MONASH University
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Self-Regulatory Driving Practices by Older Adults

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Dedication

This thesis is dedicated to the memory of my beloved mother, Miriam E. Levin (March 27, 1925-January 23, 1971) and father Jordan H. Levin (November 22, 1920-February 5, 1985). Although neither of them lived long enough to reach older adulthood, it is the life lessons they imparted that are responsible for the person I have become and the contributions I have made in the field of older adult safety and mobility. My parents were first generation Americans whose parents fled anti-Semitic persecution in Eastern Europe. My father taught me to work hard, take pride in everything I do, and be the best that I can be. My mother encouraged me to find work that was interesting and meaningful. She taught me the importance of giving back to society and pushing myself to take on new experiences and challenges. My parents' own lives exemplified these values and provide a model of not only how to age but also how to live.

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Thesis Summary

Self-regulation of driving shows promise as a strategy by which older drivers can compensate for declines in driving-related abilities and extend the time period over which they can safely drive. Self-regulation is generally described as the process of modifying one's driving by driving less or intentionally avoiding specific driving situations considered to be challenging. Research undertaken in this thesis was intended to generate new knowledge about the process of self-regulation by older drivers at multiple levels of driver performance and decision making. Of special interest was how various individual, social, and environmental factors influence this process. Both self-report and objectively derived data on health, functioning, and driving from a sample of older drivers in the greater Melbourne area of Victoria, Australia were collected and analyzed to explore the nature and extent of self-regulation, the influence of selected factors on self-regulation, and the correspondence between self-reports of self-regulatory practices and objective driving patterns and behaviors.

Three levels of driver behavior and decision making were included in the framework for examining self-regulation: tactical; strategic; and life-goal. Tactical self-regulation has to do with actual maneuvers made in traffic in response to conditions in the driving environment (e.g., reducing distractions while driving such as chatting with passengers, leaving more distance between one's car and the car ahead). Strategic self-regulation has to do largely with pre-trip decisions about the circumstances under which to drive or not to drive (e.g., avoiding night driving or other situations considered challenging, reducing driving overall). Life-goal self-regulation has to do with drivers' broader decisions in life that affect driving such as where to live in relation to the destinations one frequents or what kind of car to drive, with safety often being an important consideration in the vehicle purchase decision.

Findings from the research provide valuable insights into the self-regulatory process among older adults. First, not all reported avoidance of driving or other driving modifications can be construed as self-regulation. Drivers report many reasons for modifying their driving, only some of which relate to what is commonly considered self-regulation. Reasons for reported driving avoidance or other practices were often more closely related to lifestyle or preferences than to

self-regulation. Thus, to better understand self-regulation among older adults, it is important to understand the reasons that people have for avoiding driving situations or engaging in other practices.

Second, self-regulation is clearly a multi-dimensional concept, and one that is tied to specific driving situations, as well as level of decision making. The research also indicated that reported strategic and tactical self-regulation are influenced by different sets of individual, social, and environmental factors. Strategic self-regulation was related to participants' gender, self-perceived abilities and functioning, feelings of comfort and safety, whether they had family or friends available to drive them, and two clinical measures of functioning (the Rapid Pace Walk and the MVPT-3). Factors found to be associated with tactical self-regulation were age, self-perceived abilities, and contrast sensitivity (as measured by the Pelli-Robson contrast sensitivity test).

Third, despite the relative infrequency of reported life-goal self-regulation, this level warrants further research because of the opportunity that life-goal decisions afford for enhancing older adult safety and mobility. For example, although the trend of aging in place is firmly entrenched among many older adults, there may be opportunities to create more livable communities with more accessible housing options to foster continued mobility. Similarly, efforts to make vehicles safer and more accessible for older adults, as well as to better educate older consumers about the safety features in vehicles, are increasingly being recognized as an important part of a multi-faceted approach to keeping older adults safely mobile.

Fourth, the exploratory comparisons between objective measures of driving and drivers' self-reports suggested that there was correspondence, although modest, between some objective driving measures and their comparable self-reported measures, but a lack of correspondence for others. There may be a role for self-reports in providing a context for understanding and helping interpret naturalistic driving data with regard to some self-regulatory driving practices. However, the discrepancies found between self-reported and objective measures of more general driving exposure raise concerns because of the critical role that accurate measures play in understanding crash risk.

Continuing efforts to better understand the self-regulatory practices of older drivers at the tactical, strategic, and life-goal levels should provide additional insights into how the transition from driving to non-driving can be better managed to balance the interdependent needs of public safety and personal mobility.

General Declaration

In accordance with Monash University Doctorate Regulation 17 Doctor of Philosophy and Research Master's regulations the following declarations are made:

I hereby declare that this thesis contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

This thesis includes four original papers, which at the time of examination, were all submitted and either under review in peer reviewed journals or returned for revision. Subsequent to submitting the thesis for examination, all four of the papers were peer reviewed, revised, and accepted for publication. At the time of printing of this thesis, two of the papers are published (Molnar, Charlton, Eby, Bogard, Langford, Koppel, Kolenic, Marshall & Man-Son-Hing, 2013; Molnar, Eby, Charlton, Langford, Koppel, Marshall & Man-Son-Hing, 2013), one is available on-line as an uncorrected proof (Molnar, Eby, Langford, Charlton, St. Louis & Roberts, 2013), and one is in press (Molnar, Charlton, Eby, Langford, Koppel, Kolenic & Marshall, in press).

The core theme of the thesis is the self-regulatory driving practices of older adults. The ideas, development and writing up of all the papers in the thesis were the principal responsibility of myself, the candidate, working within the Monash University Accident Research Centre under the supervision of Judith L. Charlton.

[The inclusion of co-authors reflects the fact that the work came from active collaboration between researchers and acknowledges input into team-based research.]

In the case of Chapters 4, 6, 7, and 8, my contribution to the work involved the following:

Thesis chapter	Publication title	Publication status at time of examination
4	Tactical, Strategic, and Life-Goal Self-Regulation of Driving by Older Adults: Development and Testing of a Questionnaire	Returned for revision
6	Driving Avoidance by Older Adults: Is It Always Self-Regulation?	Submitted and under review
7	Self-Regulatory Driving Practices among Older Adults: The Effects of Individual, Social, and Environmental Factors	Submitted and under review
8	Self-Regulation of Driving by Older Adults: Comparison of Self-Report and Objective Driving Data	Submitted and under review

The nature and extent of the candidate's contribution are as stated in the Author's declaration page included in each chapter. The sections of submitted papers have been renumbered to generate a consistent presentation within the thesis.

Signed:

Date: 12 June, 2013

Acknowledgments

I want to acknowledge a number of people, without whose support I could not have completed this thesis research. On a professional level, I especially thank Dr. Judith Charlton, my main supervisor from Monash University Accident Research Centre (MUARC) and Dr. David W. Eby, my University of Michigan Transportation Research Institute (UMTRI) supervisor. Both have been mentors with keen vision, who always provided constructive guidance and oversight. The special bond and friendship developed during this process will remain always. I also thank my co-authors on the thesis papers. Their contributions have been invaluable and it was pleasure to be able to work with such esteemed and knowledgeable colleagues. I was fortunate to have support and encouragement from two world-class research institutions – MUARC and UMTRI. Thank you to all my colleagues at these institutions who helped me in so many ways, particularly my fellow members of the UMTRI Behavioral Sciences Group who were always there for me.

On a personal level, I am indebted to my family – my husband Larry, my daughter Kallen, my son Jordan, and our household canines and felines – who have encouraged, supported, and comforted me throughout the past 4 years. They rarely complained when I was distracted or unavailable for them, making the challenge of balancing being a wife and mother, a fulltime researcher, and a part-time student more manageable. Jordan, in particular, is looking forward to some home-cooked meals and a cleaner house now that I will have more time on my hands. I thank my lovely daughter Kallen for taking me to yoga regularly to keep me sane. I am also very fortunate to have several circles of friends including my walking group, book group, and bridge group, who have been generous in their support and enthusiasm throughout this process. I want to especially acknowledge Liz, Judi, and Esther for their enduring friendship and abiding interest in the work that I do.

I also want to acknowledge the poet, singer, and songwriter Leonard Cohen for the role he has played in my life, especially during this time. He has inspired me and calmed me when I felt overwhelmed, although I have never had the privilege of actually meeting him. He, like my good friend and neighbor June Anderson, whose unwavering belief in me has meant so much, epitomize what it means to age with grace and dignity.

Chapter 1: Introduction

1.1 Aging trends

The aging of the population in the United States (US), Australia, and other countries around the world has brought increased attention to the issues of older driver safety and mobility (Transportation Research Board, 2004). This is due in large part to the sheer numbers of older drivers expected on the road in the future. The world's population, which surpassed 7 billion in 2011, is older today than at any other time in history and continues to age (United Nations Population Fund, UNFPA, 2011). Worldwide, the proportion of adults age 60 and older is projected reach 22 percent by 2050, up from 11 percent in 2009 (United Nations, 2009). Projections are even greater for more developed countries where by 2050, one-third of each country's population will be age 60 and older. In many of these countries, including the US and Australia, the aging of the population is being driven by the aging of the post-World War II baby boomers who began turning age 65 in 2011 (Molnar & Eby, 2009). By 2050 for example, the number of people age 65 and over in the US is expected to reach 88 million, comprising over 20 percent of the population (US Census Bureau, 2008). Still larger increases are expected for the oldest-old in the US – those age 85 and older, who are expected to grow from about 5.8 million in 2010 to 19.0 million in 2050, when they will account for 4.3% of the population (U.S. Census Bureau, 2008). Similar increases are expected for many other developed countries. For example, the proportion of people age 65 and over in Australia is expected to reach 23-25 percent by 2056, up from 13 percent in 2006 (Australian Bureau of Statistics, 2010).

1.2 Driver licensure and driving trends among older adults

The aging of the population has been accompanied by trends of increased licensure and increased driving among older adults in the US and elsewhere. In the US, more than 90 percent of men over age 65 and 80 percent of women in this age group are estimated to hold a driver license (Federal Highway Administration, 2008). For older women in particular, this reflects a substantial increase over the past decade. This trend is also evident globally. For example, a recent study of changes in the age composition of drivers in 15 countries found that the percentage of older adults holding driver licenses in each country had increased over the past few decades, some quite substantially (Sivak & Schoettle, 2011). Projections suggest that post World

War II baby boomers will retain their licenses past age 65 at rates approaching 100 percent in the Western World (Department for Transport, 2001; OECD, 2001).

Increases in license holding among older adults have also translated into increased driving. Older adults today drive more and longer into old age (Rosenbloom, 2001) and this trend is expected to continue with the aging of the baby boomers. In the US, the average number of trips per day per adult over age 65 increased from 2.4 in 1990 to 3.2 in 2009 (Santos, McGuckin, Nakamoto, Gray & Liss, 2011). Older drivers also appear to be traveling longer distances than in the past, although this trend may be changing. For example, based on estimates from the National Household Travel Survey (NHTS), the average daily number of miles traveled by adults over age 65 in the US increased from 18.4 in 1990 to 24.0 in 2009 (Santos et al., 2011). However, similar comparisons in a shorter more recent time frame, using 2001 and 2009 NHTS data, indicated that the average daily number of miles traveled decreased for both older drivers and drivers of all ages (Santos et al., 2011). This recent downward trend may have been influenced by the increasing cost of fuel or could be due to an income saturation effect, whereby increasing income no longer translates into more driving at the high end of the income scale.

The longer-term trend of increased driving among older adults has also been observed in countries outside the US, although published data are more limited. A study by Buehler and Nobis (2010) found that among German drivers age 65 or older, daily travel distance increased from 10 to 15 km between 1982 and 2002, while percentage of trips by personal automobile increased from 28 percent to 47 percent during the same period. Data from the New Zealand Household Travel Survey (see http://www.transport.govt.nz/research/TravelSurvey/) indicate that daily travel distance among drivers age 65-74 increased from about 15 km in 1989/90 to over 20 km in 2008-2011, and among drivers age 75 and older from about 8 km to about 12 km during that same period. On a more global scale, the International Transport Forum (ITF) of the Organisation for Economic Co-operation and Development (OECD) has predicted that car ownership and travel will increase rapidly in many non-OECD countries such as China, Brazil, and India (ITF, 2011). This trend reflects a growing preference for automobile travel that has been evident in Western societies for some time, with driving considered critical to continued mobility, and in turn, an independent and socially active life (Shinar, 2007).

1.3 Motor vehicle crash patterns among older adults

The increased attention on older driver safety and mobility is also due to the elevated crash risk of at least some portion of this segment of the population. Fatal crash rates per mile driven increase noticeably across age groups beginning at age 70-74, and are highest among drivers age 85 and older (Insurance Institute for Highway Safety, 2010). Although debate continues on the nature and magnitude of the overall crash risk posed by older drivers (see e.g., Hakamies-Blomqvist, 2004; Langford, Methorst & Hakamies-Blomqvist, 2006) and there is some evidence of a recent downward trend in their fatal crashes (Cheung, McCartt & Braitman, 2008), it clear that older adults are at increased risk of death and serious injury given a crash, largely because of age-related fragility and frailty (Li, Braver & Chen, 2003). In addition, there is some evidence that older adults involved in crashes are more likely than younger drivers to be responsible for those crashes (Shinar, 2007). Given the dramatic increases expected in the older driver population in the coming decades, even a small proportion of drivers with compromised driving ability can translate into numbers that are not trivial. In addition, while current cohorts of older drivers tend to exhibit safe or careful driving practices and styles (e.g., using their seat belts, not speeding or driving after drinking; Eby, Molnar & Kartje, 2009), we do not yet know how the baby boomers will behave in this regard as they move into old age. Collectively, these issues suggest that increased societal attention on older drivers as a group is warranted.

1.4 Self regulation of driving

Driving is a complex task that requires good visual, cognitive, and psychomotor abilities. As people age, most will experience some loss in these abilities as a result of medical conditions, the medications used to treat them, or the aging process itself (Eby et al., 2009; Molnar, Eby, St. Louis & Neumeyer, 2007). At the same time, there is considerable variation in how individuals experience these declines (Eby, Trombley, Molnar & Shope, 1998; European Road Safety Observatory, 2006) and the impact of such declines on actual crash risk are not always fully known (Whelan, Langford, Oxley, Koppel & Charlton, 2006). Appropriate self-regulation of driving – that is, modifying one's driving by driving less or avoiding specific driving situations considered to be challenging, in response to declines in driving-related abilities – shows promise as a strategy by which older drivers can compensate for these declines and extend the time period over which they can safely drive (Molnar & Eby, 2009).

Research in this area is important because driving is generally the preferred means of getting around and is considered essential to independence and quality of life (Carp, 1988; Kaplan, 1995). Having to stop driving because of declining abilities can be traumatic and life changing for older adults (Dickerson, 2007; Molnar, Eby & Dobbs, 2005). Driving provides an opportunity for people to stay engaged civically and socially, and to participate in activities that enhance their well being, particularly in areas when transportation options are limited. Loss of driving can lead to increased social isolation by preventing regular contact with friends and family (Liddle, McKenna & Broome, 2004; Ragland, Satariano & McLeod, 2004), and is associated with not only a loss of independence, mobility, and freedom (Adler & Rottunda, 2006; Bauer, Rottunda & Adler, 2003; Dobbs & Dobbs, 1997) but also with feelings of diminished self-worth, reductions in self-esteem, and loss of identity (Eisenhandler, 1990). Driving cessation has also been associated with increased depressive symptoms among older adults. (Fonda, Wallace & Herzog, 2001; Marottoli et al., 1997; Ragland, Satariano & MacLeod, 2005) and more general accelerated health declines (Edwards, Lunsman, Perkins, Rebok & Roth, 2009).

Research on self-regulation is also important because to the extent that older drivers who should be restricting their driving are already doing so voluntarily, the need for societal intervention may be unnecessary or at least less pressing. One societal approach for managing older driver safety is the use of restricted licenses by licensing agencies to allow older drivers to continue to drive but with limitations – in particular, through reduced exposure to challenging driving conditions (e.g., driving at night or long distances from home). However, restricted licensing practices vary considerably across jurisdictions in the US and elsewhere (Petrucelli & Malinowski, 1992) and further work is needed to determine the overall safety benefits of such restrictions (Braitman, Chaudhary & McCartt, 2010), as well as identify which drivers are most likely to benefit from them (Nasvadi & Wister, 2009). Acceptance of restrictions by older drivers is also important because of its role in compliance. Marshall, Man-Son-Hing, Molnar, Wilson and Blair (2007) examined the acceptability of various driver restrictions for older drivers used in North America (e.g., limiting driving to daylight hours, non-rush hours, within 10 kilometers of home, on major highways). Acceptance varied across the driving situations and appeared to be inversely related to impact on autonomy and ability to access the community.

There is general agreement that at least some older drivers are aware of their functional declines and self-regulate their driving (see Molnar & Eby, 2008 for a review of this literature). However, there is considerable variation across studies, making it difficult to determine the extent of self-regulation by older drivers and how self-regulation is influenced by a variety of individual, social, and environmental factors. The lack of conclusive results in this area is due in large measure to differences across studies in terms of how self-regulation is defined and measured, the characteristics of study participants (e.g., age, gender functional status), and the extent to and way in which studies have included measures that appear to influence the adoption of self-regulatory practices such as insight into functional declines and confidence in driving ability. In addition, most studies on self-regulation have limited their measures to a narrow set of driving situations such as driving at night, on the freeway and so forth. Important questions remain about the extent to which and the conditions under which older drivers self-regulate their driving. There is a need for a more comprehensive, theoretically-informed, and uniform approach to understanding self-regulation by older drivers that encompasses both how older drivers reduce the extent of their driving exposure as well as how they modify the nature of their driving at multiple levels of driver performance and decision making. Such an approach could yield valuable insights into the decisions older drivers make as they plan for and engage in driving, as well as the broader choices they make in their lives to compensate for functional declines that can affect their driving.

1.5 Thesis overview

This thesis research was intended to generate new knowledge about the process of self-regulation by older drivers at multiple levels of driver performance and decision making. Of special interest was how various individual, social, and environmental factors influence this process. Both self-report and objectively derived data on health, functioning, and driving from a sample of older drivers in the greater Melbourne area of Victoria, Australia were collected and analyzed to explore the nature and extent of self-regulation, the influence of selected factors on self-regulation, and the correspondence between self-reports of self-regulatory practices and objective driving patterns and behaviors.

1.6 Thesis structure

This thesis is being submitted as a PhD by publication, with the format broadly following the traditional thesis structure. Four separate publications submitted to professional peer-reviewed journals are included as chapters. At the time the thesis was submitted for examination, three of the papers were under review and one had been returned for revisions. Each of the four papers included in the thesis are in their submitted formats. Subsequent to submitting the thesis for examination, all four of the papers were peer reviewed, revised, and accepted for publication. At the time of printing of the final thesis, two of the papers are published (Molnar, Charlton, Eby, Bogard, Langford, Koppel, Kolenic, Marshall & Man-Son-Hing, 2013; Molnar, Eby, Charlton, Langford, Koppel, Marshall & Man-Son-Hing, 2013), one is available on-line as an uncorrected proof (Molnar, Eby, Langford, Charlton, St. Louis & Roberts, 2013), and one is in press (Molnar, Charlton, Eby, Langford, Koppel, Kolenic & Marshall, in press). Each paper included in the thesis (submitted version) is prefaced by a brief introduction and a Declaration of Thesis Chapter signed by all the authors. Every effort has been made to reduce redundancies in the thesis, although there is necessarily some overlap in content across the chapters. Throughout the thesis, 'the researcher' refers specifically to Lisa J. Molnar, the PhD candidate.

This thesis document includes 11 Chapters. Following this first introductory chapter, Chapter 2 contains a review of the relevant literature focusing on: declines in driving-related abilities; critical driving skills; self-regulatory driving behavior; and measurement issues related to self-regulation. Chapter 3 presents the three research questions posed by the researcher, as well as the conceptual framework for the doctoral work. Chapter 4 presents the first of four PhD papers, which describes the development and testing of the main data collection instrument for the doctoral work: a computer-based questionnaire on self-regulation termed Advanced Driving Decisions and Patterns of Travel (ADDAPT). Included in the paper is information on development of the questionnaire, recruitment of the sample, collection of pilot data, data analysis, and findings relative to validity of the instrument. Chapter 5 presents the methodology used for answering the research questions and includes sections on participant recruitment, data collection, and analyses. Three papers, each answering one of the research questions, are presented in Chapters 6 through 8. Chapter 9 presents the discussion and overall conclusions for the doctoral work. The full set of references for the thesis is contained in Chapter 10. Chapter

11 contains all of the appendices including ethics approval certificates, the codebook for the questionnaire, and supplemental data analysis results.

Chapter 2: Literature Review

The population aging trends highlighted in Chapter 1 point to the importance of understanding the aging process as it affects driving, as well as the role of self-regulation in extending safe driving and managing the transition from driving to non-driving. In this chapter, an overview of the relevant literature is provided, including declines in abilities that can affect driving, critical driving skills, self-regulatory driving behavior, and measurement issues related to self-regulation. Key words and subject headings used to search the literature were derived from the researcher's knowledge of the aging and mobility literature, as well as recent reviews of the literature conducted by the researcher and colleagues (e.g., Eby, Molnar & Kartje, 2009; Eby, Molnar, Kostyniuk, St. Louis & Zanier, 2011; Molnar, Eby, St. Louis & Neumeyer, 2007). Several document databases were searched, including: MEDLINE, PSYCINFO, TRID, ProQuest, ScienceDirect, Google Scholar, UM-MIRLYN, and the University of Michigan Transportation Research Institute's (UMTRI's) Library. Collected articles and data were reviewed for appropriateness and those deemed appropriate were collected and organized, so that information could be synthesized for this review.

2.1 Declines in abilities

Building on earlier work by Eby et al. (1998), Eby et al. (2009) reviewed findings from the literature relative to how psychomotor, visual, and cognitive abilities decline with aging, and the implications of these declines for driving performance. A brief summary is provided here. Psychomotor functioning refers to an individual's coordinated and controlled ability to move and orient parts of his or her body (Kelso, 1982). A number of studies have found that psychomotor abilities tend to decline with increasing age, especially those abilities related to the speed at which movements are initiated (reaction time) and completed, the range of motion that is possible (flexibility), the accuracy of movements (coordination), and the forces required to execute the movement (strength). Such declines make it difficult for drivers to get in and out of, or operate a motor vehicle (Sivak et al., 1995).

