completing a mail-out questionnaire, and attending one installation session (about 30 minutes). In this session, the researcher will install the device and demonstrate the use of the devices and the driving diary, as well as answer any queries you might have about the project.

Your responses will remain completely confidential and anonymous. The names of individual persons are not required in any of the responses. Your driving record (including your license) will not be affected by your participation in this project.

TO REGISTER YOUR INTEREST IN PARTICIPATING
PLEASE CONTACT Mrs Louise Deeks on 6201 2369 or louise.deeks@canberra.edu.au
Appendix D: Except of Driving Diary for Study Three
Driving Diary

Please record all your driving trips for the following 2 weeks. If you have any queries, please contact Mrs Louise Deeks on (02) 6201 2369 or louise.deeks@canberra.edu.au

Reference Code: ________________________ km
Getting Started

Thank you for taking part in the study. Your participant will help us improve the current understanding of the experience and needs of older drivers. This knowledge may lead to new programs and infrastructure that aims to enhance driver safety and convenience of Older Australian drivers.

By now, you should have completed the questionnaire, and have a 1) Driving Diary, 2) a GPD trackstick, 3) an accelerometer fitted onto your vehicle, as well as 4) a waterproof actigraphy watch. The information provided by these devices is non-identifiable, completely confidential and anonymous. Your driving record will NOT be affected by your participation in this project. Please don’t hesitate to contact us if you have any queries at any point of the study.

Please drive as you normally would for the following 2 weeks, and record each of your driving trips in this driving diary.

Use a pen or pencil to ‘colour in’ all the times that you drove a car, and write down where and why you made the trip. Please also rate your driving performance of your trips underneath (1= not at all, up to 9= very well).

*See following page for example* -
1. Please fill out the driving diary every day. Use a pen or pencil to ‘colour in’ all the times that you drove a car, and write down where and why you made the trip. Please also rate your driving performance of your trips underneath (1= very poor, up to 9= very well).

<table>
<thead>
<tr>
<th>Time</th>
<th>Morning (AM)</th>
<th>Afternoon (PM)</th>
<th>Night (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Location and Purpose of Driving trips</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1 home-work (go to work)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2. work-GP- work (GP appointment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3. work-shops-home (Get dinner and go home)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. Please write down the any accidents or near misses that you had during the day.

*For example* - By driving incidents we mean things like: Falling asleep while driving, losing control because of inattention, failing to give way, swerving to miss an animal or cyclist, any crashes, minor bumps and scrapes while parking, failing to see a school zone or other speed restrictions, hard braking to avoid a collision, and so on.

Don’t worry if you make a mistake, there are a few spares at the back of the booklet that you can use.
1. What is the day **today**?

<table>
<thead>
<tr>
<th>Morning (AM)</th>
<th>Afternoon (PM)</th>
<th>Night (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6</td>
<td>7</td>
</tr>
</tbody>
</table>

**Driving Performance**

**Location and Purpose of Driving trips**

INCIDENTS?

2 Please list the following details for any incidents while driving:

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>Time of Day?</th>
<th>Details of incident?</th>
<th>How sleepy were you (1 not at all-9 very sleepy)?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. What is the day **today**? ________________________________

<table>
<thead>
<tr>
<th>Location and Purpose of Driving trips</th>
<th>Morning (AM)</th>
<th>Afternoon (PM)</th>
<th>Night (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driving Performance</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

INCIDENTS?

2. Please list the following details for any incidents while driving:

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>Time of Day?</th>
<th>Details of incident?</th>
<th>How sleepy were you (1 not at all-9 very sleepy)?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1. What is the day today? _____________________________________________________________________

<table>
<thead>
<tr>
<th>Morning (AM)</th>
<th>Afternoon (PM)</th>
<th>Night (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>5  6  7  8  9  10 11 12</td>
<td>1  2  3  4  5  6  7  8  9  10 11 12</td>
</tr>
</tbody>
</table>

Location and Purpose of Driving trips

Driving Performance

INCIDENTS?

2. Please list the following details for any incidents while driving:

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>Time of Day?</th>
<th>Details of incident?</th>
<th>How sleepy were you (1 not at all-9 very sleepy)?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Thank you for taking your time to help us. You have already completed 1 week of driving diary. That is, you are already half way through the study. Please continue to drive as you normally would and record your trips for another week.
What is the day today? ________________________________

<table>
<thead>
<tr>
<th>Morning (AM)</th>
<th>Afternoon (PM)</th>
<th>Night (PM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>Time</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
</table>

**Location and Purpose of Driving trips**

**Driving Performance**

### INCIDENTS?

2 Please list the following details for any incidents while driving:

<table>
<thead>
<tr>
<th>Type of Incident</th>
<th>Time of Day?</th>
<th>Details of incident?</th>
<th>How sleepy were you (1not at all-9 very sleepy)?</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
If you have already completed 14 days of driving (regardless of whether you’ve completed the diary), please contact Mrs Louise Deeks on (02) 6201 2369 or louise.deeks@canberra.edu.au to return the equipment and collect your incentives.

Thank you again for taking part in the study. Your time and effort is very much appreciated by the research team.
Appendix E: Checklist for Equipment Fitting Sessions (Study Three)

Checklist for participant's package (prior to participants’ arrival)

Accelerometer
- New (charged) batteries for accelerometer
- Check data space for accelerometer
- Electronically code next participant for data matching
- Magnetic Mount

Trackstick
- If using mini-trackstick, make sure it is charged
- Check data space for GPS trackstick
- Electronically code next participant for data matching
- 3M tape/suction mount

Actigraphy watch
- Check actigraphy watch is charged and have data space
- Electronically code next participant for data matching

Paper materials
- Print Questionnaire package
- Put the code on the questionnaire for data matching
- Provide participants with contact details
- Small box of chocolate?
- Put in a package to prepare for participants’ arrival
- Put the participant’s code on top of the bag

Upon participants’ arrival

- Take prepped questionnaire package, log the equipment as ‘out’
- Develop rapport, did you find the place ok? How was your morning/afternoon? Compliment on the house if visiting them. How did you hear about the project? Thank them for taking their time to help us with the study
- Give them a small box of chocolate
- Brief them with the project details. Don’t read the PIS to them (they can read themselves). Only brief important information: study aims, confidentiality, what participation involves.
- Emphasis confidentiality. We are not interested in individual details, nor anyone’s driving performance. This is about looking at their driving patterns and habits. Not about whether they are good drivers. As soon as we get the data, we de-identify them so it cannot be traced back to the individual.
Ask them if they have any questions about the study, take time to answer their questions
Briefly explain the equipment and what they are used for this study
Actigraphy: sleep and light exposure patterns
GPS: the driving locations, not where they go, mention that we won’t be able to know where exactly they go, but how far they travel away from home/city; time of day they drive, and driving duration
Accelerometer: since GPS has warm up times, this helps us to improve the data in case they drive into dense building area. Also this give use basic information about breaking, so whether its urban driving
Driving Diary: These equipment are fairly new technology, so a driving diary just in case.
Questionnaire: various information such as how long they've been driving, if they've any health conditions etc. Again, mention confidentiality. Emphasise that you will NOT peek until it has been de-identified and all you'll know is that it comes from 51343, or 68940 etc
Any questions.
Fill in questionnaire while you put things into their car.
Give them a card with your contact details
Appendix F: Sub-study on the Relationship between Cognitive Impairment and Self-regulation
Due to copyright restrictions, the published version of this journal article is not available here. Please view the published version online at:

http://dx.doi.org/10.1016/j.aap.2012.05.031