Visual abilities are also important, given that driving is a highly visual task, with most of the information that drivers process being visual (Klavora & Heslegrave, 2002). Declines in several

visual abilities can affect driving, including those related to anatomic changes, eye movements, sensitivity to light, dark adaptation, visual acuity, contrast sensitivity, visual field, spatial perception, and motion perception. In general, declines in these visual abilities become more common with increasing age (e.g., Attebo, Mitchell & Smith, 1996) through both the normal aging process and the increased prevalence of eye disease (Anstey, Wood, Lord & Walker, 2005).

Individuals' cognitive processes allow them to take visual cues in the environment and select the appropriate information, interpret it, and make decisions which must then be translated into appropriate driving actions (European Road Safety Observatory, 2006). The review by Eby et al. (2009) presented evidence for declines in many cognitive abilities as part of the aging process that are needed to performing complex tasks such as driving (e.g., Anstey et al., 2005). Key among these abilities are attention, memory, problem solving, and spatial cognition. Older drivers appear to be particularly challenged by driving situations requiring divided attention (i.e., monitoring two or more stimulus sources simultaneously or performing two tasks simultaneously; Mihal & Barrett, 1976; Kaheman, 1973; Van Wolffelaar, Brower & Rothengatter, 1991). The two types of memory processing important for driving are working memory (the conscious part of memory where thinking takes place; Siegler, 1991) and long-term memory where experiences and knowledge are stored.

Although the review examined each psychomotor, visual, and cognitive ability separately, Eby et al. (2009) emphasized that it is important to recognize that a decline in one area may interact with or exacerbate the effects of a decline in another area, although declines in one area do not necessarily predict declines in another (Department of Transport, 2001). In addition, the three areas of abilities act as a system that influences driving safety to a greater or lesser extent depending on a broad array of environmental, vehicle, and driver characteristics (Fjerdingen et al., 2004). Findings from a study with a large sample of older drivers in Maryland provided evidence for a specific set of functional abilities predictive of crashes for older drivers (Ball et al., 2006; Staplin, Gish & Wagner, 2003). Among the psychomotor abilities identified were leg strength and stamina, head and neck flexibility, and choice reaction time. Among the visual abilities identified were visual contrast sensitivity, visuospatial organization, visual search (with

divided attention), and visual information processing speed (with divided attention). Among the cognitive abilities identified were working memory and executive function.

2.2 Critical driving skills

Critical driving skills make it possible to safely and efficiently operate a motor vehicle in traffic. These skills have to do with how drivers exert control over the vehicle; interact with other road users and perform various driving maneuvers such as yielding, turning, changing lanes, and passing; and make broader decisions about trip planning and wayfinding along a route (see Eby et al., 2009 for a full review; a brief summary is provided here). As discussed in the previous section, declines in psychomotor, visual, and cognitive abilities can adversely affect many critical driving skills. For example, declines in head/neck flexibility and/or peripheral vision can undermine critical driving skills related to merging into traffic and changing lanes (Suen & Mitchell, 1998). A major advance in understanding critical driving skills came about through the development of a hierarchical model for driving skills and control by Michon (e.g., 1979, 1985), as well as recent work to extend the hierarchical model to address the interplay between critical driving skills and motives (Keskinen, 2007). Based on his view that "the most characteristic human component in this system is its behavior as an intelligent if not quite infallible problem solver," Michon (1979, p. 488-489) divided the problem solving task of drivers into three levels of skills and control – strategic (planning), tactical (maneuvering), and operational (control).

The *strategic level* encompasses the general planning stage of a trip, with most decisions taking place before the trip even begins (Smiley, 2004). Strategic behavior includes high level decisions about trip goals, mode of transit, driving route, circumstances under which to drive (e.g., time of day, weather conditions), and evaluation of the costs and risks involved (Michon, 1985; Smiley, 2004). Strategic decisions have implications for driving risk; for example, avoidance of adverse driving conditions by older drivers can be considered a risk compensatory behavior (Summala, 1996). The *tactical level* has to do with the actual maneuvers drivers make in traffic in response to conditions in the driving environment at any given time. These include maneuvers such as obstacle avoidance, gap and headway acceptance, turning, and overtaking. Drivers must adapt their individual behavior to other road user's behavior and to the specific traffic situations that arise; thus, knowledge of traffic rules and behaving in accordance with

these rules are part of the skill set at this level (Berg, 2006). However, because driving is largely a self-paced task, there can be large amounts of variance in how these tasks are carried out (Summala, 1996). The *operational level* has to do with the details of driving and includes such things as the method used to scan the roadway, the amplitude and frequency of steering movements, and the variation in speed (Smiley, 2004). Skills at this level need to be automated for the most part; otherwise, drivers would have considerable difficulty managing the large flow of information they have to deal with while driving (Berg, 2006).

In work focusing specifically on younger drivers, Michon's hierarchical model of driver skills and control was expanded to four levels (e.g., Hatakka, Keskinen, Gregersen, Glad & Hernetkoski, 2002; Keskinen, 1996, 2007; Keskinen, Hatakka, Laapotti, Katila & Peraaho, 2004; Laapotti & Keskinen, 2004). The first three levels correspond directly to Michon's operational, tactical, and strategic levels. The fourth level has to do with drivers' general motives and attitudes in life and how they interact with drivers' skills to affect driving; this level is connected not only to the motives and personal development of drivers but also to the cultural norms of society (Laapotti & Keskinen, 2004). The premise underlying the fourth level is that factors related to what individuals' personal characteristics and how they live their day-to-day lives also affect approaches to driving and specific driving behaviors (Berg, 2006). Among these factors are personality traits such as self-control, as well as lifestyle, social background, gender, age, and group affiliation (Gregerson & Berg, 1994; Hatakka, 1998; Jessor, 1987; Schulze, 1990).

Michon's model of strategic, tactical, and operational levels serves as a useful foundation for not only understanding the critical driving skills of older adults, but also provides a framework for thinking about the decisions that older adults make with regard to self-regulating their driving and driving-related behavior. Adding a fourth level to Michon's model provides valuable additional insights because it is often these larger motives, tendencies, and social relationships in the broader sense that affect individuals' goals and the context of driving (Berg, 2006). This fourth level has been termed "life-goal" by the researcher and colleagues in work focusing specifically on older drivers (Eby et al., 2009). Table 1 below provides brief descriptions of the four levels, as well as examples of each relative to driving.

Table 1. Levels of Driver Performance and Decision Making		
Level	**Description**	**Examples**
Operational	Details of driving itself.	Methods for scanning the roadway, amplitude and frequency of steering movements.
Tactical	Decisions about maneuvers to undertake in traffic or while driving.	Decisions about speed at which to drive, the distance to leave behind the car ahead, whether to engage in various secondary tasks in car such as grooming, reading a map, conversing with passengers.
Strategic	Pre-trip decisions about trip goals, mode of transit, driving route, circumstances under which to drive.	Decisions about whether to drive at night, in bad weather, in busy traffic, during rush hour, on freeways, and in other driving situations.
Life-goal	Drivers' general motives and attitudes in life that affect driving more indirectly.	Decisions about where to live in relation to frequented destinations, what type of vehicle to purchase.

2.3 Self-regulatory driving behavior

Driving reduction and cessation is an individual process that is influenced by a host of factors (see Eby et al., 2009 for a full review; a brief summary is provided here). Some drivers stop driving suddenly because of a medical problem or other precipitating event. For many drivers, however, driving cessation unfolds as a gradual process as they become increasingly more vulnerable to difficulties in traffic, limit their driving under certain conditions, and drive progressively less than before (Hakamies-Blomqvist & Wahlström, 1998). While there is still much to learn about the driving cessation process, we know there is considerable variation in how older drivers respond to driving-related problems, what steps they take to continue driving safely, and how well they adapt if they choose or are forced to stop driving. For example, as part of the driving cessation process, many drivers with functional declines begin to modify or adjust their driving patterns by driving less or intentionally avoiding driving situations considered to be challenging, a process commonly known as self-regulation (e.g., Baldock, Mathias, McLean & Berndt, 2006; Ball et al., 1998; D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008; Molnar & Eby, 2008; Stalvey & Owsley, 2000). However, other drivers do not appear to practice appropriate self-regulation.

2.3.1 Extent and type of self-regulation

A review of the literature on self-regulation by older drivers was conducted by Molnar and Eby (2008). The review identified evidence from several studies indicating that many older drivers report self-regulating by reducing their driving exposure (e.g., Benekohal, Michaels, Shim & Resende, 1994; Charlton et al., 2006; Klavora & Heslegrave, 2002; Marottoli et al., 1993; Raitanen, Tormakangas, Mollenkopf & Marcellini, 2003; Ruechel & Mann, 2005). There was also evidence that many older drivers report self-regulating by avoiding specific driving situations such as driving at night, in bad weather, in heavy traffic, and making left turns (e.g., Baldock et al., 2006; Ball et al., 1998; Benekohal et al., 1994; Charlton, Oxley, Fildes & Les, 2001; Charlton et al., 2006; Hakamies-Blomqvist & Wahlström, 1998; Klavora & Heslegrave, 2002; Kostyniuk & Molnar, 2007, 2008; Ruechel & Mann, 2005; Stalvey & Owlsley, 2000). However, there was considerable variation across these latter studies, making the findings less conclusive relative to the widespread adoption of such self-regulatory practices. Rates of self-reported avoidance of night driving, for example, varied from 8 percent (Baldock et al., 2006) to 25 percent (Charlton et al., 2006), to 60 percent (Ruechel & Mann, 2005), to 80 percent (Ball et al., 1998). These differences in rates of reported self-regulation may be due to differences across studies with respect to the individual characteristics of participants, their driving patterns, and the social and cultural context within which their driving takes place, as well as the methods used to examine self-regulation.

2.3.2 Individual factors affecting self-regulation

Most studies of self-regulation have focused on individual factors such as demographic characteristics of older adults (e.g., gender and age), as well as objective and subjective measures of health and functioning. There have been mixed results with regard to whether various individual factors are related to self-regulation, particularly actual declines in functional abilities that older adults may be experiencing. Several studies have found impairments in vision to be associated with reported self-regulation (e.g., Ball et al., 1998; Charlton et al., 2006; Unsworth, Wells, Browning, Thomas & Kendig, 2007; West et al., 2003). For example, Ball et al. (1998) found that individuals with clinically-determined visual and/or attentional impairments reported avoidance of several challenging situations, while those with impaired mental status did not appear to self-regulate their driving. Charlton et al. (2006) examined the prevalence and type of self-regulation among drivers age 55 and older in Victoria, Australia, using a telephone survey.

Findings indicated that self-reported vision problems were associated with avoidance but impaired decision making was not, and that driving confidence was strongly predictive of avoidance behavior.

Other studies have found that relatively large proportions of drivers with visual impairment did not self-regulate appropriately (e.g., Okonkwo, Crowe, Wadley & Ball, 2007; Stalvey & Owsley, 2000). For example, findings from a telephone survey of high risk drivers (those with visual acuity and/or visual processing deficits, a high level of driving exposure, and a history of crash involvement) age 65 and older indicated that, based on self-report, most did not acknowledge their visual impairment, more than 75 percent did not self-regulate by avoiding driving situations that placed the greatest demand on visual processing abilities, and the majority rarely performed specific alternative driving strategies (Stalvey & Owsley, 2000). Similarly, Okonkwo et al. (2007) found that rates of reported driving avoidance at night did not differ between drivers considered to be high risk (based on an objective measure of visual attention from which crash risk was estimated) and low risk drivers, although the high risk drivers reported more driving avoidance overall.

Physical functioning, as measured by various standardized tests, has not been consistently shown to be associated with self-regulation (e.g., Baldock et al., 2006; Baldock, Thompson & Mathias, 2008; Charlton et al., 2001; Vance et al., 2006). In a preliminary investigation of self-regulation among a small sample of older drivers in Australia, Charlton et al. (2001) compared self-reports from participants about their driving with results from functional and on-road assessments. Overall, self-regulation was found to be associated with poorer levels of functional ability, suggesting that at least some drivers with impaired visual, cognitive, and psychomotor abilities did self-regulate their driving, but self-regulation was not associated reliably with driving performance as measured on the on-road driving assessment. However, in a study by Vance et al. (2006), physical functioning (based on measures of lower extremity function and falls) was not found to predict reported driving avoidance or exposure. Baldock et al. (2008), following up with older drivers who had been interviewed 5 years earlier on their self-regulatory practices, found very little change in self-reported driving confidence and avoidance of difficult driving situations despite significant declines in functional abilities, based on clinical measures of mental status, visual acuity, contrast sensitivity, and visual attention.

Study findings on the effects of cognitive impairment on self-regulation are also mixed. Cognitive functioning, as measured by the Useful Field of View, was found to be associated with decreased driving exposure in at least two studies (Ross et al., 2009; Vance et al., 2006). However, other studies using self-report measures did not find factors related to cognitive function (e.g., problems with balance, memory, confusion, or concentration) to be frequently mentioned as reasons for restricting driving (e.g., Betz & Lowenstein, 2010; Ragland et al., 2004). Researchers have suggested that lack of significant effects for many cognitive functioning variables may be due to samples being relatively healthy and cognitively intact.

Non-significant associations between cognitive functioning and self-regulation may also reflect a lack of insight among participants with cognitive impairments into their cognitive limitations or a lack of awareness that cognitive impairment is a risk factor for crash involvement (Betz & Lowenstein, 2010). This latter explanation points to the complexity of the relationship between cognitive functioning and self-regulation. For some forms of progressive dementia such as Alzheimer's disease, one would expect that as the disease progresses, individuals will increasingly lack awareness or insight into their cognitive deficits, which will undermine their use of self-regulation as a compensatory strategy (e.g., Carr, Meuser & Morris, 2006; Cotrell & Wild, 1999; Gil et al., 2001). This is because dementia not only affects cognitive skills for driving (e.g., memory, executive functioning, visuospatial skills) but also those skills necessary to benefit from self-regulation and planning for driving transition and cessation (e.g., insight, reasoning). Thus, some studies show that driving performance of individuals with dementia is worse than drivers without cognitive impairment (Man-Son-Hing, Marshall, Molnar & Wilson, 2007) and those affects by dementia do not change their driving behaviors even after a crash (Lucas-Blaustein et al., 1988).

Individuals with progressive dementia will inevitably need to stop driving at some point (Croston, Meuser, Berg-Weger, Grant & Carr, 2009). However, in the early stages of the disease, driving safety may not be seriously compromised, as evidenced by a recent study that used vehicle instrumentation to monitor the driving of adults with early-stage dementia under naturalistic driving conditions (Eby, Silverstein, Molnar, LeBlanc & Adler, 2012). Studies show that up to 45 percent of all dementia patients may still drive (e.g., Carr, Jackson & Alquire, 1990;

Logsdon, Teri & Larson, 1992). Given the high current prevalence of dementia (e.g., over 5 million adults in the US) and expected increases in the coming years, it will become increasingly important to understand and address the transitioning process from driving to non-driving among older drivers with dementia.

Studies that have examined the effect of age on self-regulation have yielded mixed results, with some finding that self-regulatory practices increase with increasing age (e.g., Charlton et al., 2006; Donorfio, D'Ambrosio, Coughlin & Mohyde, 2008a; Gwyther & Holland, 2012; Sargent-Cox, Windsor, Walker & Anstey, 2011; Unsworth et al., 2007) and others finding no such relationship (e.g., Blanchard & Myers, 2010; Molnar, Eby, Roberts, St. Louis & Langford, 2009). Interpreting these findings is complicated by differences in study design and other factors. For example, many studies only include older drivers in their sample, with restricted age ranges examined. In addition, the few studies that have included young and middle-age drivers in their samples asked participants whether they avoided various driving situations without delving deeper into the motivations for such avoidance. It is likely that motivations for avoidance are quite different among young and old adults, making it unclear if the studies were really getting at actual self-regulation across all the age groups. Age is also likely to be highly correlated with many other factors that might influence self-regulation. For example, Donorfio, D'Ambrosio, Coughlin and Mohyde (2008b) found that an individual's health status and the interaction between age and health were essential considerations in decisions regarding self-regulation and driving; that is, while individuals tended to self-regulate more with age, the effect became more pronounced as health status declined. The ability to discern such interactions is enhanced by a longitudinal study design; however, most studies of self-regulation to date have been cross-sectional.

Findings relative to the relationship between self-regulation and gender have generally been consistent, with women being more likely to report self-regulation than men (e.g., Charlton et al., 2006; D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008; Hakamies-Blomqvist & Wahlström, 1998; Kostyniuk & Molnar, 2008; Naumann, Dellinger & Kresnow, 2011; West et al., 2003). Nevertheless, findings from some recent studies have not supported this association with regard to older drivers (e.g., Blanchard & Myers, 2010; Gwyther & Holland, 2012; Molnar et al., 2009; Ross et al., 2009; Unsworth et al., 2007). For example, Gwyther and Holland (2012)

examined self-reported avoidance of various driving situation among a sample of adults age 18 to 78. While overall, women were more likely than men to report avoidance, this relationship only held for younger and middle-year participants; there were no significant differences by gender in the older age group. Ross et al. (2009) studied the 5-year driving habit trajectories among a sample of older adults and found gender to be associated with reduced driving space (e.g., driving distance from home) but not avoidance of specific driving situations (e.g., at night, on high traffic roads, in unfamiliar areas, on freeways, in bad weather, driving alone). Unsworth et al. (2007) used logistic regression and found that men and women were equally likely to modify their driving, although women were more likely to give up driving altogether, taking into account individual health and vision problems.

These findings on the lack of a gender effect on self-regulation are consistent with other studies in which adding a driving confidence variable resulted in a reduced contribution by such factors as age and gender in explaining driving avoidance (e.g., Charlton et al., 2006). They also provide support for Kostyniuk and Molnar's (2008) proposition that individuals' perceived level of confidence in various driving situations may help explain the gender effect found in many studies. Kostyniuk and Molnar (2008) also speculated that future cohorts of women who have been driving most of their lives may exhibit driving behaviors more similar to men. This observation is consistent with findings from another study that the driving cessation of women who had an active driving history was more similar to what is known about the driving cessation of men, suggesting that decisions about stopping driving are related to personal driving history rather than gender per se (Hakamies-Blomqvist & Siren, 2003). The finding by Unsworth et al. (2007) that women were more likely than men to stop driving appears to be at odds with these conclusions, although the study did not appear to explicitly control for personal driving history.

It appears that awareness of and insight into functional impairments is an important precursor to adopting self-regulatory practices (e.g., Ball et al., 1998; Freund, Colgrove, Burke & McLeod, 2005; Holland & Rabbit, 1992; Owsley, McGwin, Phillips, McNeal & Stalvey, 2004; Owsley, Stalvey & Phillips, 2003; Stalvey & Owsley, 2003) and may be more important than actual driving ability (Anstey, Wood, Lord & Walker, 2005). For example, Anstey et al. (2005) reviewed the literature on cognitive, sensory, motor, and physical factors associated with safe driving and concluded that insight into age-related changes plays a key role in how older adults

alter their driving behavior – with individuals' self-perceptions about their abilities influencing their decisions to drive in challenging situations such as peak travel times and nighttime driving, or adverse weather conditions. They noted that lack of insight into possible cognitive, sensory, or physical limitations (e.g., as evidenced by individuals who performed poorly relative to peers but thought they did well) may constitute a risk factor for poor driving performance and crash risk. Findings from a study by Owsley et al. (2003) provided evidence that increasing self-awareness of functional impairments can promote self-regulation. They evaluated an educational curriculum targeted to older drivers at high risk of crashing due to vision impairment, previous recent crash involvement, and high frequency of driving. Compared to a control group, drivers receiving the educational curriculum were more likely to acknowledge less than excellent vision and reported greater avoidance of visually challenging driving situations. Similarly, Holland and Rabbit (1992) found that when older adults with sensory problems (as measured by eyesight and hearing tests) were given feedback on these impairments (i.e., eyesight and hearing test results), they reported changing their driving to avoid challenging situations. Finally, Ackerman et al. (2010) found that providing feedback on visual speed of processing (a cognitive ability considered important for safe driving) was associated with increased reports of driving avoidance but not reduced driving exposure or more accurate self-ratings of driving ability.

Perceptions of confidence or comfort in specific driving situations have also been closely tied to self-regulation in terms of avoiding those situations (e.g., Baldock et al., 2006; Blanchard & Myers, 2010; Charlton et al., 2006; MacDonald, Myers & Blanchard, 2008; Molnar & Eby, 2008; Rudman, Friedland, Chipman & Sciortino, 2006). In fact, this has been one of the most consistent findings in the literature, regardless of how confidence or comfort is measured. For example, Baldock et al. (2006) concluded that older drivers do report self-regulating in a manner consistent with driving ability, but only for a small number of specific situations in which they have low confidence and are most able to avoid. They found three situations related to poorer performance on an on-road driving test: driving in the rain, driving at night, and driving at night in the rain. More recently, MacDonald et al. (2008) examined the role of driver perceptions (especially confidence and comfort) in self-regulatory behaviors, using the Driving Comfort Scales (DCS; see Myers, Paradis & Blanchard, 2008) and found driver comfort to be significantly related to reported self-regulation across various driving situations. In addition, other work using the DCS in conjunction with objectively derived driving data found lower

comfort to be significantly related to reduced driving exposure in general and at night, average and maximum radii from home, and driving in challenging situations such as on the highway (Blanchard & Myers, 2010).

These findings underscore the conclusion by Charlton et al. (2006) and others that although it is important to examine objective measures of functioning, self-perceptions of functioning should not be ignored as predictors of self-regulation. The seeming importance of self-perceptions of health and functioning is also consistent with the broader health behavior change literature. For example, Strecher, DeVellis, Becker, and Rosenstock (1986) argued that it is individuals' perception about their capabilities and not necessarily their true capabilities that influence behavior. They noted the consistency of their conclusions with Bandura's (1977) assertion that an individual's expectations about the ability to execute or engage in a behavior, an important precursor for behavior change, reflects the individual's perceived rather than actual capabilities and it is these perceptions and not one's true abilities that influence behavior. The similarity in conclusions from work done outside the transportation field point to the importance of examining self-regulation itself within a broader context, taking into account the contributions from researchers and practitioners working in complementary fields of research.

2.3.3 A broader context of self-regulation

Of particular interest to the understanding of self-regulation of driving is the broader model of self-regulation that serves as a key component of social cognitive theory (e.g., Bandura, 1977; 1991, 2005). As conceptualized by Bandura and others, self-regulation operates through three distinct sub-processes: self-monitoring of beliefs in which an individual uses his or her cognitive ability to view behavior as it is occurring or in retrospect; self-judgment in which an individual compares his or her own behavior against someone else's or an ideal behavior; and self-reaction, in which an individual comes to conclusions about himself or herself and his or her abilities as a result of observation and judgment (Clark, Janz, Dodge & Sharpe, 1992). Self-regulation also encompasses the mechanism of self-efficacy which has to do with individuals' "…beliefs about their capabilities to exercise control over their level of functioning and over events that affect their lives" (Bandura, 1991, p.257). Higher perceived self-efficacy contributes to individuals'

ability to use self-regulatory strategies to achieve desired behavioral goals and outcomes (Clark et al., 1992).

According to Bandura (2005), although models of self-regulation may differ in their details, all are founded on the premise that cognitive factors are significant contributors to health behavior. That is, individuals continuously manage their own behavior, thereby playing a key role in the development and maintenance of healthy habits. He points to a variety of efforts that have used self-regulation to promote healthy lifestyles such as increased physical activity, adoption of healthful nutrition practices, weight and/or cholesterol reduction, and smoking cessation, noting that "whatever other factors may serve as guides and motivators, they are unlikely to produce lasting behavioral changes unless individuals develop the means to exercise control over their motivation and health related behavior" (p. 246). Thus, the literature on social cognitive theory underscores the importance of cognitive functioning in the self-regulation process.

2.3.4 Social and environmental factors affecting self-regulation

Social and environmental factors have been less extensively studied than individual factors; however, they may play an important role in influencing self-regulation by serving as facilitators or barriers. One factor of interest has to do with whether older adults have others dependent on them to drive. This has been explored in different ways. For example, Charlton et al. (2006) found the odds of reported self-regulatory avoidance behaviors among study participants who were the principal driver in the household to be half of that of participants who were not the main driver.

Baldock et al. (2006) examined what he termed "regulatory self-efficacy" or the ease of avoiding difficult driving situations, as well as six perceived barriers to self-regulation (lifestyle, relied on to drive, no public transport, do not like public transportation, family or friends unavailable to drive, would not ask family or friends) among a sample of Australian older drivers. Study findings indicated that driving alone and on high traffic roads were considered the most difficult situations to avoid, while parallel parking and driving in rush hour traffic were considered the easiest to avoid. The greatest perceived barriers were lifestyle (i.e., a style of living that required a certain amount of driving, 70 percent), lack of availability of others to provide transportation (42 percent), and unwillingness to ask others for rides (44 percent). Findings from Stalvey and

Owsley (2000) in the US were similar with regard to barriers to self-regulation (i.e., 57 percent considered unavailability of friends/family to be a barrier and 54 percent lifestyle), with one notable exception. The most frequently-mentioned barrier was lack of public transportation (70 percent), whereas only a quarter of the Australian drivers mentioned that as a barrier. In addition, about 35 percent of participants in both the Australian and the US studies reported that others relied on them for rides. Blanchard and Myers (2010) also examined perceived barriers to driving reduction among a Canadian sample of older drivers. Among the barriers identified were maintaining current lifestyle (63 percent), location of shops and services (59 percent), difficulty with public transit (47 percent), not wanting to bother others (42 percent), availability of others to drive (24 percent), others relying on them (24 percent), and difficulty getting places (22 percent). Perceived barriers were significantly associated with all objectively-derived measures of driving examined (e.g., distance, duration, number of trips, stops, days, driving at night) except radius from home.

Older adults' access to and use of educational materials to help them facilitate the transition from driving to non-driving has been explored in a few studies. For example, in a survey of informants for older adults with dementia, findings suggested that two-thirds of the participants reported receiving no community resources or education as part of the driving retirement process (Croston, Meuser, Berg-Weger, Grant & Carr, 2009). In a similar vein, Sargent-Cox et al. (2011) examined the role of "health literacy" in self-regulation, based on the premise that accurate knowledge and understanding of factors affecting driving safety may underpin appropriate self-regulation of driving. They found that health knowledge was less important than health experience (measured by the presence of health conditions). According to the authors, of greater importance was the finding that up to 85.7 percent of participants reported that they did not receive advice from their physician about the potential impact of their medical condition on driving.

2.3.5 Self-regulation and crash risk

What is less conclusive in the research literature is how such self-regulation translates into actual safety benefits for older drivers, as few studies have been done on self-regulation and crash risk and the findings are mixed (e.g., Ball et al., 1998; Ball et al., 2006; Charlton et al., 2006; DeRaedt & Kristofferson, 2000; Owsley et al., 2004; Raitanen et al., 2003; Ross et al., 2009).

DeRaedt and Kristofferson (2000) found that "bad" drivers (as rated by experts based on their scores on an on-road test) who reported self-regulating their driving had fewer crashes compared with those who did not. Other researchers have found no association between self-regulation and self-reported crashes (Raitanen et al., 2003) or police-reported crashes (Owsley et al., 2004). Still others found crashes to be more prevalent among those who self-regulated, based on self-report (Charlton et al., 2006) and police-report (Ball et al., 1998). As noted by several of these authors, the challenge in interpreting most findings on the association between crash risk and self-regulation is that they come from retrospective studies, which limits the ability to infer cause and effect. In one of the few longitudinal studies of older drivers, Ross et al. (2009) found that while self-regulation among drivers classified as high risk increased over time, these drivers were still twice as likely to be involved in at-fault crashes over a 5-year period, using police-reported crash records (Ball et al., 2006).

Collectively, the findings on the role of self-regulation in older driver safety suggest that licensing agencies cannot rely on older adults to appropriately self-regulate their driving as the only strategy for managing those at risk. In particular, drivers who lack insight about their functional declines due to cognitive impairment such as dementia may not be able to appropriately self-regulate their driving. The literature also underscores the conclusion by Charlton et al. (2006) that "…the processes involved in self-regulation are complex and the factors that influence the adoption of self-regulatory behaviours are likely to be multi-faceted" (pg. 364).

2.4 Measurement issues related to self-regulation

Most studies of self-regulation have relied on self-report by drivers. While self-report through questionnaires, travel diaries, and interviews allows researchers to explore in detail the various aspects of self-regulatory behavior, including broader behaviors and attitudes that affect driving, concerns have been raised about the validity and reliability of such self-reports. For example, while driving exposure has been measured in previous studies using telephone (DeCarlo, Scilley, Wells & Owsley, 2003; Owsley, Stalvey, Wells & Sloane, 1999), paper (Kiernan, Cox, Kovatchev, Kiernan & Giuliano, 1999), and computer (Wolf, Guensler, Washington & Frank, 2000) surveys, the validity and accuracy of survey estimates of driving exposure have not been examined or are questionable (Huebner, Porter & Marshall, 2006; Staplin, Gish & Wagner,

2003). In a specific example of this, Staplin et al. (2003) found large discrepancies between particpants' responses to two separate items for measuring self-reported miles driven and were therefore not able to use these data in their assessment of crash risk.

Advances in technology now make it possible to examine driving exposure, patterns, and habits using low-cost global positioning system (GPS) technology to record a vehicle's location on a continuous basis along with the date and time (e.g., see Grengs, Wang & Kosyniuk, 2008; LeBlanc et al., 2006; LeBlanc, Sayer, Winkler & Bogard, 2007, Porter & Whitton, 2002). The ability to collect these objective data represents a major step forward and helps address concerns that have been raised about the validity and accuracy of self-reported estimates of driving exposure (e.g., see Huebner et al., 2006; Staplin, Gish & Joyce, 2008; Staplin, Gish & Wagner, 2003). Data collection using GPS has been favorably viewed in at least one study, with older drivers preferring in-vehicle technology to measure driving exposure over using travel diaries (Marshall et al., 2007). At the same time, there are also challenges associated with interpreting objective data collected through in-vehicle instrumentation, particularly when information about the context of the driving situation is unknown. For straightforward driving behaviors such as exposure variables (e.g., miles or kilometers driven in a given period of time), objective data may be superior to self-reports, although further empirical testing would be useful. However, for better understanding the context of driving and broader concepts of decision making, there may be a role for self-report, particularly when used in conjunction with objectively-derived data.

Despite the promise of in-car recording devices (ICRDs) using GPS technology, there has been limited research comparing GPS and self-reported data with regard to the trip-specific driving patterns of drivers, particularly for older drivers beginning to experience age-related declines that can affect driving. Relatively few published studies were found that compared self-reported driving by older adults as a group with objectively derived driving data (e.g., Blanchard, Myers & Porter, 2010; Huebner et al., 2006; Marshall et al., 2007; Myers, Trang & Crizzle, 2011). Marshall et al. (2007) recruited 20 Canadian older drivers and compared self-reported driving data from travel diaries to two types of electronic data logging devices, the CarChip and FleetPulse™. They found moderate and strong correlations, respectively, between travel diaries and the CarChip and FleetPulse™ devices. In contrast, Huebner et al. (2006) and Blanchard et al. (2010), using Canadian samples of 20 and 61, respectively, found that older drivers both

under and over estimated their weekly driving distance, based on comparisons between self-reports of weekly driving distance and driving data from the CarChip device. Blanchard et al. (2010) discussed variations in protocols and analyses that may have accounted for the differences between their findings and those of Marshall et al. (2007). For example, participants in the Marshall et al. (2007) study were asked upfront to record the distance for each trip and therefore, may have checked their odometer, whereas participants in the Huebner et al. (2006) did not know they would be asked about driving distance until they were actually interviewed at the end of the week after driving had occurred.

2.5 Summary

As drivers age, most will experience declines in visual, cognitive, or psychomotor abilities that can affect driving. Self-regulation of driving represents an opportunity for older drivers to compensate for some of these declines by modifying their driving and decision making at the tactical, strategic, and life-goal levels. However, considerable knowledge gaps remain about the self-regulation process among older drivers, and the individual, social, and environmental factors that influence it. Studies have generally focused on a narrow set of self-regulatory practices, failing to take into account broader choices and decision making that influence driving. In addition, most studies have relied solely on driver self-reports to examine self-regulation. Thus, objective data are lacking about the extent to which older drivers drive less or avoid specific driving situations. A comprehensive and theoretically based examination of self-regulatory practices is needed, using objective data to examine the actual driving behaviors engaged in by older drivers, as well as self-reported data to better understand the context within which these driving behaviors occur and the intended behaviors of drivers both on and off the road.

Chapter 3: Research Questions and Conceptual Framework

The overall objective of this PhD research is to better understand the process of self-regulation by older drivers at the tactical, strategic, and life-goal levels of driver performance and decision making, and how it relates to important individual, social, and environmental factors.

3.1 Research questions

Specific research questions posed by the PhD researcher are:

1. What is the nature and extent of self-regulation by older drivers?

2. How is self-regulation influenced by various individual, social, and environmental factors?

3. How do self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors?

Research Question 1 encompasses self-regulatory practices at the tactical, strategic, and life-goal levels. At the tactical level, these practices include avoiding distractions inside the vehicle while driving, and modifying driving maneuvers in traffic relative to vehicle speed and distance between vehicles. At the strategic level, these include reductions in the overall amount of driving that drivers do, avoidance of specific driving circumstances that drivers find challenging (e.g., driving at night or on the freeway) strategies for planning routes and wayfinding along those routes. At the life-goal level, these include broader decisions about the type of vehicle to buy or where to live in relation to driving destinations. Research Question 2 addresses a range of individual factors including driver age, gender, impairments in visual, cognitive, and psychomotor functioning (both actual and perceived), and driver comfort/confidence. Also of interest are social factors such as lifestyle preferences and activities, as well as environmental factors such as the availability of various transportation options. Research Question 3 is examined by comparing self-reported questionnaire data on driving measures with a set of comparable objective measures derived from GPS and vehicle data (e.g., kilometers driven per

week, number of trips per week, and percent of trips during nighttime, in rush hour traffic, on high speed roads).

3.2 Conceptual framework

The thesis research conceptualizes self-regulation as both reducing the extent of driving exposure and modifying the nature of driving exposure. As a framework for thinking about self-regulation, a model of driver behavior and decision making including four levels was used: operational, tactical, strategic, and life-goal. The first three levels are based on Michon's (1979, 1985) hierarchical model of driver behavior. As described previously, the lowest level, operational, has to do with the details of driving that are largely automated (e.g., steering movements, braking; Berg, 2006). The tactical level has to do with the actual maneuvers drivers make in traffic in response to conditions in the driving environment (e.g., obstacle avoidance, gap and headway acceptance, turning, passing). Strategic behavior includes higher level decisions about trip goals, mode of transit, driving route, circumstances under which to drive (e.g., time of day, type of roadway, traffic conditions), and evaluation of the costs and risks involved (Michon, 1985; Smiley, 2004).

The fourth level, termed the "life-goal" level by the researcher and colleagues (Eby et al., 2009), was adapted from work by Hatakka et al. (2002), Keskinen (1996), Keskinen et al. (2004), Laapotti and Keskinene (2004), and others to address older drivers' general motives and attitudes in life and how they affect driving. Although the life-goal level was developed to address the elevated crash risk of young drivers (Gregersen & Berg, 1994), it has direct applicability to older drivers and the broader decisions they make. The greatest opportunity for self-regulation of driving is at the higher levels of decision making. For example, at the strategic level, many older drivers make changes in terms of how much they drive and under what circumstances (e.g., time of day, type of road). At the life-goal level, lifestyle decisions are made about where to live in relation to destinations of choice or what kind of car to drive, with safety often being an important consideration in the vehicle purchase decision (Eby & Molnar, 2012). Thus, extending Michon's three-levels to include the "life goal" level provides a valuable framework for thinking about the decisions that older adults make that affect their driving safety.

A conceptual model of self-regulation by older drivers at the life-goal, strategic, and tactical levels, and the individual, social, and environmental factors that influence self-regulation has been developed by the researcher to guide the proposed research (Figure 1). Driver actions at the operational level were not included in the model, as they are largely automated and not amenable to self-regulation. It should be noted that this framework was intended to help the researcher conceptualize the self-regulatory process (and the myriad of factors that contribute to it) rather than as a theoretical model to be empirically tested. It was beyond the scope of the doctoral research to examine every component in the conceptual model.

The conceptual model developed by the researcher focuses on those steps that need to occur (or factors that need to be present or overcome) for the process of self-regulation to be initiated by older drivers. As drivers age, they are likely to experience one or more declines in visual, cognitive, or psychomotor abilities as a result of medical conditions, the medications used to treat those conditions, or the aging process itself. These declines, in turn, can affect the critical driving skills needed for safe driving. Drivers who have some level of insight into these declines will experience (at some level) feelings of reduced comfort with one or more driving situations. Their feelings of comfort may also be reduced as a result of other individual, social or environmental factors (e.g., concerns expressed by family members, friends, or health care professionals; other drivers honking at them on the road, or experiencing near crashes). Based on these feelings of reduced comfort, drivers may decide to self-regulate their driving. The extent to which their intent to self-regulate is translated into actual self-regulatory behavior will also be influenced individual, social, and environmental factors which may serve as facilitators or barriers to self-regulation.

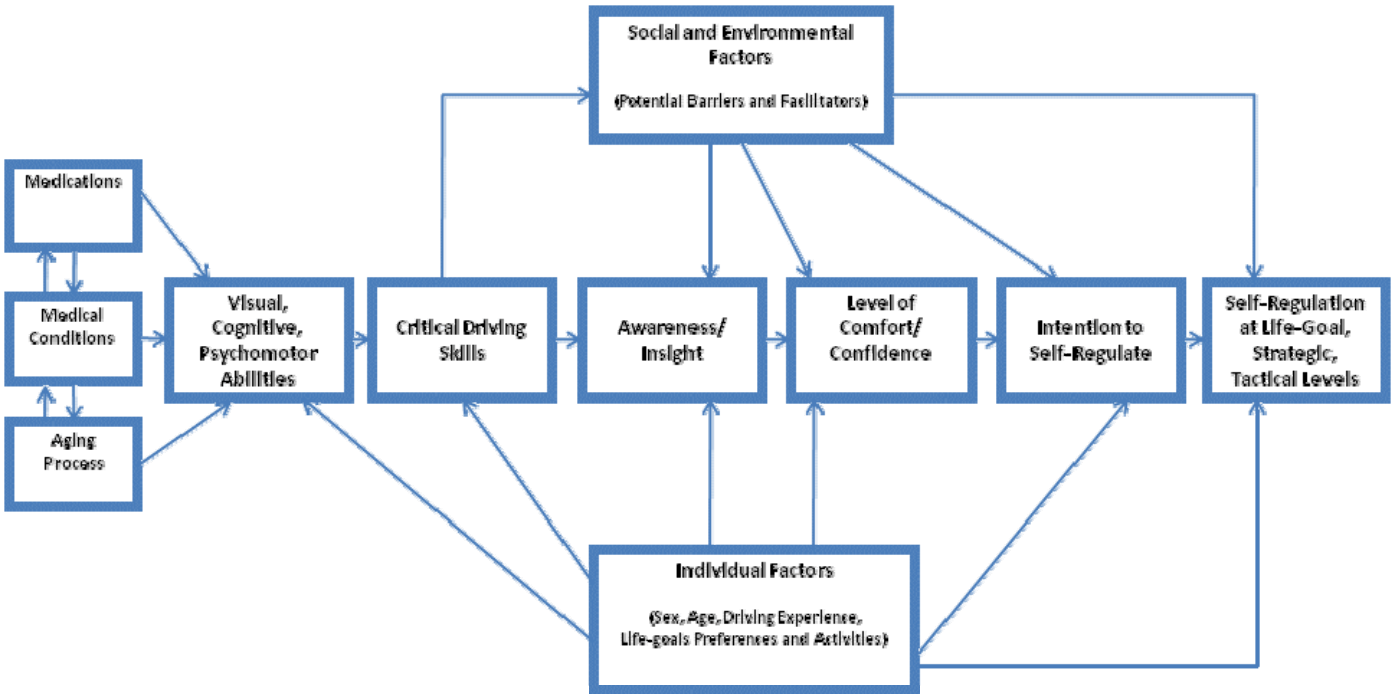

Figure 1: Conceptual Model of Self-Regulation

Chapter 4: Tactical, Strategic, and Life-Goal Self-Regulation of Driving by Older Adults: Development and Testing of a Questionnaire (Publication 1)

This first paper documents the development and pilot testing of the self-regulation questionnaire (see Molnar et al., 2009) that was adapted for use with the Ozcandrive sample for the PhD research. The purpose of the work reported was to develop and test a questionnaire to measure, in a comprehensive manner, the reported tactical, strategic, and life-goal self-regulatory practices employed by older drivers. Specific aims of the study were to: 1) develop a computer-based questionnaire that can be used in the US and elsewhere to study self-regulation; 2) recruit a sample of older drivers in Michigan comprised of individuals with clinically-determined functional impairments in vision, cognition, or psychomotor ability, as well as older adults recruited from the general population; and 3) pilot test the questionnaire with participants in the sample to assess its ease of use and understandability, as well its construct validity. This paper was submitted to the Journal of Safety Research. At the time the thesis was submitted for examination, the paper had been returned for revision and was being revised. Included here is the submitted version of the paper. Subsequent to submitting the thesis for examination, the paper was accepted for publication, and is available on-line as an uncorrected proof (see Molnar, Eby, Langford, Charlton, St. Louis & Roberts, 2013). The final version of the paper extends the findings from the paper included here by presenting and statistically testing differences in socio-demographic characteristics between the general and the clinic populations. The only statistically significant difference was that participants in the general population were more likely to have been born in the USA. However, every member of both the general and clinic populations had lived in the USA for more than 5 years.

Monash University

Declaration for Thesis Chapter 4:

Molnar, L.J., Eby, D.W., Langford, J., Charlton, J.L., St. Louis, R. & Roberts, J.S. (returned for revision). Tactical, Strategic, and Life-Goal Self-Regulation of Driving by Older Adults: Development and Testing of a Questionnaire.

Declaration by candidate

In the case of the publication presented in Chapter 4, the nature and extent of my contribution to the work was the following:

Nature of contribution	**Extent of contribution (%)**
▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, drafting of text, preparation of figures/tables, revision/editing for intellectual content	80%

The following co-authors contributed to the work. None of the co-authors were students at Monash University (and therefore no indication of the extent of their contribution in percentage terms was required).

Name	
Dr. David W. Eby	▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Jim Langford	▪ Concept and design – initial concept, development of study design ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Judith L. Charlton	▪ Concept and design – initial concept, development of study design ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables,

	revision/editing for intellectual content
Ms. Renée St. Louis	▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. J. Scott Roberts	▪ Concept and design – initial concept, development of study design ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content

Candidate's Signature	[redacted]	**Date** 11-02-2013

Declaration by co-authors

The undersigned hereby certify that:

(1) the above declaration correctly reflects the nature and extent of the candidate's contribution to this work, and the nature of the contribution of each of the co-authors.
(2) they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
(3) they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
(4) there are no other authors of the publication according to these criteria;
(5) potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit; and
(6) the original data are stored at the following location(s) and will be held for at least five years from the date indicated below:

Location(s)	[1] University of Michigan Transportation Research Institute, Ann Arbor, MI USA [2] Monash University Accident Research Centre, Clayton Campus [3] University of Michigan School of Public Health, Ann Arbor, MI USA

[Please note that the location(s) must be institutional in nature, and should be indicated here as a department, centre or institute, with specific campus identification where relevant.]

Signature 1	[redacted] Dr. David W. Eby[1]	**Date** 08-02-2013

Signature 2	[redacted] Dr. Jim Langford[2]	28-01-2013
Signature 3	[redacted] Dr. Judith L. Charlton[2]	12-02-2013
Signature 4	[redacted] Ms. Renée St. Louis[1]	08-02-2013
Signature 5	[redacted] Dr. J. Scott Roberts[3]	05-02-2013

Tactical, Strategic, and Life-Goal Self-Regulation of Driving by Older Adults: Development and Testing of a Questionnaire

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Abstract

Appropriate self-regulation of driving; that is, adjusting one's driving patterns by driving less or avoiding specific situations considered to be challenging, shows promise as a strategy for enabling older drivers to extend the time period over which they can safely drive. However, the extent of self-regulatory practices by older drivers varies considerably across studies. The purpose of this study was to develop and test a questionnaire to measure self-regulation at multiple levels of driver performance and decision making, using a sample of older drivers in Michigan comprised of individuals with clinically-determined functional impairments in vision, cognition, or psychomotor ability, as well as older adults recruited from the general population. Results suggest that the questionnaire is a user-friendly instrument for gathering information from older adults about their self-regulatory practices and that the instrument has good construct validity. Feedback on the questionnaire was positive, with most participants considering the questions easy to read and understand (98.5 and 89.1 percent, respectively) and finding the length to be reasonable (93.4 percent). Most (91.2 percent) were satisfied with the computer format, despite the fact that only 11.0 percent described their level experience with computers as high. Construct validity of the questionnaire was assessed in two ways: 1) by making comparisons between the clinic and general populations along a number of dimensions on which they might be expected to differ, including their self-ratings for health and functioning, abilities for safe driving, and feelings of driving comfort and safety; and 2) looking for statistically significant correlations between variables that one would reasonably expect to be correlated. Overall, participants rated their general health and functioning, as well as various abilities for safe driving quite highly. However, participants from the clinic population rated themselves lower than participants from the general population on several abilities including seeing clearly during the day, seeing clearly at night, remembering things, and processing information. While participants reported high levels of driving comfort and safety for most driving situations, the clinic population reported lower levels of comfort and safety than the general population for every driving circumstance except driving alone. Analyses showed very high correlations among the concepts of comfort and safety overall and the absolute mean scores were nearly identical for each driving circumstance. Finally, the clinic population was more likely to report trying to avoid driving at night, in unfamiliar areas, and on the expressway, as well as chatting with passengers.

Introduction

Driving is a complex task that requires visual, cognitive, and psychomotor abilities. As people age, most will experience some loss in these abilities as a result of medical conditions, the medications used to treat them, or the aging process itself (Eby, Molnar & Kartje, 2009; Molnar, Eby, St. Louis & Neumeyer, 2007). At the same time, there is considerable variation in the extent to which individuals experience these declines (Eby, Trombley, Molnar & Shope, 1998; European Road Safety Observatory, 2006) and the impact of such declines on actual crash risk is not always fully known (Whelan, Langford, Oxley, Koppel & Charlton, 2006).

Self-regulation has been described as the process of adjusting driving patterns by driving less or intentionally avoiding driving situations considered to be challenging (e.g., D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008). Appropriate self-regulation shows promise as a strategy for compensating for these declines and enabling older drivers to extend the time period over which they can safely drive (Molnar & Eby, 2009). Research in this area is important because most older drivers prefer driving as the means of maintaining mobility and consider driving to be essential to independence and quality of life (Carp, 1988; Kaplan, 1995). Having to stop driving because of declining abilities can be traumatic and life changing for older adults (Dickerson et al., 2007; Molnar, Eby & Dobbs, 2005), and has been associated with increased social isolation (Liddle, McKenna & Broome, 2004; Ragland, Satariano & MacLeod, 2004), loss of independence, mobility, and freedom (Adler & Rottunda, 2006; Bauer, Rottunda & Adler, 2003; Dobbs & Dobbs, 1997), and increased depressive symptoms (Fonda, Wallace & Herzog, 2001; Marottoli et al., 1997; Ragland, Satariano & MacLeod, 2005).

There is general agreement that at least some older drivers are aware of their functional declines and self-regulate their driving (see Molnar & Eby, 2008 for a review of this literature). However, there is considerable variation across studies with regard to the extent of self-regulation by older drivers and how self-regulation is influenced by a variety of individual, social, and environmental factors. Rates of self-reported avoidance of night driving, for example, vary from 8 percent (Baldock, Mathias, McLean & Berndt, 2006) to 25 percent (Charlton, Oxley, Fildes, Newstead, Koppel & O'Hare, 2006), to 60 percent (Ruechel & Mann,

2005), to 80 percent (Ball, Owsley, Stalvey, Roenker, Sloane & Graves,1998). There are also mixed results with regard to the association between self-regulation by older drivers and the functional declines they may be experiencing (see Baldock et al., 2006; Ball et al., 1998; Charlton, Oxley, Fildes & Les, 2001; Charlton et al., 2006; Stalvey & Owsley, 2003), suggesting that older adults may not always self-regulate their driving appropriately. While it appears that sex (Charlton et al., 2001; Gwyther & Holland, 2011; Kostyniuk & Molnar, 2007, 2008; Hakamies-Blomqvist & Wahlström, 1998), self-perceptions of driving confidence (Baldock et al., 2006; Charlton et al., 2001), and awareness of and insight into functional impairments (Ball et al., 1998; Freund, Colgrove, Burke & McLeod, 2005; Owsley et al., 2004; Owsley, Stalvey & Phillips, 2003) play a role in self-regulation, these factors are not consistently examined in studies and when they are, their influence on self-regulation is not always supported. For example, older drivers studied longitudinally in Australia reported declines in functional abilities over time but few changes in self-regulatory behaviors (Baldock, Thompson & Mathias, 2008).

The lack of conclusive results in this area is due in large measure to considerable differences across studies in terms of how self-regulation is defined and measured, the characteristics of study subjects (e.g., age, sex, functional status), and the extent to and way in which studies have included measures that seem to influence the adoption of self-regulatory practices (e.g., insight into functional declines and confidence in driving ability), as well as, in some cases, the failure to control for confounding variables. In addition, most studies on self-regulation have limited their measures to a narrow set of driving situations such as not driving at night, not driving on the freeway, and so forth. Important questions remain about the extent to which and the conditions under which older adults do self-regulate their driving. There is a need for a more comprehensive, theoretically-informed, and uniform approach to investigating self-regulation by older drivers that encompasses not only the extent to which older drivers drive less or avoid specific driving situations, but also the broader choices they make in compensating for functional declines such as the types of vehicles they buy, the vehicle design features they choose, and even where they choose to live.

Study Background

The study reported here is part of a larger program of research at the University of Michigan Transportation Research Institute (UMTRI), investigating: the nature and extent of self-regulation by older drivers; how self-regulation is influenced by various individual, social, and environmental factors; and how self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors. Self-regulation is conceptualized as occurring at three levels of driver performance and decision making: tactical, strategic, and life-goals, thus extending the research focus beyond the narrow set of driving circumstances typically examined in studies of self-regulation.

The tactical and strategic levels come from Michon's hierarchical model for driving skills and control (Michon, 1985). The strategic level encompasses the general planning stage of a trip, with most decisions taking place before the trip even begins (Smiley, 2004). Strategic self-regulatory practices include reductions in the overall amount of driving that drivers do, avoidance of specific driving circumstances which drivers consider to be challenging (e.g., at night or on the freeway) and strategies for planning routes. The tactical level has to do with the actual maneuvers drivers make in traffic in response to conditions in the driving environment at any given time. Tactical self-regulatory practices include avoiding distractions inside the vehicle while driving, and modifying driving maneuvers in traffic relative to vehicle speed and distance between vehicles. Michon's model also included an operational level which has to do with the details of driving that are largely automated; however, driver actions at the operational level are not included here as they are generally not amenable to conscious manipulation.

The life-goal level (a term coined by Eby et al., 2009) builds on work by Keskinen and others on young drivers (e.g., Keskinen, 1996, 2007; Keskinen, Hatakka, Laapotti, Katila, & Peraaho, 2004; Laapotti & Keskinen, 2004) focusing on drivers' general motives and attitudes in life and how they interact with drivers' skills to affect driving. The premise underlying the life-goal level is that factors related to what individuals are like and how they live day-to-day (e.g., self-control and lifestyle preferences) also affect approaches to driving and specific driving behaviors (Berg, 2006). Life-goal self-regulatory practices include broader decisions such as what type of vehicle

to buy or where to live in relation to driving destinations. This level has direct applicability to older drivers and the decisions they make because it is often these larger motives, tendencies, and social relationships that influence individual goals and the context of driving. In addition, the greatest opportunity for self-regulation of driving is at the higher levels of decision making; that is the strategic and life-goal levels. For example, at the life-goal level, safety is often an important consideration in the vehicle purchase decision (Eby & Molnar, 2012).

The purpose of this study was to develop and test a questionnaire to measure, in a comprehensive manner, the self-reported tactical, strategic, and life-goal self-regulatory practices employed by older drivers. Specific aims of the study were to: 1) develop a computer-based questionnaire that can be used in the US and elsewhere to study self-regulation; 2) recruit a sample of older drivers in Michigan comprised of individuals with clinically-determined functional impairments in vision, cognition, or psychomotor ability, as well as older adults recruited from the general population; and 3) pilot test the questionnaire with participants in the sample to assess its ease of use and understandability, as well its construct validity.

Methods

This study took place in two phases: the first phase involved developing the questionnaire instrument and the second phase involved pilot testing it with a sample of older drivers. Prior to commencing study tasks, approval for working with human subjects was obtained from the University of Michigan (U-M) Institutional Review Board. Fuller details on the study can be found in Molnar, Eby, Roberts, St. Louis, and Langford (2009).

Questionnaire development

Development of the questionnaire was based on review of the relevant literature on older driver self-regulation, consultation with experts in the field, and analysis of data from an existing UMTRI naturalistic driving database containing driving data for 26 drivers age 60-70 (LeBlanc et al., 2006) to identify common driving circumstances that might be included in the questionnaire. The questionnaire instrument underwent several rounds of review and revision by members of the study team to ensure that the content was comprehensive and appropriate (i.e.,

that the instrument addressed the full set of issues identified as being important to driving self-regulation), and that the layout was user-friendly, instructions were clear, and the language used was easy to understand. To facilitate this process, input was sought from a small convenience sample of older adults on the design of the instrument, through individual and group discussions. The final questionnaire instrument addressed several topics including: current driving patterns and changes over time; alternative transportation options; health and functional abilities; self-regulatory driving practices at the life-goal, strategic, and tactical levels; life-goal preferences and activities; feelings of driving comfort and safety; ability to self-regulate; and participant socio-demographic characteristics. The questionnaire was designed to take about 30-45 minutes to complete.

Participant recruitment

Inclusion criteria for study participation included: 1) being age 70 or older; 2) having a valid driver license; and 3) living in Southeastern Michigan. Two subgroups of participants were recruited. The first consisted of older adults recruited from the general population. Driver history files provided by the Michigan Department of State (MDOS) were used to select a random sample of 1,500 drivers age 70 and older residing in Southeastern Michigan. Letters were sent to each selected person in the sample inviting him or her to participate in the study. Interested individuals who contacted the study team were screened for study eligibility via telephone, and if eligible, scheduled to complete the questionnaire.

The second subgroup consisted of individuals who had recently attended one of the specialty clinics at the U-M Turner Geriatric Clinic or Kellogg Eye Center for losses in vision, cognition, or psychomotor functioning. The Turner Geriatric Clinic provides comprehensive multi-disciplinary assessment and ongoing primary care for older adults. It offers several specialty clinics that specifically target individuals with cognitive and/or psychomotor impairments. Kellogg Eye Center contains a Low Vision and Visual Rehabilitation Clinic as well as a general eye clinic, treating patients with vision loss ranging from mild visual impairment to legal blindness. Recruitment took place through the use of flyers in waiting areas and examination rooms, as well as referrals from physicians/health professionals in the clinics. All potential participants were screened via telephone to make sure they were eligible to participate, and if

eligible, scheduled for questionnaire completion. The total sample for the study, using both methods of participant recruitment, was 137; 105 from the general population and 32 from the clinic population (with all participants in the latter population coming from Kellogg Eye Center or one of the specialty clinics targeting cognitive impairment). This number was considered sufficiently large to provide meaningful pilot test results.

Questionnaire administration

The computer-based questionnaire was self-administered by study participants during a session in which a member of the research team was present. This took place either at UMTRI or the Turner Geriatric Clinic, depending on availability of project team staff and facilities, and preferences of study participants. In either location, administration of the questionnaire instrument occurred in a private setting. After completing a written informed consent, participants immediately completed the questionnaire. They also completed a brief interview to provide feedback on the instrument itself and their experience in completing it (e.g., clearness of instructions, understandability of language). Participation in all of the study protocols occurred over one session and lasted from 45 minutes to 1 hour. Each participant was paid $35 for his or her time at the end of the session.

Analysis

Data from the pilot test were entered into an electronic database and analyzed using *SAS* Software. The main purposes of the analyses were to summarize study participants' feedback about the questionnaire content and administration, and to assess construct validity of the questionnaire. Construct validity was assessed using two standard approaches (see Groves et al., 2004). First, responses were compared for the two recruitment populations (clinic and general) who would be expected to differ along such dimensions as functioning, abilities for safe driving, and feelings of driving comfort. Depending on the extent of differing responses between groups, one might also expect to see differences in actual self-regulation (see e.g., Charlton et al., 2006; Ross et al., 2009). Correlations were also examined between questionnaire items that, in theory, ought to be related (e.g., health, functioning, and abilities; feelings of comfort and feelings of safety across various driving situations). In addition, although the study was intended as a pilot

test, the relatively large sample allowed for preliminary exploration of differences by sex and age group (age 70-79 versus 80-88), as well as identification of overall patterns of self-regulation.

Univariate analyses were conducted to generate percentage distributions for nominal/ordinal level variables (e.g., sex, age group, whether or not participants reported trying to avoid various driving circumstances) and means for interval/ratio scale variables (e.g., self-ratings of abilities for safe driving, feelings of comfort in various driving circumstances). Bivariate analyses were also based on the level of measurement of each variable of interest and involved examination of participant responses for each questionnaire item by recruitment population (general versus clinic), sex (men versus women), and age group (age 70-79 versus age 80-88), as well as selected variables thought to influence self-regulation (e.g., perceptions of abilities and feelings of comfort). For nominal/ordinal level dependent variables, either the Chi-Square test or Fisher's Exact test were used. A Chi-Square test was used for contingency tables with at least 5 observations in each cell; otherwise, a Fisher's Exact test was used. For interval/ratio scale variables, a nonparametric test, the Wilcoxon Signed Rank test, was used rather than a t-test to compare group means for each of the variables of interest because several of the variables were not normally distributed or the sample sizes were small (see Cody & Smith, 1997). Nonparametric methods generally have the additional advantage of being resistant to outliers and other extreme values. Two-tailed tests were used for each of the group mean comparisons. Spearman Correlations were used to compare sets of interval/ratio scale variables.

Results

Characteristics of study participants for the pilot test of the questionnaire are shown in Table 1. The majority of participants were age 70-79. The mean age of participants was 76.7 (SD=4.8; values not shown in table). The sample was about evenly split between men and women. The majority were married and most lived in a residence (home, condo, or apartment) that they owned. Regardless of residence type, most had lived there for more than 5 years. About 10 percent of participants were born outside of the US but all participants had lived in the US for more than 5 years. Collectively, the areas in which participants lived represented a mix of urban, suburban, and rural. The majority of households consisted of the participant and at least one

other individual, with over three-quarters of participants reporting that someone else in the household also drove, and over a quarter reporting that others were dependent on them to drive. Most no longer worked outside the home. Household income and education levels covered a broad range, although more than half had a college degree or higher.

Table 1. Characteristics of Study Participants (n=137)		
	N*	**%**
Age		
70-79	99	72.3
80-88	38	27.7
Sex		
Male	69	50.4
Female	68	49.6
Marital status		
Married	81	59.1
Separated/divorced/never married	27	19.7
Widowed	27	19.7
Residence type		
Own home/condo/apartment	106	77.4
Rent or family home/condo/apartment	18	13.1
Senior/retirement community	10	7.3
Other	3	2.2
Length of time at current residence		
Less than 1 year	5	3.6
1-5 years	12	8.8
More than 5 years	119	86.9
Country of origin		
US	124	90.5
Other	13	9.5
Length of time in USA		
More than 5 years	137	100
Population density		
Urban	51	37.2
Suburban	69	50.4
Rural	16	11.7
Total number in household (including participant)		
One	43	31.4
Two	77	56.2
Three or more	12	8.8
Other drivers in household (if live with others)		
Yes	86	84.3
No	14	13.7
Others dependent on participant to drive them		
Yes	37	27.0
No	98	71.5
Work outside home for pay		
Full-time	2	1.5
Part-time/Occasional	16	11.6
No	113	82.5
Total household income		
<$20,000	14	10.2
$20,000-$49,000	51	37.2
$50,000-$79,000	30	21.9
$80,000-$99,000	14	10.2
$100,000+	15	10.9
Education		
High school degree or less	28	20.5
Some college or college degree	53	38.7
Some graduate education or graduate degree	56	40.9

* Numbers may not add to 137 due to non-responses.

Feedback on questionnaire content and administration

Feedback from study participants about the content and administration of the questionnaire instrument indicated that most found it easy to read and understand, and were satisfied with using a computer to complete it (Table 2). In fact, almost three-quarters reported that given a choice of other options, they preferred to take the questionnaire on the computer, despite the fact that most reported only low or medium levels of experience with computers. The length of the questionnaire was also considered reasonable. Participants' feedback on the questionnaire did not differ by the population they were recruited from (general versus clinic), sex, or age group (70-79 and 80-88), with the one exception that the older age group was less satisfied with using the computer ($p < 0.05$). Still, over 80 percent of the older age group reported being satisfied with using the computer to complete the questionnaire.

Table 2. Feedback on Questionnaire Content/Administration: N and Percent for Those Responding "Yes" (overall n=137)

	N	%
Overall, were the questions easy to read – that is, brief and to the point?	135	98.5
Overall, were the questions easy to understand – that is, was the wording clear and the language appropriate?	122	89.1
Overall, were you satisfied using a computer to complete the questionnaire?	125	91.2
If you had a choice, would you prefer to take this questionnaire as part of a written survey, telephone survey, a verbal interview, or on a computer like you did today?		
Written survey	12	8.8
Telephone survey	5	3.7
Verbal interview	11	8.0
Computer	100	73.0
No preference	9	6.6
How would you describe your level of experience with computers?		
Low	57	41.6
Medium	65	47.5
High	15	11.0
Overall did the length of the survey seem reasonable?	128	93.4

Questionnaire Results

This section discusses overall questionnaire results, as well as highlights differences by recruitment population, sex, and age group. Data for the general and clinic populations are categorized separately in tables, given our interest in differences between these two populations as one measure of construct validity. There were few differences by sex or age. Overall, participants reported driving an average of 5.6 days per week and 89.9 miles per week (SD=1.6, 100.5, respectively). Men reported driving more days per week (mean=6.1 for men and 5.2 for women; $p < 0.001$) and more miles per week (mean=112.8 for men and 66.3 for women; $p < 0.001$). There were no differences in reported driving frequency for the general and clinic populations, or between participants age 70-79 and age 80-88.

Ratings of health and functional abilities

Participants rated themselves relatively high in terms of their overall health and functioning, as measured by their ability to walk half a mile and climb two flights of stairs (Table 3). Participants recruited from the general population rated their overall health slightly but significantly higher than participants from the clinic population ($p< 0.05$). Overall, participants rated their abilities for safe driving relatively high. The lowest rating was for the ability to see clearly at night, but even this received a mean rating of 5.2 out of a possible score of 7. Participants recruited from the general population rated themselves higher than participants recruited from the clinic population on a number of dimensions including their ability to see clearly during the day, see clearly at night, remember things, and process information, as well as their ability to drive safely compared to others their age and to themselves 5 years ago. Ratings did not differ by sex or age group.

Table 3. Mean Ratings for Health, Functioning, and Abilities for Safe Driving					
	Overall Sample (n=137)		General Population (n=105)	Clinic Population (n=32)	Wilcoxon
	Mean	SD	Mean	Mean	Sig.
How would you rate the following in general? (with 1being poor and 7 being excellent)					
Your overall health	5.6	1.1	5.7	5.4	ns
Your ability to walk ½ mile	5.9	1.7	5.9	5.8	ns
Your ability to climb 2 flights of stairs	5.7	1.8	5.8	5.5	ns
How would you rate the following for safe driving? (with 1 being poor and 7 being excellent)					
Your ability to see clearly during the day	6.5	0.7	6.7	6.1	$p < .0001$
Your ability to see clearly at night	5.2	1.5	5.5	4.2	$p < .0001$
Your ability to remember things	5.7	1.1	5.8	5.4	$p < .05$
Your ability to process information, especially when paying attention to two or more things	5.5	1.2	5.7	4.9	$p < .01$
Your upper body strength and flexibility	5.8	1.2	5.8	5.8	ns
Your lower body strength and general flexibility	5.6	1.3	5.7	5.5	ns
How would you rate your ability to drive safely compared to…? (with 1 being poor and 7 being excellent)					
Others your age	6.2	1.0	6.3	5.7	$p < .05$
Yourself 5 years ago	5.9	1.1	6.0	5.4	$p < .01$

Driving confidence and feelings of driving comfort and safety

Participants were asked "How confident are you that you can safely drive to places you need to go (with 1 being not at all and 7 being completely)." Reported confidence among participants overall was high (Mean=6.7, SD=0.8). Participants from the general population reported higher confidence than participants from the clinic population (6.8 versus 6.4, $p < 0.01$), although the difference was small and ratings from both groups were high. Reported confidence did not differ by sex or age group.

Participants were asked about their feelings of comfort in a number of driving circumstances. Overall, participants were most comfortable driving alone and least comfortable driving at night in bad weather (Table 4). Participants recruited from the general population reported being more comfortable than participants recruited from the clinic population for every driving circumstance except driving alone. There were several differences by sex, with men reporting being more comfortable driving on high traffic roads ($p< 0.05$), in unfamiliar areas ($p< 0.05$), at night in bad weather ($p< 0.05$), in rush hour ($p< 0.05$), on the expressway ($p< 0.01$), and backing up ($p< 0.05$). There were no differences between the younger and older age groups. Participants were

also asked about their feelings of safety across the same set of circumstances to examine whether perceptions of comfort and safety had the same associations for participants. Safety related to the risk of getting in a crash, while comfort related to how at ease participants felt in specific driving situations. Participant responses were generally similar to those for feelings of comfort (Table 4). However, while men and women differed on several dimensions of driving comfort, the only sex difference for safety was for driving in unfamiliar areas, with women reporting feeling less safe.

Table 4. Mean Ratings of Feelings of Driving Comfort and Safety

	Overall Sample (n=137)		**Gen. Pop. (n=105)**	**Clinic Pop. (n=32)**	**Wilcoxon**
	Mean	**SD**	**Mean**	**Mean**	**Sig.**
How comfortable do you feel in the following situations? (with 1 being not at all and 7 being completely)					
Driving at night	4.6	2.0	5.1	3.1	$p < .0001$
Making unprotected left turns across oncoming traffic	5.4	1.8	5.6	4.7	$p < .01$
Driving in bad weather (rain, snow, fog, etc.)	4.6	1.8	4.8	3.7	$p < .01$
Driving on high traffic roads	5.3	1.7	5.6	4.1	$p < .0001$
Driving in unfamiliar areas	4.9	1.8	5.2	4.0	$p < .01$
Driving alone	6.5	0.8	6.5	6.5	ns
Driving at night in bad weather	4.0	2.0	4.4	2.6	$p < .0001$
Driving in rush hour traffic	5.2	1.7	5.5	4.2	$p < .001$
Driving on the expressway	5.8	1.7	6.1	4.5	$p < .0001$
Backing up	5.7	1.5	6.0	4.7	$p < .0001$
How safe do you feel in the following situations, in terms of your risk of getting in a crash? (with 1 being not at all and 7 being completely)					
Driving at night			5.2	3.3	$p<.0001$
Making unprotected left turns across oncoming traffic			5.3	4.6	$p<.05$
Driving in bad weather (rain, snow, fog, etc.)			4.5	3.4	$p<.01$
Driving on high traffic roads			5.5	4.1	$p<.001$
Driving in unfamiliar areas			5.3	4.2	$p<.01$
Driving alone			6.2	6.3	NS
Driving at night in bad weather			4.4	3.0	$p<.001$
Driving in rush hour traffic			5.4	4.3	$p<.01$
Driving on the expressway			5.7	4.7	$p<.01$
Backing up			5.8	4.8	$p<.05$

Self-regulatory practices

Participants were asked about a number of self-regulatory practices at the life-goal, strategic, and tactical levels. Participants were asked three main questions to get at life-goal self-regulation including whether during the past year they had moved to a location closer to the destinations they frequented, whether they had moved to a place with options for getting around other than driving themselves, and whether they had bought a different vehicle for safety reasons. Relatively few participants reported making any of these changes. Given the low overall numbers of participants who self-regulated at this level, it is not surprising that there were no differences in life-goal self-regulatory practices by recruitment population, sex, or age group.

At the strategic level, sizable percentages of participants reported that they try to avoid most of the driving circumstances presented (Table 5). Participants were most likely to report trying to avoid driving at night, driving in bad weather, driving at night in bad weather, and driving in rush hour. They were least likely to report trying to avoid driving alone. Three-quarters or more reported planning out their trips or combining trips. Only 6 percent reported bringing along someone to help them navigate. Participants recruited from the general population were considerably less likely than participants recruited from the clinics to report trying to avoid driving at night ($p < 0.01$), in unfamiliar areas ($p < 0.05$), and on the expressway ($p < 0.01$).

Table 5. Self-Regulation at Strategic Level: N and Percent for Those Reporting "Yes," Overall and By Population							
	Overall Sample (n=137)		General Pop. (n=105)		Clinic Pop. (n=32)		X^2/Fisher's Exact Test
	N	% of all	N	% of all	N	% of all	Sig.
Do you try to avoid driving at night?	73	53.7	49	47.1	24	75.0	p < .01
Do you try to avoid making unprotected left turns across oncoming traffic?	37	27.4	24	23.3	13	40.6	ns
Do you try to avoid driving in bad weather?	89	65.4	64	61.5	25	78.1	ns
Do you try to avoid driving on high-traffic roads?	44	32.4	30	28.9	14	43.8	ns
Do you try to avoid driving in unfamiliar areas?	44	32.4	28	26.9	16	50.0	p < .05
Do you try to avoid driving alone?	6	4.4	5	4.8	1	3.1	ns
Do you try to avoid driving at night in bad weather?	100	73.5	73	70.2	27	84.4	ns
Do you try to avoid driving in rush hour?	80	58.8	57	54.8	23	71.9	ns
Do you try to avoid driving on the expressway?	25	18.4	13	12.5	12	37.5	p < .01
Do you try to avoid backing up?	31	22.8	21	20.2	10	31.3	ns
Do you plan your trip ahead of time and write down your route?	92	68.2	69	67.0	23	71.9	ns
Do you make a practice run ahead of time to become familiar with your route?	39	28.9	30	29.1	9	28.1	ns
Do you reduce your overall travel by combining several trips into a single outing?	113	83.1	87	83.7	26	81.3	ns
Do you bring along a passenger to help you navigate?	12	8.8	10	10.2	2	5.3	ns

At the tactical level, at least a quarter or more of participants reported trying to avoid in-vehicle distractions while driving with over 90 percent reporting trying to avoid talking on a cell phone, reading a road map, or personal grooming (Table 6). Three-quarters or more reported leaving greater distances between their car and the car ahead. Participants recruited from the general population were considerably less likely than participants recruited from the clinics to report trying to avoid conversations with passengers. There were no differences by sex. Younger participants were less likely than older participants to report trying to avoid conversations with passengers ($p < 0.01$).

Table 6. Self-Regulation at Tactical Level: N and Percent for Those Reporting "Yes," Overall and By Population							
	Overall Sample (n=137)		General Pop. (n=105)		Clinic Pop. (n=32)		X^2/Fisher's Exact Test
Item	N	% of all	N	% of all	N	% of all	Sig.
Do you leave greater distances between your car and the car ahead of you?	108	80.0	83	80.6	25	78.1	ns
While driving, do you try to avoid talking conversationally with passengers?	36	26.5	21	20.2	15	46.9	$p < 0.1$
While driving, do you try to avoid eating?	108	79.4	82	78.9	26	81.3	ns
While driving, do you try to avoid reading a road map?	127	93.4	98	94.2	29	90.6	ns
While driving, do you try to avoid changing the radio stations?	42	30.9	35	33.7	7	21.9	ns
While driving, do you try to avoid talking on a cell phone ?	126	92.7	98	94.2	28	87.5	ns
While driving, do you try to avoid personal grooming?	127	93.4	97	93.3	30	93.8	ns

Correlations among variables

As part of assessing the questionnaire's construct validity, we generated correlations for various pairs of variables that could reasonably be expected to be correlated, based on the literature. Most of the variables related to health, functioning, and abilities for safe driving were correlated with one another (see Table A1 in Appendix). Of note were the following statistically significant correlations: 0.64 for the ability to walk a half mile and the ability to climb two flights of stairs; 0.53 for overall health and the ability to walk half a mile; 0.40 for overall health and the ability to climb two flights of stairs; 0.65 for the ability to remember things and the ability to process information; 0.50 for the ability to see clearly during the day and the ability to see clearly during the night; 0.59 for the ability to walk half a mile and lower body strength/general mobility; and 0.47 for the ability to climb two flights of stairs and lower body strength and general mobility (p's < 0.0001).

All of the health, functioning, and abilities for safe driving variables were also significantly correlated with self-ratings for general ability to drive compared to others your age and general ability to drive compared to self 5 years ago (with significant correlations ranging from 0.20 to 0.36, p's $< .05$ or better; see Table A1 in Appendix). In addition, for each driving circumstance

presented in the questionnaire (e.g., driving at night, making unprotected turns), participants' feelings of comfort in that situation were significantly correlated with their feelings of safety in the same situation (see Table A2 in Appendix). Spearman correlations between comfort and safety were significant at $p < .001$ for each of the driving circumstances and ranged from 0.82 for both driving in rush hour traffic and backing up to 0.67 for driving alone (the only correlation less than 0.71).

To explore associations between feelings of comfort/safety and self-regulation, comparisons were made for each of the specific driving circumstances between the mean comfort/safety scores of participants who tried to avoid that specific driving circumstance and the mean comfort/safety scores of participants who did not try to avoid that situation. For every driving circumstance, driving avoidance was associated with both comfort and safety; that is, in every case, those participants who tried to avoid a driving circumstance reported being less comfortable and less safe with that situation (p's $< .01$ or better; see Table A3 in Appendix).

Discussion

This project developed and tested a questionnaire designed to examine the nature and extent of self-regulation by older drivers, and the factors that influence the broad array of self-regulatory practices at the life-goal, strategic, and tactical levels of driver performance and decision making. Results suggest that the questionnaire is a user-friendly instrument for gathering information from older adults about their self-regulatory practices and that the instrument has good construct validity. Feedback on the questionnaire was positive, with most participants considering the questions easy to read and understand (98.5 and 89.1 percent, respectively) and finding the length to be reasonable (93.4 percent). Most (91.2 percent) were satisfied with the computer format, despite the fact that only 11.0 percent described their level experience with computers as high. Older participants were less satisfied with the computer format, although satisfaction was still high (81.6 percent) Overall, almost three-quarters of participants reported that if given a choice, they would prefer to take the questionnaire on a computer rather than as part of a written survey, telephone survey, or verbal interview.

Construct validity of the questionnaire was assessed in two ways: 1) by making comparisons between the clinic and general populations along a number of dimensions on which they might be expected to differ, including their self-ratings for health and functioning, abilities for safe driving, and feelings of driving comfort and safety; and 2) looking for statistically significant correlations between variables that one would reasonably expect to be correlated. Overall, participants rated their general health and functioning, as well as various abilities for safe driving quite highly. However, participants from the clinic population rated themselves lower than participants from the general population on several abilities including seeing clearly during the day, seeing clearly at night, remembering things, and processing information. It is not surprising that no differences were found between the groups on psychomotor abilities given that most of the participants from the clinic population ended up being recruited from the vision clinics or cognitive disorders clinics, rather than the movement disorder clinics at the university. While participants reported high levels of comfort and safety for most circumstances, except for driving at night in bad weather (4.0 for comfort, 4.1 for safety), the clinic population reported lower levels of comfort and safety than the general population for every driving circumstance except driving alone. Analyses showed very high correlations among the concepts of comfort and safety overall and the absolute mean scores were nearly identical for each driving circumstance.

Although the clinic population appeared to be more likely to engage in strategic self-regulation in every driving circumstance presented to participants, only three of these reached statistical significance: avoiding driving at night, avoiding driving in unfamiliar areas, and avoiding driving on the expressway. The other apparent differences were in the expected direction, however, and the lack of significance may have been due to the relatively small sample size for the clinic population and, for at least some of the circumstances, the low likelihood of self-regulation occurring at all (e.g., only six participants at all reported trying to avoid driving alone, and 12 bringing along a passenger to help navigate). Further, the results are in line with other studies that have found that functionally impaired populations do self-regulate their driving but not in all situations and not in their entirety (e.g., Braitman & Williams, 2011; Okonkwo, Crowe, Wadley & Ball, 2007; Ross et al., 2009).

There were no differences between the clinic and general populations at the life-goal level. Given that so few people reported any life-goal self-regulatory practices, the lack of differences between the groups is not surprising. This is the first study to examine life-goal self-regulation. Life-goal self-regulatory practices involve major life decisions and many people may not be ready to face those decisions when they still consider themselves to be relatively highly functioning as did our sample. Further work is needed to follow drivers over longer periods of time to collect information on life-goal self-regulatory practices and the factors that influence them because of the opportunity that life-goal decisions afford for enhancing older adult safety and mobility. For example, although aging in place is favored by many older adults, there may be opportunities to create more livable communities with more accessible housing options to foster continued mobility. Similarly, issues related to making vehicles safer and more accessible for older adults, as well as better educating older consumers about the safety features in vehicles are increasingly being recognized as worthwhile (e.g., Eby & Molnar, 2012).

While the primary purpose of this study was to develop and pilot test a questionnaire using a new conceptual framework for self-regulation, the results also provide some general insights into self-regulatory behaviors among older adults. At the strategic level, sizable numbers of participants reported that they try to avoid a variety of specific driving circumstances. Most notably, over half of participants tried to avoid driving at night or in rush hour traffic, two-thirds tried to avoid driving in bad weather, and close to three-quarters tried to avoid driving at night in bad weather. Other driving circumstances including making unprotected left turns, driving on high traffic roads, and driving in unfamiliar areas were also avoided by close to one third or more of participants. Many planned out their trips ahead of time or reduced overall travel by combining trips. At the tactical level, a majority of participants tried to avoid in-vehicle distractions with the exception of changing radio stations, and most try to leave more room between their cars and the cars ahead of them. These results point to the utility of examining self-regulation at multiple levels of driver performance and decision making.

Few differences in these self-regulatory practices were found between men and women, or between younger and older participants. It may be that we did not find more differences by sex or age group because of the generally high level of functioning among our sample. Although

women reported lower feelings of comfort than men for many driving circumstances (driving on high-traffic roads, in unfamiliar areas, at night in bad weather, in rush hour traffic, on the expressway, and backing up) they were not more likely than men to report avoiding these driving circumstances. Women's reported feelings of safety were similar to men's for all driving situations except driving in unfamiliar areas. Younger and older participants did not differ in their responses for either comfort or safety. Further investigation of the relationship between feelings of comfort/safety and self-regulation is clearly warranted, although our findings suggest that the two concepts may be interchangeable, except, notably, when comfort and safety ratings are compared among men and women.

Further research should be useful in building on our preliminary results to delve more deeply into factors that affect self-regulation and their interactions. For example, we explored the respective roles that feelings of comfort and safety in various driving circumstances play in the self-reported avoidance of those situations. We found that both driving comfort and safety were highly related to driving avoidance. In other words, if participants did not feel comfortable or did not feel safe driving in certain situations, they also reported that they avoided those situations. The result relative to comfort supports previous work showing that driving self-regulation is based at least partially on perceived comfort while driving (e.g., Blanchard & Myers, 2010; MacDonald, Myers & Blanchard, 2008; Meng & Siren, 2012). In follow-up work building on this project, multivariate methods will be used to explore the relationships among comfort, safety, and other important variables that collectively appear to influence the self-regulatory practices of older adults. In addition, self-regulatory practices at all levels, but especially the life-goal level, will be explored more fully.

The study had some limitations. Although the general population portion of the sample was recruited from an initial random sample of licensed older drivers in Southeastern Michigan, participants were, nevertheless, volunteers. All participants from the clinic population were self-selected into the study, sometimes after initially being approached by their physicians. Furthermore, recruiting participants from the clinic population who met the eligibility criteria of being at least age 70 and still driving proved to be much more challenging than expected and the final number of participants (32) was too small to allow us to separate out participants with

visual, cognitive, and psychomotor impairments for analysis. Instead, we had to combine all types of impairment (visual, cognitive, and psychomotor) for comparisons with the general population. Our sample was highly educated and primarily White, and non-Hispanic (although specific racial and ethnic information was not included in the questionnaire), limiting our ability to make comparisons with the larger population. Because this was a pilot test of a questionnaire instrument, the data were all self-reported and the analyses were necessarily exploratory and descriptive in nature. In later stages of the research program, the questionnaire data will be supplemented by objective measures of functional ability and naturalistic driving data to further untangle the complexity of the self-regulatory process among older adults.

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Appendix

Table A1. Correlation Between Health, Functioning, and Abilities Variables											
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
A	1	.53*	.40*	.38*	.24#	.26#	.32+	.40*	.48*	.21^	.33*
B	.53*	1	.64*	.23#	.13	.12	.25#	.39*	.59*	.25#	.26#
C	.40*	.64*	1	.19^	.07	.03	.22#	.38*	.47*	.22^	.23#
D	.38*	.23#	.19^	1	.50*	.32+	.36*	.28#	.29+	.20^	.36*
E	.24#	.13	.07	.50*	1	.38*	.45*	.34*	.29+	.28+	.33+
F	.26#	.12	.03	.32+	.38*	1	.65*	.22^	.26#	.22^	.24#
G	.32+	.25#	.22#	.36*	.45*	.65*	1	.32+	.40*	.32+	.33*
H	.40*	.39*	.38*	.28#	.34*	.22^	.32+	1	.63*	.29+	.36*
I	.48*	.59*	.47*	.29+	.29+	.26#	.40*	.63*	1	.29+	.30+
J	.21^	.25#	.22^	.20^	.28+	.22^	.32+	.29+	.29+	1	.70*
K	.33*	.26#	.23#	.36*	.33+	.24#	.33*	.36*	.30+	.70*	1

*p<.0001
+p<.001
#p<.01
^p<.05

A: How would you rate your overall health?
B: How would you rate your ability to walk half a mile?
C: How would you rate your ability to climb two flights of stairs?
D: For safe driving, how would you rate your ability to see clearly during the day?
E: For safe driving, how would you rate your ability to see clearly at night?
F: For safe driving, how would you rate your ability to remember things?
G: For safe driving, how would you rate your ability to process information, especially when paying attention to two or more things?
H: For safe driving, how would you rate your upper body strength and flexibility, including your neck, arms and hands?
I: For safe driving, how would you rate your lower body strength and general mobility, including your legs and feet?
J: How would you rate your ability to drive safely compared to other drivers your age?
K: How would you rate your ability to drive safely compared to yourself 5 years ago?

Table A2. Spearman Correlations between Feelings of Comfort and Feelings of Safety			
	N	**Correlation Coefficient**	**P-Value**
Feelings of Comfort/Feelings of Safety			
Driving at night	127	.81	p<.0001
Making unprotected left turns across oncoming traffic	126	.76	p<.0001
Driving in bad weather (rain, snow, fog, etc.)	122	.71	p<.0001
Driving on high traffic roads	125	.71	p<.0001
Driving in unfamiliar areas	123	.72	p<.0001
Driving alone	127	.67	p<.0001
Driving at night in bad weather	127	.82	p<.0001
Driving in rush hour traffic	126	.78	p<.0001
Driving on the expressway	128	.82	p<.0001
Backing up	123	.76	p<.0001

Table A3. Comparison of Mean Comfort/Safety Scores for Specific Driving Situations by Whether Participants Reported Trying to Avoid Those Driving Situations					
	Participants who try to avoid driving situation		Participants who do not try to avoid driving situation		Wilcoxon
	N	Mean	N	Mean	
Specific driving situation avoided or not avoided relative to feelings of comfort for that driving situation					
Driving at night	70	3.3	62	6.2	p<.0001
Making unprotected left turns	35	4.0	96	5.9	p<.0001
Driving in bad weather (rain, snow, fog, etc.)	85	4.0	45	5.6	p<.0001
Driving on high traffic roads	41	4.2	90	5.8	p<.0001
Driving in unfamiliar areas	42	3.5	91	5.6	p<.0001
Driving alone	6	4.8	124	6.6	p<.001
Driving at night in bad weather	97	3.3	35	6.0	p<.0001
Driving in rush hour traffic	79	4.6	53	6.1	p<.0001
Driving on the expressway	25	3.4	106	6.3	p<.0001
Backing up	30	3.9	90	6.3	p<.0001
Specific driving situation avoided or not avoided relative to feelings of safety for that driving situation					
Driving at night	69	3.6	58	6.0	p<.0001
Making unprotected left turns	35	4.1	93	5.5	p<.0001
Driving in bad weather (rain, snow, fog, etc.)	81	3.9	45	5.0	p<.001
Driving on high traffic roads	41	4.3	86	5.5	p<.001
Driving in unfamiliar areas	41	4.0	83	5.5	p<.0001
Driving alone	6	4.8	125	6.2	p<.01
Driving at night in bad weather	93	3.6	35	5.5	p<.0001
Driving in rush hour traffic	74	4.7	53	5.7	p<.001
Driving on the expressway	25	3.4	105	6.0	p<.0001
Backing up	29	3.9	98	6.0	p<.0001

Chapter 5: Research Design and Methods

To answer the three research questions identified in Chapter 3, the researcher used a subset of data from Ozcandrive, a longitudinal cohort study underway by Monash University Accident Research Centre (MUARC). Ozcandrive is a partnership with the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive; see Marshall et al., 2012; Marshall, Man-Son-Hing et al., 2013) an interdisciplinary, health-focused research program dedicated to improving the safety of older drivers. Candrive/Ozcandrive represents the first study to follow a large group of older drivers over several years, and collect comprehensive self-report and objectively-derived data on health, functioning, and driving. A major focus of the study is to document the natural driving life course of older drivers, including the transition from driving to non-driving, using self-reported and objectively-derived driving and clinical data. The researcher used data from the portion of the Ozcandrive sample recruited from the greater Melbourne area of Victoria, Australia.

The study design employed by the researcher called for use of three types of data from Ozcandrive: 1) self-report questionnaire data on self-regulation and factors that may influence it, using an adapted version of the questionnaire described in Chapter 4; 2) clinical assessment data on visual, cognitive, and psychomotor functioning; and 3) naturalistic driving data collected through in-car recording devices (ICRDs) installed in participants' personal vehicles. Recruitment of the sample, administration of the comprehensive clinical assessment, and installation and downloading of the ICRD data were part of the regular Candrive/Ozcandrive protocols and were carried out by the MUARC project team. Oversight of questionnaire administration (for the self-regulation instrument developed specifically for the PhD research) was the responsibility of the researcher. The researcher was also responsible for deriving driving measures from the raw ICRD data and conducting all analyses to answer the research questions. Table 2 below shows the types of data that were used to answer each of the three thesis research questions. Further detail about the research design and methods follows the table. The Ozcandrive study, including the add-on PhD research was approved by the Monash University Human Research Ethics Committee (see Appendix A in Chapter 11for ethics approval certificates). At the time this PhD research was undertaken, 246 of the total 257 participants in

the Ozcandrive Melbourne area sample had been recruited and had undergone the clinical assessment and completed the researcher's questionnaire on self-regulation, while ICRD data had been processed for 220 study participants.

Table 2: Type of Data Used for Each Research Question			
Research Question	**Approach**		
	Self-Regulation Questionnaire	**Clinical Assessment**	**Naturalistic Driving (ICRD)**
1. What is the nature and extent of self-regulation by older drivers?	X		
2. How is self-regulation influenced by various individual, social, and environmental factors?	X	X	
3. How do self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors?	X		X

5.1. Participant recruitment

Study participants for the Ozcandrive Melbourne area sample were primarily recruited through letters mailed to Victorian drivers who had recently participated in a MUARC driving survey and indicated their willingness to be contacted for future older driver studies, as well as through membership of the Royal Automobile Club of Victoria (RACV). In addition, participants were recruited through community and city newspapers, newsletters, posters, and presentations to various senior-related associations. Recruitment began in June 2010 and closed in June 2011. Potential participants who expressed interest in the study were contacted via telephone by a research assistant from Ozcandrive and screened for eligibility and study commitment. The overall aim was to recruit older, active drivers who would potentially be able to participate in the study for up to 5 years.

Inclusion criteria for Ozcandrive were: having a general class driver license and having been actively driving for at least 1 year; being age 75 or older; driving at least 4 times per week; having agreed to undergo an annual physical, cognitive, and vision assessment, and be contacted at least quarterly for vehicle data pickup and interview; residing in the local region of the study city for at least 10 months a year; being followed actively by a family physician; intending to

continue driving for the next 5 years; being fluent in English; consenting to release driving information from the licensing authority; having access to a vehicle of model year 2003 or newer; and driving one vehicle for at least 70 percent of the time. Exclusion criteria were: a planned move out of the region; a medical contraindication to driving within the previous 6 months (according to the Austroads guide; Austroads, 2006); or a diagnosis of progressive conditions that could affect driving (e.g., Alzheimer's disease, macular degeneration).

5.2 Data Collection

5.2.1 Clinical assessment data

As part of the larger Candrive/Ozcandrive study, participants completed a comprehensive clinical assessment after enrolling in the study that included standardized tests and physical examination to assess cognition, vision, and psychomotor functioning. The clinical assessment protocols were developed/adapted and pilot tested by the Candrive researchers (see Woolnough et al., 2012). The assessment battery was conducted in a consulting room by a research assistant with health/psychology training and took between 2 and 3 hours to complete. The duration of 3 hours (plus scheduled breaks) was considered acceptable by 98 percent of participants in a pilot study conducted in Canada (Marshall, Wilson et al., 2013). As part of the Candrive/Ozcandrive protocol, participants underwent a baseline clinical assessment at the beginning of their participation in the study and then returned each year for an annual re-assessment. Only the baseline clinical assessment was used by the researcher for the PhD research.

Specific clinical assessment measures used by the researcher were: visual acuity of both eyes using the Snellen chart (Anderson & Holliday, 1995; Davey, 1981); contrast sensitivity as measured by the Pelli-Robson test (Pelli, Robson & Wilkins, 1988); cognitive functioning using the Trail Making Test B (Moses, 2004); Rapid Pace Walk (American Medical Association, 2003), and Motor Free Visual Perception (MVPT) test (Colarusso & Hammill, 2003). As described by Woolnough et al. (2012), these measures were operationalized in the Candrive protocol as follows: for Trail Making test Part B, the time to completion in seconds and the total number of errors were recorded; for the Rapid Pace Walk, the total number of seconds to walk 10 feet and then turn around and walk another 10 feet was recorded; for the Visual Acuity (Snellen eye chart), scores were recorded as the smallest row of letters that could be accurately

detected (no errors) while standing 10 feet from the Snellen chart, with the test being completed for the left eye, the right eye, and both eyes. For the MVPT test, participants were presented with a series of 13 target items. For each target item, they had to choose which one of four incomplete drawings, if completed, would match the target item (Vance et al., 2006). The total time to complete the series was recorded. Contrast sensitivity was measured using the established protocol for the Pelli Robson sensitivity chart, with higher scores denoting better contrast sensitivity (Owsley, Stalvey, Wells, Sloane & McGwin, 2001).

5.2.2 ICRD data

At the time participants came in for their clinical assessment, their primary vehicle was installed with a custom-designed ICRD (OttoView-CD), developed for Candrive by Persentech Inc. in Winnipeg, Manitoba (see Smith et al., 2012). The power supply and data for the ICRD came from the vehicle via the On Board Diagnostic (OBDII) port (present in all vehicle models 2003 or later in Australia). The ICRD automatically started when the vehicle ignition was turned on and shut down when the vehicle ignition was turned off. Vehicle location information was also collected, using a GPS antenna mounted on the dash and a receiver in the main device box. In cases in which the participant shared a vehicle with others, a radio frequency identifier system (antenna plus key chain fob used by the study participant) was used to identify the participant as the vehicle driver so that driving data for nonparticipants could be removed. Participants' data were stored on an SD memory card at a rate of 1 Hz.

Participants were asked to drive as they normally would with the ICRD installed in their vehicle. Anyone reporting that he or she shared a vehicle with another person was asked to keep a driving log to record any trips made by another driver, if there was not an RFID antenna and fob set up. At the end of 4 months of driving, data from the ICRD were downloaded as part of the first quarterly data download. Following the data download, all participants were interviewed to clarify any data issues that had arisen during the driving period, as well as provide information about other vehicles they may have driven in addition to their primary vehicle, including the number of days per week and self-estimated total kilometers driven. Participants were also queried about whether they had driven the other vehicle on a regular basis or during a single block of time (e.g., a rental car during a vacation).

5.2.3. Questionnaire data

Participants completed the researcher's computer-based questionnaire on self-regulation, termed the Advanced Driving Decisions and Patterns of Travel (ADDAPT) instrument after completing approximately 4 months of driving for the study. The questionnaire was adapted from a questionnaire developed and pilot tested at UMTRI (Molnar et al., 2009; also see Chapter 4). Revisions to the original instrument were made based on participant feedback on the questionnaire during the pilot testing, as well as analyses of the actual response patterns for specific questionnaire items. Some questions that were especially problematic for participants were dropped (e.g., items asking participants to rate the accessibility, acceptability, affordability, and adaptability of various transportation options were confusing). Other items were added to better facilitate comparison with the ICRD data to answer research question 3. Open-ended responses were used to either develop new items (e.g., asking about starting an exercise program or fitness routine as a life-goal modification) or develop response options for items that had previously been open-ended (e.g., reasons for driving modification). In addition, the questionnaire language was modified for use by Australasian drivers to ensure that terms were culturally appropriate and applicable to their driving environment (e.g., asking about right hand turns instead of left hand turns to get at turning across traffic). This process took place in consultation with the Ozcandrive researchers.

ADDAPT was designed to examine reported self-regulation at multiple levels of driver performance and decision making, including the tactical, strategic, and life-goal levels. The following general topics were included in the questionnaire: current driving patterns and changes over time; alternative transportation options; participant socio-demographic characteristics; general health and functioning; abilities for safe driving; self-regulatory driving practices at the life-goal, strategic, and tactical levels; life-goal preferences and activities related to driving (e.g., importance of various types of trips); feelings of driving comfort and safety; and ability to self-regulate (i.e., the extent to which individuals who wanted to self-regulate could actually do so).

At the life-goal level, respondents were asked about three lifestyle-related changes they might have made during the past year that could impact driving (with the decision to include these three changes based on results of pilot testing of the questionnaire): moving to a new location;

purchasing a different vehicle; and starting an exercise program. At the strategic level, driving avoidance behavior was measured by a series of yes/no questions asking respondents if they tried to avoid driving at night, in bad weather, on busy roads, in unfamiliar areas, alone, at night in bad weather, during rush hour traffic, or on the freeway, as well as making right turns across oncoming traffic at intersections without right hand turn arrows and reversing. Respondents were also asked if they planned their route ahead of time, made a practice run to become familiar with their route, combined trips into a single outing, or brought passengers along to help navigate, as well as whether they had reduced the amount of driving they did over the past year in any way including driving fewer days or kilometers per week, taking fewer trips per week, or reducing the distance of their trips. At the tactical level, respondents were asked a series of yes/no questions about trying to avoid various in-vehicle distractions while driving, including chatting with passengers, eating, reading a road map, changing radio stations, talking on a mobile phone, or personal grooming. Respondents were also asked if they tried to leave more room than they used to between their car and the car ahead of them. Other measures in the questionnaire are described more fully in the publications in Chapters 6-8. In addition, the full codebook for the questionnaire is contained in Appendix B of Chapter 11.

ADDAPT was also designed to identify individuals' reported motivations for modifying their driving. To that end, respondents who reported making modifications at the life-goal, strategic, or tactical levels were asked what their reasons were. At the life-goal level, respondents who reported moving to a new location were asked whether the move was influenced by wanting to be closer to the places they normally drove to, wanting more options for getting around, or other reasons related to driving or mobility. Respondents who had purchased a different vehicle were asked whether their decision was influenced by not feeling comfortable driving their previous car, not feeling safe driving their previous car, or other reasons related to driving. Finally, respondents who reported that they had started a regular exercise program or fitness regime were asked to provide reasons in an open-ended response format. No response options were provided for this item as it had not been included in the original questionnaire and, thus, it was not known what reasons might be expected.

Participants who responded in the affirmative to any of questions about driving modification at the strategic or tactical levels were asked what their reasons were. Six of the response options for the strategic and tactical levels were related to what is commonly thought of as self-regulation: 1) difficulty seeing during the day or night; 2) difficulty remembering things; 3) difficulty concentrating on more than one thing at a time; 4) reduced strength, flexibility, or general mobility; 5) not feeling comfortable; 6) not feeling safe relative to getting in a crash. Two response options were related to what would be considered lifestyle or preferences rather than self-regulation: have always tried to avoid that situation/engage in that practice; don't need to avoid the situation/engage in that practice. There was also an option for "other" (with the respondent asked to describe the reason). Multiple reasons for each reported behavior could be recorded.

ADDAPT was self-administered by study participants during a session in which an Ozcandrive research assistant was present in the room to provide assistance if needed. Completion of the questionnaire took on average 30-45 minutes. Research assistants received in-person training on the questionnaire from the researcher during a visit to MUARC soon after the Ozcandrive study was initiated.

5.3 Data Processing

5.3.1 Clinical assessment data

All clinical assessment data were recorded by Ozcandrive research assistants on special forms designed with Teleform Software to allow the conversion of hand-written data into an electronic format. Forms were checked for completeness, scanned, and uploaded to a section of Candrive's website that was only accessible to project staff. Once the forms were uploaded and verified, they were submitted to the Ottawa Hospital Research Institute's Methods Centre, contracted to manage and process the Candrive data. The forms were rechecked by the Methods Centre for errors and returned to Ozcandrive if corrections were needed. Appropriate protocols were used to ensure data confidentiality and security.

5.3.2 ICRD data

All downloaded ICRD data were sent by Ozcandrive project staff to the Winnipeg Candrive site using a file transfer protocol server at the University of Manitoba for preliminary data processing. Data were then sent to UMTRI where they were cleaned during a multi-stage process, based on information provided by the Winnipeg site. Further processing was also done to the raw ICRD data to derive actual measures of driving that could be used in the researcher's analyses. All of these processes are described in detail in the methods section of Publication 4 in Chapter 8.

5.3.3. Questionnaire data

All questionnaire data were electronically recorded by participants, using the computer-based instrument. The data files were sent to UMTRI electronically and transferred into an EXCEL spreadsheet. All data were checked for consistency and completeness.

5.4 Data Analyses

All data analyses were conducted using IBM SPSS Statistics version 19, and in consultation with a statistician. Exploratory analyses were conducted to examine distributions and overall patterns in the data. As part of this process, univariate statistics were generated to plot and describe the data, and identify preliminary findings of interest. Selected bivariate analyses were also conducted using t-tests, Wilcoxon Signed Ranked Tests, Chi-Square tests, or Fisher's Exact Tests, depending on the level of the variables being analyzed (nominal, ordinal, interval, ratio) and other properties (e.g., normally distributed, cell size). For example, participants' overall avoidance behavior, without taking into account motivations for that avoidance, was examined by gender, age, and self-ratings of abilities and feelings of comfort for several strategic level driving situations, based on self-report (Molnar et al., 2012; see Appendix C of Chapter 11 for paper published in Australasian Road Safety Research, Policing, and Education Conference Proceedings).

The outcomes of these exploratory analyses helped guide decisions about appropriate statistical techniques for answering the research questions, as well as variables to include in statistical models. Several variables were dropped from further analyses because the questionnaire items

did not yield sufficient variability to distinguish between respondents. For example, 98.8 percent of participants reported that public transport was available in their neighborhood and 99.6 percent reported that private transport was available in their neighborhood. These variables were therefore not included in models as potential predictor variables. Additional variables related to driving exposure (measured by days per week and kilometers per week driven) were also investigated as potential predictors and moderators. Due to lack of significance, these effects were not included in the final models. The data analyses used to answer each of the three research questions are described in the appropriate publications contained in Chapters 6-8.

Because a major contribution of the PhD research was to separate out self-regulation from more general driving modification or avoidance, it is worth repeating some of the discussion on how self-regulation was operationalized for the analyses. For each potential driving modification asked about at the strategic and tactical levels, participants were classified into one of three groups based on whether they reported making the modification and if so, what their motivations were: 1) non-modifiers (those who did not report modifying their driving); 2) self-regulators (those who reported modifying their driving either by avoiding a particular situation or engaging in a particular practice for reasons related to perceived challenges associated with driving; and 3) others (those who reported modifying their driving but for reasons other than perceived driving-related challenges). To be considered a self-regulator, participants had to choose at least one of six self-regulatory reasons. The life-goal level was not submitted to the same analysis given the relatively small numbers of respondents reporting life-goal changes. Distributions of these three classifications across the various strategic and tactical situations are shown in Table 3 below.

Table 3: Driver Groups at Strategic and Tactical Levels					
	Strategic Level		Tactical Level		
Situation	N	%	Situation	N	%
Driving at night			Chatting with passengers while driving		
Non-modifiers	191	77.6	Non-modifiers	174	71.3
Self-regulators	40	16.3	Self-regulators	34	13.9
Others	15	6.1	Others	36	14.8
Making unprotected right turns			Eating while driving		
Non-modifiers	220	89.4	Non-modifiers	51	20.9
Self-regulators	17	6.9	Self-regulators	84	34.4
Others	9	3.7	Others	109	44.7
Driving in bad weather			Reading a road map while driving		
Non-modifiers	160	65.0	Non-modifiers	19	7.8
Self-regulators	49	19.9	Self-regulators	101	41.4
Others	37	15.0	Others	124	50.8
Driving on busy roads			Changing radio stations while driving		
Non-modifiers	205	83.3	Non-modifiers	168	68.9
Self-regulators	12	4.9	Self-regulators	25	10.2
Others	29	11.8	Others	51	20.9
Driving in unfamiliar areas			Talking on a mobile phone while driving		
Non-modifiers	212	86.2	Non-modifiers	9	3.7
Self-regulators	21	8.5	Self-regulators	89	36.9
Others	13	5.3	Others	143	59.3
Driving alone			Personal grooming while driving		
Non-modifiers	242	98.8	Non-modifiers	10	4.2
Self-regulators	-	-	Self-regulators	58	24.2
Others	3	1.2	Others	172	71.7
Driving at night in bad weather			Leave more room between your car and car ahead		
Non-modifiers	136	55.7	Non-modifiers	140	58.1
Self-regulators	70	28.7	Self-regulators	86	35.7
Others	38	15.6	Others	15	6.2
Driving during rush hour traffic					
Non-modifiers	131	51.0			
Self-regulators	32	12.5			
Others	81	31.5			
Driving on the freeway					
Non-modifiers	224	91.8			
Self-regulators	10	4.1			
Others	10	4.1			
Reversing					
Non-modifiers	215	88.1			
Self-regulators	16	6.6			
Others	13	5.3			
Plan your route ahead of time					
Non-modifiers	74	30.7			
Self-regulators	48	19.9			
Others	119	49.4			
Make a practice run to become familiar with your route	221	92.1			
Non-modifiers	1	0.4			
Self-regulators	18	7.5			
Others					
Combine trips into a single outing					
Non-modifiers	76	31.5			
Self-regulators	5	2.1			
Others Does for other reasons	160	66.4			
Bring passengers along to help navigate					
Non-modifiers	238	98.9			
Self-regulators	1	0.4			
Others	2	0.8			
Reduced your driving in the past year					
Non-modifiers	227	92.3			
Self-regulators	3	1.2			
Others	16	6.5			

* Numbers may not add to 246 for each situation due to missing data.

To help confirm that these classifications did in fact represent three distinct groups, a one-way analysis of variance (ANOVA) with a Bonferroni correction was used to examine the relationship between each of the three-way variables identified in Table 3 and a large set of self-reported health, functioning, and driving-related measures (e.g., overall health, various abilities for safe driving, enjoyment, importance of various activities such as shopping and spending time with family or friends, feelings of driving comfort and safety). Appendix D in Chapter 11 contains a set of tables showing results of these analyses. Collectively, results from the tables suggest that there were enough significant differences between each of three driver groups on various measures examined that it would not be advisable to collapse any of the groups; that is, the three groups do appear to be distinct along a number of important dimensions. Therefore, in subsequent analyses focusing on reported strategic and tactical self-regulation, only "self-regulators" (i.e., those who reported modifying their driving either by avoiding a particular situation or engaging in a particular practice for reasons related to perceived challenges associated with driving) were included unless otherwise noted.

Chapter 6: Driving Avoidance by Older Adults: Is It Always Self-Regulation? (Publication 2)

This paper addresses the researcher's first research question: What is the nature and extent of self-regulation by older drivers? The paper examines reported self-regulatory practices among older adults, taking into account the specific motivations for why people modify their driving by avoiding certain situations or engaging in other practices. This is important because there are many reasons for avoiding driving situations that have nothing to do with self-regulation, such as no longer needing to take trips at certain times of day because of changes in preferences or lifestyles. Therefore, a better understanding of the nature and extent of self-regulation requires an approach that can disentangle reported self-regulatory driving behaviors from reported driving avoidance or reduction for other reasons. At the time the thesis was submitted for examination, this paper was under review by Accident Analysis and Prevention. Included here is the submitted version of the paper. Subsequent to submitting the thesis for examination, the paper was revised and accepted for publication, and is now published (see Molnar, Eby, Charlton, Langford, Koppel, Marshall & Man-Son-Hing, 2013).

Monash University

Declaration for Thesis Chapter 6:

Molnar, L.J., Eby, D.W., Charlton, J.L., Langford, J., Koppel, S., Marshall, S. & Man-Son-Hing, M. (under review). Driving Avoidance by Older Adults: Is It Always Self-Regulation?

Declaration by candidate

In the case of the publication presented in Chapter 6, the nature and extent of my contribution to the work was the following:

Nature of contribution	**Extent of contribution (%)**
▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, drafting of text, preparation of figures/tables, revision/editing for intellectual content	80%

The following co-authors contributed to the work. None of the co-authors were students at Monash University (and therefore no indication of the extent of their contribution in percentage terms was required).

Name	
Dr. David W. Eby	▪ Concept and design – initial concept, development of study design ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
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Declaration by co-authors

The undersigned hereby certify that:

(7) the above declaration correctly reflects the nature and extent of the candidate's contribution to this work, and the nature of the contribution of each of the co-authors.
(8) they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
(9) they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
(10) there are no other authors of the publication according to these criteria;
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Driving Avoidance by Older Adults: Is It Always Self-Regulation?

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Abstract

Self-regulation shows promise as a means by which older adults can continue to drive at some level without having to stop altogether. Self-regulation is generally described as the process of modifying or adjusting one's driving patterns by driving less or intentionally avoiding driving situations considered to be challenging, typically in response to an awareness that driving skills have declined. However, most studies asking older adults whether they avoid certain driving situations or have reduced the amount of driving they do under certain circumstances have not delved deeper into the motivations for such avoidance or driving reduction. There are many reasons for modifying driving that have nothing to do with self-regulation, such as no longer needing to take trips at certain times of day because of changes in preferences or lifestyles. The purpose of this study was to examine self-regulatory practices among older adults at multiple levels of driver performance and decision making, taking into account the specific motivations for avoiding particular driving situations or engaging in other driving practices. Study participants completed a computer-based questionnaire on driving self-regulation. Results suggest that self-regulation is a complex process that cannot be defined simply by the reported driving modifications made by drivers. Understanding the motivations for these behaviors is necessary and the study showed that they are varied and differ considerably across driving situations. Reasons for driving avoidance or other practices were often more closely related to lifestyle or preferences than to self-regulation. Based on these findings, three distinct groups were identified with regard to whether and for what reasons participants modified their driving.

Introduction

The aging of the population in many countries around the world has led to increasing research attention on how best to extend the period over which older adults can safely drive. A number of factors have contributed to this research interest. As people age, many will experience declines in visual, cognitive, or psychomotor skills as a result of medical conditions that become more prevalent with age or the medications used to treat those conditions (Eby, Molnar & Kartje, 2009; Molnar, Eby, St. Louis & Neumeyer, 2007). At the same time, there is considerable variation in the extent to which individuals experience these declines and their effects on safe driving (Eby, Trombley, Molnar & Shope, 1998; European Road Safety Observatory, 2006). Older adults, like most people, prefer driving as their means of maintaining mobility and consider driving to be essential to independence and quality of life (Dickerson et al., 2007; Whelan, Langford, Oxley, Koppel & Charlton, 2006). Having to give up driving has been associated with a number of adverse consequences, including loss of independence, mobility, and freedom (Adler & Rottunda, 2006; Bauer, Rottunda & Adler, 2003), increased social isolation (Liddle, McKenna & Broome, 2004; Ragland, Satariano & MacLeod, 2004), increased symptoms of depression (Fonda, Wallace & Herzog, 2001; Marottoli, Mendes de Leon, Glass et al., 1997; Ragland, Satariano & MacLeod, 2005); and more general accelerated health declines (Edwards, Lunsman, Perkins, Rebok & Roth, 2009).

Self-regulation shows promise as a means by which older adults can continue to drive at some level without having to stop altogether, although the evidence for reduced crash risk is still inconclusive (e.g., see Molnar & Eby, 2008; Unsworth, Wells, Browning, Thoman & Kendig, 2007). Self-regulation is generally described as the process of modifying or adjusting one's driving patterns by driving less or intentionally avoiding driving situations considered to be challenging (e.g., Baldock, Mathias, McLean & Berndt, 2006; Ball et al., 1998; D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008; Molnar & Eby, 2008; Stalvey & Owsley, 2000). In particular, many researchers view self-regulation as a strategy to compensate specifically for declining health or loss of functional abilities that can compromise driving (e.g., Hakamies-Blomqvist & Wahlström, 1998; Sullivan, Smith, Horswill & Lurie-Beck, 2011). For example, older adults' self-regulatory practices have been described as: "…compensation for age-related

declines in abilities by reducing their annual mileage as well as regulating when and where they drive" (Dobbs & Dobbs, 2001, p. 101); making "…adjustments in their driving behaviour that adequately match changing cognitive, sensory, and motor capabilities" (Charlton, Oxley, Fildes, Oxley, Newstead, Koppel & Hare, 2006, p. 363); and as a process requiring "…an awareness of physical, cognitive, and sensory limitations" (Sargent-Cox, Windsor, Walker & Anstey, 2011, p.898).

Essential to these definitions is the idea that drivers are aware of declines in driving skills and self-regulate their driving so that they can continue driving in some capacity – that is, for safety or related reasons, they reduce their driving overall or avoid certain driving situations that they find challenging such as driving at night, in bad weather, during rush hour traffic, in unfamiliar areas, and on the freeway (e.g., Baldock et al., 2006; Jones, Cho, Abendschoen-Milani & Geilen, 2011; Sullivan et al., 2011). However, most studies asking older adults whether they avoid certain driving situations or have reduced the amount of driving they do under certain circumstances have not delved deeper into the motivations for such avoidance or driving reduction. There are many reasons for avoiding driving situations that have nothing to do with self-regulation, such as no longer needing to take trips at certain times of day because of changes in preferences or lifestyles (see e.g., Ball et al., 1998; Charlton et al., 2006; Myers et al., 2008; Blanchard & Myers, 2010). In addition, recent findings that younger drivers also engage in avoidance behavior (e.g., Naumann, Dellinger & Kresnow, 2011) support the contention that driving avoidance is not always related to declining abilities associated with aging.

Overall, studies have yielded mixed results with regard to the extent and type of self-regulation that occurs among older adults, and considerable knowledge gaps remain about the self-regulation process and the individual, social, and environmental factors that influence it. The lack of conclusive results in this area is due in large measure to considerable differences across studies in terms of how self-regulation is conceptualized and measured, the characteristics of study participants such as age, gender, and functional status, and the extent to and way in which studies have included measures that seem to influence the adoption of self-regulatory practices such as insight into functional declines and confidence in driving ability. Most studies have also

limited their measures to a relatively narrow set of driving situations without taking into account broader choices and decisions that influence driving behaviors.

The research on self-regulation is now at a point where a deeper understanding of the issue is needed. While there is general agreement that at least some older drivers are aware of their functional declines and make concomitant adjustments in their driving (see Molnar & Eby, 2008 for a review of this literature), important questions remain about the extent to which and the conditions under which older adults do self-regulate or otherwise modify their driving. There is a need for a more comprehensive approach to understanding self-regulation by older drivers that encompasses not only the extent to which older adults drive less or avoid specific driving situations, but also the broader choices they make in compensating for functional declines such as the types of vehicles they buy, the vehicle design features they choose, and even where they choose to live. Importantly, an approach is needed to uncover the reasons people have for avoiding particular situations or otherwise reducing their driving so that avoidance due to self-regulation can be disentangled from avoidance due to other reasons such as lifestyle or preferences.

Study Background

The purpose of this study was to examine self-regulatory practices among older adults, taking into account the specific motivations for why people modify their driving by avoiding certain situations or engaging in other practices. The study is part of a larger program of research investigating: the nature and extent of self-regulation by older drivers at multiple levels of driver performance and decision making; how self-regulation is influenced by various individual, social, and environmental factors; and how self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors. The research is being undertaken by the University of Michigan Transportation Research Institute (UMTRI) and Monash University Accident Research Centre (MUARC), as part of the latter's Ozcandrive study which includes older drivers in both Australia and New Zealand. The Ozcandrive project is a partnership with the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive) project, an interdisciplinary, health-focused research program dedicated to improving the safety of older

drivers (see www.Candrive.ca). The Candrive/Ozcandrive project is the first study to follow a large group of older drivers over several years to collect comprehensive data on health, functioning, and driving. A major focus of the study is to document the natural driving life course of older drivers, including the transition from driving to non-driving, using self-reported and objectively-derived driving and clinical data.

Research Framework

As described in Molnar, Eby, Roberts, St. Louis, and Langford (2009), self-regulation can occur at three levels of driver performance and decision making: tactical, strategic, and life-goal. The tactical and strategic levels come from Michon's hierarchical model for driving skills and control (Michon, 1979, 1985), while the life-goal level (a term coined by Eby et al., 2009) builds on work by Keskinen and others on young drivers (e.g., Keskinen, 1996, 2007; Keskinen, Hatakka, Laapotti, Katila & Peraaho, 2004; Laapotti & Keskinen, 2004). Strategic self-regulation has to do largely with pre-trip decisions about the circumstances under which to drive or not to drive (e.g., avoiding night driving or other situations considered challenging, reducing driving overall). Tactical self-regulation has to do with actual maneuvers made in traffic in response to conditions in the driving environment (e.g., reducing distractions while driving such as chatting with passengers, leaving more distance between one's car and the car ahead). Life-goal self-regulation has to do with drivers' broader decisions in life that affect driving such as where to live in relation to the destinations one frequent or what kind of car to drive, with safety often being an important consideration in the vehicle purchase decision (Eby & Molnar, 2012). It should be noted that Michon's (1985) operational level is not included in this conceptualization of self-regulation because it has to do with driving behaviors and decisions that are largely automated and not generally amenable to self-regulation.

Methods

The study used a subset of data from the Candrive/Ozcandrive prospective study of older drivers discussed earlier. Specifically, participants in the Australian cohort of the Ozcandrive sample (i.e., those Ozcandrive participants recruited from the greater Melbourne area in Victoria,

Australia) completed a computer-based questionnaire on driving self-regulation about 4 months after being recruited into the study. The questionnaire included detailed items on various avoidance behaviors as well as items on the motivations for engaging in these behaviors. Participants completed the questionnaire in addition to their regular obligations as participants in Candrive/Ozcandrive. Full detail on the Candrive/Ozcandrive study protocols can be found in Marshall et al. (2012). Of special interest for this study are the protocols related to participant recruitment summarized briefly below.

Participant recruitment

Study participants were primarily recruited through community and city newspapers, newsletters, posters, and presentations to various senior-related associations. Potential participants who expressed interest in the study were contacted via telephone by a research assistant from Ozcandrive and screened for eligibility and study commitment. The overall aim was to recruit older, active drivers who would potentially be able to participate in the study for up to 5 years. Recruitment for the Australian site began in June 2010 and closed in June 2011.

Inclusion criteria for Ozcandrive included: having a general class driver license and having been actively driving for at least 1 year; being age 75 or older; driving at least 4 times per week; having agreed to undergo an annual physical and cognitive assessment and be contacted at least quarterly for vehicle data pickup and interview; residing in the local region of the study city for at least 10 months a year; being followed actively by a family physician; intending to continue driving for the next 5 years; fluent in English; consenting to release driving information from licensing authority; access to a vehicle of model year 2002 or newer; and driving one vehicle for at least 70 percent of the time. Exclusion criteria included: planned move out of the region; medical contraindication to driving within the previous 6 months (according to the Austroads guide); and diagnosis of progressive conditions that could affect driving (e.g., Alzheimer's disease, macular degeneration).

Questionnaire development and testing

The computer-based self-regulation instrument, termed the Advanced Driving Decisions and Patterns of Travel (ADDAPT) questionnaire, was initially developed at UMTRI. Full detail on

development and testing of the questionnaire can be found in Molnar et al. (2009); a brief summary is presented here. Development of ADDAPT was based on review of the literature and consultation with experts. The instrument addressed the following topics: current driving patterns and changes over time; alternative transportation options; general health and functioning; abilities for safe driving; self-regulatory driving practices at the life-goal, strategic, and tactical levels; life-goal preferences and activities; feelings of driving comfort and safety; ability to self-regulate; and participant socio-demographic characteristics. ADDAPT was designed to take about 30-45 minutes to complete. It was pilot tested with a sample of 132 adults age 70 and older residing in Michigan, USA, comprised of both older adults recruited from the general population and older adults recruited from specialty geriatric clinics at the University of Michigan with losses in vision, psycho-motor skills, or cognition. Based on pilot results and advice from the Australian authors, ADDAPT was revised and tailored to Australasian older drivers.

Measures

At the life-goal level, respondents were asked about three lifestyle-related changes they might have made during the past year that could impact driving. First, they were asked if they had moved to a new location and if so, whether the move was influenced by wanting to be closer to the places they normally drove to, wanting more options for getting around, or other reasons related to driving or mobility. Second, they were asked if they had purchased a different vehicle, and if so, whether their decision was influenced by not feeling comfortable driving their previous car, not feeling safe driving their previous car, or other reasons related to driving. Finally, they were asked if they had started a regular exercise program or fitness regime, and if so what their reasons were.

At the strategic level, driving avoidance behavior was measured by a series of yes/no questions asking respondents if they tried to avoid various driving situations including driving at night, in bad weather, on busy roads, in unfamiliar areas, alone, at night in bad weather, during rush hour traffic, or on the freeway, as well as making right turns across oncoming traffic at intersections without right hand turn arrows and reversing. Respondents were also asked if they planned their route ahead of time, made a practice run to become familiar with their route, combined trips into

a single outing, or brought passengers along to help navigate, as well as whether they had reduced the amount of driving they did over the past year in any way including driving fewer days or kilometers per week, taking fewer trips per week, or reducing the distance of their trips.

At the tactical level, respondents were asked a series of yes/no questions about trying to avoid various in-vehicle distractions while driving, including chatting with passengers, eating, reading a road map, changing radio stations, talking on a mobile phone, or personal grooming. Respondents were also asked if they tried to leave more room than they used to between their car and the car ahead of them.

Respondents who responded in the affirmative to any of the questions about modifying their driving by avoiding driving situations or engaging in other driving practices at the tactical and strategic levels were asked what their reasons were. The set of reasons presented to respondents included: 1) difficulty seeing during the day or night; 2) difficulty remembering things; 3) difficulty concentrating on more than one thing at a time; 4) reduced strength, flexibility, or general mobility; 5) don't feel comfortable driving in the driving situation/not engaging in that practice, 6) don't feel safe driving in the situation (with safety defined in terms of risk of getting in a crash rather than personal security)/not engaging in that practice; 7) have always tried to avoid the situation/engage in that practice; 8) don't need to avoid the situation/engage in that practice, or 9) other (with the respondent asked to write in the actual reason). Respondents had the option of giving multiple reasons for each reported behavior.

As part of the analysis, a three-level variable was created for each potential driving modification, based on the reasons given for making that modification. Six response options presented to respondents related to what is commonly thought of as self-regulation, as discussed earlier. Two response options were related to what would be considered lifestyle or preferences. Self-regulation was operationalized as any driving avoidance or other practice reported by respondents for which respondents intentionally chose at least one of the first six self-regulatory reasons. That is, if a respondent reported trying to avoid driving at night because of the single reason that he or she was uncomfortable driving at night, then that was considered avoiding driving at night for self-regulation. At the same time, if a respondent reported trying to avoid

driving at night because he or she was uncomfortable driving at night but also because he or she did not need to drive at night, this was also considered self-regulation. The three levels of each variable included: 1) non-modifiers (those who did not modify their driving); 2) self-regulators (those who modified their driving either by avoiding a particular situation or engaging in a particular practice for reasons related to self-regulation; 3) others (those who modified their driving but not for reasons related to self-regulation).

Administration of the ADDAPT questionnaire

Prior to administering the questionnaire, approval was received from the Monash University Human Research Ethics Committee. Participants completed the questionnaire approximately 4 months after they began participating in the Ozcandrive study. The questionnaire was self-administered on a computer by study participants during a session in which a member of the research team was present in the room to provide assistance as necessary. Completion of the questionnaire took on average 30-45 minutes.

Results

At the time of the study reported here, 246 of the total 261 participants in the Ozcandrive Melbourne area sample had been recruited and their questionnaire data available for inclusion in the analyses. Characteristics of these study participants are summarized in Table 1. The mean age of participants was 79.7 (SD=3.51). The majority of participants were male and married. All but three considered themselves to be urban residents. Most participants lived in a residence (i.e., house, flat, or apartment) that they owned and most had lived at that residence for more than 10 years. The majority of households consisted of the participant and at least one other individual. Over 45% of participants reported that someone else in the household also drove and over one-third reported that others were dependent on them to drive. Most reported being retired, although a sizable number were in paid work and nearly two-thirds reported doing volunteer work in the community. Household income and education levels covered a broad range, although two-thirds reported an income of less than $AUD 50,000 and half had completed at least high school or technical school.

Table 1. Sample Characteristics		
Characteristic	**Number***	**Percent**
Gender		
Male	179	72.8
Female	67	27.2
Marital Status		
Married/Common law	148	61.7
Separated/Divorced	18	7.5
Widowed	60	25.0
Single	14	5.8
Do you consider yourself an urban or rural resident		
Urban	243	98.8
Rural	2	0.8
Other	1	0.4
Housing Arrangement		
Owned house, flat, apartment	185	77.1
Rented house, flat, apartment	9	3.8
Family member's house, flat, apartment	3	1.3
Senior/retirement community that provides transportation	29	12.1
Senior/retirement community not providing transportation	11	4.6
Other	3	1.3
Length at present location		
Less than 1 year	5	2.1
1-5 years	35	14.6
6-10 years	29	12.1
More than 10 years	171	71.3
Number of people in the household, including respondent		
1	92	38.3
2	135	56.3
3 or more	13	5.4
Number of drivers in the household, including respondent		
1	131	54.6
2	102	42.5
3 or more	7	2.9
Are you the primary driver - yes	218	90.8
Does anyone in or outside the household depend on you to drive them - yes	85	35.4
Are you retired - yes	229	96.2
Do you currently do any paid work - yes	25	11.7
Do you currently do any volunteer work in the community - yes	154	65.3
Household income (Australian dollars; AUD)		
Less than $20,000	25	12.2
$20,000-$49,999	110	53.7
$50,000-$79,999	44	21.5
$80,000-$99,999	13	6.3
$100,000 or more	13	6.3
Education		
Primary School	59	24.0
High school	27	11.0
Trade/Technical Certificate	37	15.0
Diploma	72	29.3
Degree	37	15.0
Post-graduate	14	5.7

*Numbers in each category may not add to 246 due to missing data.

Overall avoidance and other practices/behaviors

Table 2 presents summary information on reported avoidance and other practices/behaviors at the life-goal, strategic, and tactical levels. At the life-goal level, only four respondents (2%) reported having moved to a new location in the past year, 11% reported having purchased a different vehicle, and 28% reported having begun a regular exercise program or fitness regime.

At the strategic level, sizable percentages of participants reported trying to avoid most of the driving situations presented (Table 2). In ascending order, participants were most likely to report trying to avoid driving during rush hour traffic, driving at night in bad weather, driving in bad weather, and driving at night (46, 44, 35, and 22%, respectively). They were least likely to report trying to avoid driving alone (1%). Over two-thirds reported planning their routes ahead of time or combining trips into a single outing. Only 1% reported bringing along a passenger to help them navigate and less than 8% reported making a practice run to become familiar with the route.

At the tactical level, at least one-quarter or more of all respondents reported trying to avoid in-vehicle distractions with over 90% reporting trying to avoid talking on a mobile phone, personal grooming, or reading a road map (Table 2). Over 40% reported leaving greater distances than they used to between their car and the car ahead of them.

Table 2. Reported Avoidance and Other Practices/Behaviors at the Life-Goal, Strategic, and Tactical Levels				
	Yes		No	
	Number	Percent	Number	Percent
Life-Goal Level				
Moved to a new location	4	1.6	242	98.4
Bought a new vehicle	28	11.4	218	88.6
Began a regular exercise program or fitness regime	69	28.2	176	71.8
Strategic Level				
Do you try to avoid…?				
Driving at night	55	22.4	191	77.6
Making unprotected right turns	26	10.6	220	89.4
Driving in bad weather	86	35.0	160	65.0
Driving on busy roads	41	16.7	205	83.3
Driving in unfamiliar areas	34	13.8	212	86.2
Driving alone	3	1.2	242	98.8
Driving at night in bad weather	108	44.3	136	55.7
Driving during rush hour traffic	113	46.3	131	53.7
Driving on the freeway	20	8.2	224	91.8
Reversing	29	11.9	215	88.1
Do/have you?				
Plan your route ahead of time	167	69.3	74	30.7
Make a practice run to become familiar with your route	19	7.9	221	92.1
Combine trips into a single outing	165	68.5	76	31.5
Bring passengers along to help navigate	3	1.2	238	98.8
Reduced your driving in the past year in any way	19	7.7	227	92.3
Tactical Level				
While driving, do you try to avoid…?				
Chatting with passengers	70	28.7	174	71.3
Eating	193	79.1	51	20.9
Reading a road map	225	92.2	7.8	19
Changing radio stations	76	31.1	168	68.9
Talking on a mobile phone	233	96.3	9	3.7
Personal grooming	230	95.8	10	4.2
Do you…?				
Leave more room between your car and the car ahead	101	41.9	140	58.1

Motivations for avoidance and other practices/behaviors

As discussed earlier, respondents who reported making changes in the past year at the life-goal level were asked about factors that may have influenced their decision. One of the four respondents who had moved to a new location in the past year reported that the move was influenced by a driving-related reason (i.e., that he or she wanted to be closer to normally visited destinations). Of the 28 respondents who reported having bought a different vehicle, one reported not feeling comfortable driving his or her previous car and eight cited other driving-related reasons (e.g., switched cars to prepare when/if hips or knees fail, did not like poor turning circle of previous car, could not see over dashboard of previous car adequately). Of the 69 respondents who reported having begun a regular exercise program or fitness regime, most recorded verbatim reasons having to do with a desire to maintain or improve their health and fitness. Several respondents specifically mentioned wanting to improve their flexibility, strength, or general mobility.

Table 3 summarizes reported motivations for avoiding driving situations or engaging in other driving practices at the strategic and tactical levels. As can be seen, overall motivations varied considerably across the levels and specific driving situations. At the strategic level, the most frequently cited reasons for avoiding a driving situation tended to be "don't feel comfortable" (with percentages ranging from 27 to 62) and "don't need to" (with percentages ranging from 4 to 71). Sizable proportions also cited "have always tried to" and "don't feel safe." The most frequently cited reasons for engaging in other practices (e.g., planning route ahead of time) tended to be "have always tried to engage in practice" (with percentages ranging from 33 to 75) or "other" (with percentages ranging from 14 to 67), although a quarter of respondents reporting that they planned their route ahead of time attributed this practice to not feeling comfortable going out without doing so.

	Table 3. Reported Motivations for Avoidance and Other Practices at the Strategic and Tactical Levels								
	Reasons for Practice (% Reporting Each Reason)								
Practice (Total N reporting practice)	Difficulty seeing during day or night (N, total reporting practice)	Difficulty remem-bering things (N, total reporting practice)	Difficulty concen-trating on more than one thing at a time (N, total reporting practice)	Reduced strength, flexibility, general mobility (N, total reporting practice)	Don't feel comfort-able (N, total reporting practice)	Don't feel safe (N, total reporting practice)	Have always tried to (N, total reporting practice)	Don't need to do it (N, total reporting practice)	Other (N, total reporting practice)
	%	%	%	%	%	%	%	%	%
Strategic Level									
Avoidance									
At night (55)	16.4	0	1.8	1.8	61.8	21.8	14.5	49.1	16.4
Making turns (26)	0	0	0	0	46.2	23.1	19.2	3.8	26.9
Bad weather (86)	12.8	0	2.3	1.2	48.8	23.3	29.1	52.3	14.0
Busy roads (41)	0	0	4.9	0	26.8	9.8	34.1	51.2	12.2
Unfamiliar areas (34)	0	2.9	11.8	2.9	52.9	11.8	14.7	23.5	14.7
Driving alone (3)	0	0	0	0	0	0	0	0	0
At night in bad weather (108)	10.2	0	1.9	0.9	57.4	21.3	29.6	50.0	7.4
Rush hour (113)	0	0	2.7	0	26.5	10.6	27.4	70.8	10.6
On the freeway (20)	0	0	5.0	0	40.0	10.0	30.0	40.0	20.0
Reversing (29)	6.9	0	3.4	13.8	34.5	13.8	31.0	10.3	10.3
Practice									
Plan route (167)	0	1.8	1.8	0	25.1	12.0	75.4	-	13.8
Make practice run (19)	0	0	0	0	5.3	0	26.3	-	57.9
Combining trips (165)	0	0	0	0	3.0	0.6	64.2	-	87.8*
Bring passenger (3)	0	0	0	0	33.3	33.3	33.3	-	66.7
Reduced driving (19)	4.8	0	0	9.5	0	0	-	42.9	71.4
Tactical Level									
Avoidance									
Chatting (70)	0	1.4	27.1	0	24.3	10.0	52.9	-	18.6
Eating (193)	0.5	0	2.6	2.1	32.6	21.2	69.9	-	17.1
Reading map (225)	0.4	0	5.8	0	15.6	39.1	36.4	19.1	28.4
Changing radio (76)	0	0	6.6	0	19.7	22.4	35.5	25.0	21.1
Talking on phone (233)	0.4	0	4.3	0	12.0	35.3	-	-	57.3**
Personal grooming (230)	0	0	4.3	0	10.4	22.2	22.6	77.4	11.3
Practice									
Leave more room (101)	0	0	0	2.0	51.5	55.4	-	-	21.8

* Of the 87.8% reporting other reasons for combining trips into a single outing, 43% selected a special category called "financial reasons" (e.g., saving fuel or wear and tear on vehicle) and 24.8%selecgted a special category called "environmental reasons" (e.g., lowering emissions).
** The most commonly-reported reason in the "other" category was that talking on a mobile phone while driving was against the law. In addition, of the 57.3% reporting other reasons for avoiding talking on a mobile phone, 19.4% reported that they did not have a mobile phone.

Looking specifically at the motivations considered to relate to self-regulation (the first six categories), fewer respondents cited difficulties in visual, cognitive, or psychomotor skills compared with more general feelings of discomfort or lack of safety. Notable exceptions were found for a few situations for which sizable minorities cited difficulty seeing during the day or night (avoiding driving at night or in bad weather), difficulty concentrating on more than one thing at a time (avoiding driving in unfamiliar areas), and reduced strength, flexibility, or general mobility (avoiding reversing). The reason "don't feel safe" was cited by respondents across all situations but considerably less frequently than "don't feel comfortable."

At the tactical level, the most frequently cited reasons for avoiding in-vehicle distractions were "have always tried to avoid" (with percentages ranging from 23 to 70) or "don't need to avoid" (with percentages ranging from 19 to 77). By comparison, most respondents who reported leaving more room than they used to between their car and the car ahead of them attributed this practice to not feeling comfortable or not feeling safe leaving less room (52% and 55%, respectively).

Extent and type of self-regulation taking motivations into account

Based on respondents' self-reported motivations for avoiding specific driving situations or engaging in other practices, a three-level variable was created for each situation at the strategic and tactical levels (Table 4). The life-goal level was not submitted to the same analysis given the relatively small numbers of respondents reporting life-goal changes in the past year.

Table 4. Driver Groups at Strategic and Tactical Levels		
	Number*	**Percent**
Strategic Level		
Driving at night		
Non-modifiers	191	77.6
Self-regulators	40	16.3
Others	15	6.1
Making unprotected right turns		
Non-modifiers	220	89.4
Self-regulators	17	6.9
Others	9	3.7
Driving in bad weather		
Non-modifiers	160	65.0
Self-regulators	49	19.9
Others	37	15.0
Driving on busy roads		
Non-modifiers	205	83.3
Self-regulators	12	4.9
Others	29	11.8
Driving in unfamiliar areas		
Non-modifiers	212	86.2
Self-regulators	21	8.5
Others	13	5.3
Driving alone		
Non-modifiers	242	98.8
Self-regulators	-	-
Others	3	1.2
Driving at night in bad weather		
Non-modifiers	136	55.7
Self-regulators	70	28.7
Others	38	15.6
Driving during rush hour traffic		
Non-modifiers	131	51.0
Self-regulators	32	12.5
Others	81	31.5
Driving on the freeway		
Non-modifiers	224	91.8
Self-regulators	10	4.1
Others	10	4.1
Reversing		
Non-modifiers	215	88.1
Self-regulators	16	6.6
Others	13	5.3
Plan your route ahead of time		
Non-modifiers	74	30.7
Self-regulators	48	19.9
Others	119	49.4
Make a practice run to become familiar with your route		
Non-modifiers	221	92.1
Self-regulators	1	0.4
Others	18	7.5
Combine trips into a single outing		
Non-modifiers	76	31.5
Self-regulators	5	2.1
Others Does for other reasons	160	66.4
Bring passengers along to help navigate		
Non-modifiers	238	98.9
Self-regulators	1	0.4
Others	2	0.8
Reduced your driving in the past year in any way		
Non-modifiers	227	92.3
Self-regulators	3	1.2
Others	16	6.5
Tactical Level		
Chatting with passengers while driving		
Non-modifiers	174	71.3
Self-regulators	34	13.9
Others	36	14.8

Eating while driving		
Non-modifiers	51	20.9
Self-regulators	84	34.4
Others	109	44.7
Reading a road map while driving		
Non-modifiers	19	7.8
Self-regulators	101	41.4
Others	124	50.8
Changing radio stations while driving		
Non-modifiers	168	68.9
Self-regulators	25	10.2
Others	51	20.9
Talking on a mobile phone while driving		
Non-modifiers	9	3.7
Self-regulators	89	36.9
Others	143	59.3
Personal grooming while driving		
Non-modifiers	10	4.2
Self-regulators	58	24.2
Others	172	71.7
Leave more room between your car and the car ahead		
Non-modifiers	140	58.1
Self-regulators	86	35.7
Others	15	6.2

* Numbers may not add to 246 for each situation due to missing data.

At the strategic level, separating out respondents who modified their driving for reasons related to self-regulation ("self-regulators") from respondents who modified their driving but not for reasons related to self-regulation ("others") led to different outcomes depending on the driving situation being examined. Considerable numbers of respondents across the driving situations were deemed "others." At the same time, for many situations, self-regulators remained the majority of respondents who modified their driving for any reason (e.g., for driving at night, making unprotected left turns, and driving in bad weather, unfamiliar areas, and at night in bad weather). For other driving situations, however, after separating out "others" from the overall group of respondents who modified their driving for any reason, there were less than half remaining as "self-regulators" (e.g., driving on busy roads, driving in rush hour traffic, planning out route ahead of time), and in a few cases (e.g., making a practice run, combining trips into a single outing), fewer than 10 percent were deemed "self-regulators."

At the tactical level, "self-regulators" outnumbered "others" for only one driving situation: leaving more room between respondents' car and the car ahead of them. For all of the in-vehicle distractions, the majority of respondents who modified their driving cited reasons not related to self-regulation. As a result, there were up to twice or three times as many respondents in the

"others" group as the "self-regulators" group for some situations (e.g., changing radio stations while driving, personal grooming while driving).

Conclusion and Discussion

This study examined the nature and extent of self-regulation by older drivers at multiple levels of driver performance and decision making, taking into account the specific motivations for avoiding particular driving situations or engaging in other driving practices. Results suggest that self-regulation is a complex process that cannot be defined simply by the reported driving modification – avoiding certain driving situations or engaging in other practices. Understanding the motivations for these behaviors is necessary and the study showed that they are varied and differ considerably across driving situations. Reasons for driving avoidance or other practices were often more closely related to lifestyle or preferences than to self-regulation, consistent with findings by others (e.g., Charlton et al., 2006; Myers et al., 2008; Blanchard & Myers, 2010). Thus, to better understand self-regulation among older adults, it is not sufficient to ask people if they avoid specific driving situations or engage in practices that seemingly suggest self-regulatory behavior; it is important to understand their reasons for doing so. Another important finding from this study is that self-regulatory behavior appears to be closely tied to the specific driving situation in which it is being examined; thus, context should be taken into account in understanding self-regulation.

Three distinct groups of older adults with respect to self-regulation were identified based on their reported motivations for modifying their driving, consisting of non-modifiers, self-regulators, and others. It is possible that some individuals who cited non-self-regulatory reasons for modifying their driving were actually self-regulators who either did not recognize it or chose not to admit to it. Further work is underway to examine these three groups more fully through statistical modeling to identify differences, particularly between the groups who do modify their driving, that go beyond their stated reasons for avoidance or engagement. If these groups are in fact different in important ways with regard to driving avoidance patterns, this could be reflected in differences in other health and driving measures.

This study is the first to address life-goal self-regulation. Relatively few respondents reported engaging in life-goal self-regulatory practices. While this result makes it difficult to reach meaningful conclusions about motivations for life-goal changes, it does show how infrequent life-goal decisions are made. Life-goal self-regulatory practices involve important decisions that affect most aspects of a person's life (of which driving is just one part). Many people may not be ready to face those decisions when they still consider themselves to be relatively highly functioning as was the Ozcandrive sample. As participants age over the course of the 5-year study, one would expect increased loss in functioning and possibly more life-goal self-regulation. However, the research reported here was confined to data generated early in the first year of the study, when participants were relatively healthy and active in their driving (as indicated by the eligibility requirement that they were driving at least four times per week at the time of recruitment). It is important to continue to study self-regulation at this level, especially because of the opportunity that life-goal decisions afford for enhancing older adult mobility. Different study designs may be necessary to recruit sufficient numbers of participants making decisions at the life-goal level so that motivations can be fully explored.

The study had some limitations. The sample was comprised of a convenience cohort of drivers age 75 years and older. A convenience rather than random sampling approach was used because a truly random and representative sample can only be achieved through mandatory participation, which would have been neither possible nor desired. The reasons which prevented a random sample included: concern for possible negative impact on licensure will almost certainly lead to a level of volunteer bias; and 'cold calling' potential recruits is unlikely to yield a high response rate for a study requiring a 5-year commitment from participants. Thus, there was likely a bias towards a healthier sample, resulting possibly in less self-regulation being reported than might have been found in a more general population with a greater range of impairments. All self-regulatory practices were self-reported and may not represent the actual behavior or decision of participants. Further work is underway to supplement the self-reported data with naturalistic driving data to further untangle the complexity of the self-regulatory process among older adults.

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Chapter 7: Self-Regulatory Driving Practices among Older Adults: The Effects of Individual, Social, and Environmental Factors (Publication 3)

This paper addresses the researcher's second research question: How is self-regulation influenced by various individual, social, and environmental factors? The purpose of the work presented in the paper was to better understand how both reported strategic and tactical self-regulatory driving practices are influenced by various factors. Of special interest was the relative influence of several variables on the reported adoption of self-regulation including self-perceptions of health, functioning, and abilities for safe driving, and driving confidence and comfort. In addition, the study was designed to disentangle reported self-regulatory practices from other types of reported driving modifications due to reasons related to lifestyle or preferences by focusing only on those driving behaviors motivated in some way by declining abilities associated with aging. At the time the thesis was submitted for examination, this paper was under review at The Journal of Gerontology Series B: Social Sciences. Included here is the submitted version of the paper. Subsequent to submitting the thesis for examination, the paper was withdrawn from the Journal of Gerontology and resubmitted to Traffic Injury Prevention. It was peer reviewed, revised, and accepted for publication. At the time of printing of the final thesis, it was in press (see Molnar, Charlton, Eby, Langford, Koppel, Kolenic & Marshall, in press).

Monash University

Declaration for Thesis Chapter 7:

Molnar, L.J., Charlton, J.L., Eby, D.W., Langford, J., Koppel, S., Kolenic, G.E., Marshall, S. (under review). Self-Regulatory Driving Practices among Older Adults: The Effects of Individual, Social, and Environmental Factors.

Declaration by candidate

In the case of the publication presented in Chapter 7, the nature and extent of my contribution to the work was the following:

Nature of contribution	**Extent of contribution (%)**
▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, drafting of text, preparation of figures/tables, revision/editing for intellectual content	80%

The following co-authors contributed to the work. None of the co-authors were students at Monash University (and therefore no indication of the extent of their contribution in percentage terms was required).

Name	
Dr. Judith L. Charlton	▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. David W. Eby	▪ Concept and design – initial concept, development of study design ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Jim Langford	▪ Concept and design – initial concept, development of study design ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content

Dr. Sjaan Koppel	▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Ms. Giselle E. Kolenic	▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Shawn Marshall	▪ Concept and design – initial concept, development of study design ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content

Candidate's Signature	[redacted]	**Date** 11-02-2013

Declaration by co-authors

The undersigned hereby certify that:

(13) the above declaration correctly reflects the nature and extent of the candidate's contribution to this work, and the nature of the contribution of each of the co-authors.
(14) they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
(15) they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
(16) there are no other authors of the publication according to these criteria;
(17) potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit; and
(18) the original data are stored at the following location(s) and will be held for at least five years from the date indicated below:

Location(s)	[1] Monash University Accident Research Centre, Clayton Campus [2] University of Michigan Transportation Research Institute, Ann Arbor, MI, USA [3] The University of Michigan Center for Statistical Consultation and Research, Ann Arbor, MI, USA [4] The Ottawa Hospital Rehabilitation Centre, Ottawa ON, Canada

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Self-Regulatory Driving Practices among Older Adults:
The Effects of Individual, Social, and Environmental Factors

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Abstract

Objectives: The primary objective of this study was to better understand how self-regulatory driving practices among older adults, at multiple levels of driver performance and decision making, are influenced by various individual, social, and environmental factors.

Methods: The study used a subset of data from a longitudinal cohort study in Australia. Upon study enrollment, participants underwent a comprehensive clinical assessment during which data on visual, cognitive, and psychomotor functioning were collected. Approximately 4 months later, participants completed the Advanced Driving Decisions and Patterns of Travel (ADDAPT) questionnaire, a computer-based self-regulation instrument developed and pilot-tested at the University of Michigan.

Results: Self-regulation among older adults was found to be a multi-dimensional concept. Rates of self-regulation were tied closely to specific driving situations, as well as level of decision making. In addition, self-regulatory practices at the strategic and tactical levels of decision making were influenced by different sets of individual, social, and environmental factors.

Discussion: Continuing efforts to better understand the self-regulatory practices of older drivers at the tactical, strategic, and even life-goal levels should provide important insights into how the transition from driving to non-driving can be better managed to balance the interdependent needs of public safety and personal mobility.

Introduction

The aging of the population in the United States (US) and elsewhere has brought increased attention to the issues of older driver safety and mobility (Transportation Research Board, 2004), due to both the sheer numbers of older drivers expected on the road, as well as the expectation of elevated crash risk of at least some portion of these drivers. By 2050, the number of older people age 65 and over in the US is expected to reach 88 million, comprising over 20 percent of the population (US Census Bureau, 2008). Fatal crash rates per mile driven increase noticeably across age groups beginning at age 70-74, and are highest among drivers age 85 and older (Insurance Institute for Highway Safety, 2010), due largely to age-related fragility and frailty (Li, Braver & Chen, 2003). Although debate continues on the nature and magnitude of the overall crash risk posed by older drivers (see e.g., Hakamies-Blomqvist, 2004; Langford, Methorst & Hakamies-Blomqvist, 2006) and recent evidence suggests a downward trend in fatal crashes (Cheung, McCartt & Braitman, 2008), societal attention on older drivers is warranted. At the same time, society must balance concerns with public safety against the possible loss of mobility and other adverse consequences that can come from having to stop driving (Dickerson et al., 2007). For example, driving cessation has been associated with increased social isolation (e.g., Liddle, McKenna & Broome, 2004; Ragland, Satariano & MacLeod, 2004), increased symptoms of depression (e.g., Fonda, Wallace & Herzog, 2001; Marottoli, Mendes de Leon, Glass et al., 1997; Ragland, Satariano & MacLeod, 2005), and more general accelerated health declines (Edwards, Lunsman, Perkins, Rebok & Roth, 2009).

One approach suggested for managing older driver safety is the use of restricted licenses by licensing agencies to allow older drivers to continue to drive but with limitations – in particular, through reduced exposure to challenging driving conditions (e.g., driving at night or long distances from home). However, restricted licensing practices vary considerably across jurisdictions in the US and elsewhere (Petrucelli & Malinowski, 1992) and further work is needed to determine the overall safety benefits of such restrictions (Braitman, Chaudhary & McCartt, 2010), as well as identify which drivers are most likely to benefit from them (Nasvadi & Wister, 2009). Acceptance of restrictions by older drivers is also important because of its role in compliance. Marshall, Man-Son-Hing, Molnar, Wilson and Blair (2007) examined the

acceptability of various driver restrictions for older drivers used in North America (e.g., limiting driving to daylight hours, non-rush hours, within 10 kilometers of home, on major highways). Acceptance varied across the driving situations and appeared to be inversely related to impact on autonomy and ability to access the community.

To the extent that older drivers who should be restricting their driving are already doing so voluntarily, the need for interventions by licensing agencies may be less pressing. It is clear from the literature that at least some older drivers already restrict their driving by driving less or avoiding situations considered challenging, in response to an awareness that driving abilities have declined. This process is commonly referred to as self-regulation. In a review of the literature on self-regulation among older drivers, Molnar and Eby (2008) found that many older drivers self-regulated by reducing their overall driving exposure (e.g., Benekohal, Michaels, Shim & Resende, 1994; Charlton et al., 2006; Klavora & Heslegrave, 2002; Marottoli et al., 1993; Raitanen, Tormakangas, Mollenkopf & Marcellini, 2003; Ruechel & Mann, 2005). However, the evidence was less conclusive with regard to how widespread specific driving avoidance behaviors were such as avoiding driving at night, in heavy traffic, on the freeway, during rush hour, in bad weather, and making turns across oncoming traffic at intersections without protected traffic signals and reversing. Rates of self-reported avoidance of night driving, for example, varied from 8 percent (Baldock, et al., 2006) to 25 percent (Charlton et al., 2006), to 60 percent (Ruechel & Mann, 2005), to 80 percent (Ball et al.,1998). These differences in rates of self-regulation may be due to differences across studies with respect to the individual characteristics of participants, their driving patterns, and the social and cultural context within which their driving takes place, as well as the methods used to examine self-regulation.

There have also been mixed results with regard to whether various factors are related to self-regulation, particularly actual declines in functional abilities that older adults may be experiencing. Ball et al. (1998) found that individuals with clinically-determined visual and/or attentional impairments reported avoidance of several challenging situations, while those with impaired mental status did not appear to self-regulate their driving. Similarly, Charlton et al. (2006) found self-reported vision problems to be associated with driving avoidance but impaired decision making was not. However, other studies have found that relatively large proportions of

drivers with visual impairment did not self-regulate by avoiding driving situations that placed the greatest demand on visual processing abilities (e.g., Okonkwo, Crowe, Wadley & Ball, 2007; Stalvey & Owsley, 2000). Similarly, physical functioning, as measured by various standardized tests, has not been consistently shown to be associated with self-regulation (e.g., Charlton, Oxley, Fildes & Les, 2001; Vance et al., 2006).

Findings relating to the relationship between self-regulation and gender have generally been consistent, with women more likely to report self-regulation than men (e.g., Charlton et al., 2006; D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008; Hakamies & Blomqvist, 1998; Kostyniuk & Molnar, 2008; Naumann, Dellinger & Kresnow, 2011; Unsworth, Wells, Browning, Thoman & Kendig, 2007; West et al., 2003). Nevertheless, findings from some recent studies have not supported this association with regard to older drivers (e.g., Gwyther & Holland, 2012; Molnar, Eby, Roberts, St. Louis & Langford, 2009, Ross et al., 2009). Kostyniuk and Molnar (2008) suggested that the gender effect found in many studies may be partially be explained by individuals' perceived level of confidence in various driving situations. This is consistent with findings from other studies in which adding a confidence variable resulted in a reduced contribution by such factors as age and gender in explaining driving avoidance (e.g., Charlton et al., 2006).

It appears that awareness of and insight into functional impairments is an important precursor to adopting self-regulatory practices (e.g., Ball et al., 1998; Freund, Colgrove, Burke & McLeod, 2005; Holland & Rabbit, 1992; Owsley, McGwin, Phillips, McNeal & Stalvey, 2004; Owsley, Stalvey & Phillips, 2003; Stalvey & Owsley, 2003) and may be more important than actual driving ability (Anstey, Wood, Lord & Walker, 2005). For example, Anstey et al. (2005) reviewed the literature on cognitive, sensory, motor, and physical factors associated with safe driving and concluded that insight into age-related changes plays a key role in how older adults alter their driving behavior – with individuals' awareness of and self-perceptions about their abilities influencing their decisions to drive in challenging situations such as peak travel times and nighttime driving, or adverse weather conditions. They noted that lack of insight into possible cognitive, sensory, or physical limitations (e.g., as evidenced by individuals who

performed poorly relative to peers but thought they did well) may constitute a risk factor for poor driving performance and crash risk.

Self-perceptions of confidence or comfort in specific driving situations have also been closely tied to self-regulation in terms of avoiding those situations (e.g., Baldock et al., 2006; Charlton et al., 2006; Molnar & Eby, 2008; Myers, Paradis & Blanchard, 2008; Rudman, Friedland, Chipman & Sciortino , 2006). In fact, this has been one of the most consistent findings in the literature, regardless of how confidence or comfort is measured. For example, Baldock et al. (2006) concluded that older drivers do appear to self-regulate in a manner consistent with driving ability, but only for a small number of specific situations in which they have low confidence and are most able to avoid. They found three avoidance situations related to poorer performance on an on-road driving test: driving in the rain, driving at night, and driving at night in the rain. More recently, MacDonald, Myers and Blanchard (2008) examined the role of driver perceptions (especially confidence and comfort) in self-regulatory behaviors, using the Driving Comfort Scales (DCS) and found driver comfort to be significantly related to self-regulation across various driving situations. In addition, other work using the DCS in conjunction with objectively derived driving data (Blanchard & Myers, 2010) found lower comfort to be significantly related to reduced exposure in general and at night, average and maximum radii from home, and driving in challenging situations such as on the highway.

What is less conclusive in the research literature is how such self-regulation translates into actual safety benefits for older drivers. Few studies have been done on self-regulation and crash risk and the findings are mixed (e.g., Ball et al., 1998; Charlton et al., 2006; DeRaedt & Kristofferson, 2000; Owsley et al., 2004; Raitanen et al., 2003; Ross et al., 2009). Collectively, the findings on the role of self-regulation in older driver safety suggest that licensing agencies cannot rely on all older adults to appropriately self-regulate their driving. In particular, drivers who lack insight about their functional declines due to cognitive impairment such as dementia may not be able to appropriately self-regulate their driving. The literature also underscores the conclusion by Charlton et al. (2006) that “the processes involved in self-regulation are complex and the factors that influence the adoption of self-regulatory behaviours are likely to be multi-faceted” (p. 364).

It is not surprising that important questions remain about the extent to which and the conditions under which older drivers do self-regulate their driving. In addition, most studies have asked older adults whether they modify their driving in different ways without delving deeper into the motivations for making these modifications. There are many reasons for avoiding driving situations or modifying driving in other ways that are unrelated to compensating for declining health or loss of functional abilities. For example, older adults may modify their driving because of changes in preferences or lifestyles resulting in greater flexibility in scheduling trips or simply less need to travel under certain conditions (see e.g., Ball et al., 1998; Blanchard & Myers, 2010; Charlton et al., 2006; Myers et al., 2008).

Finally, most studies have focused on a relatively narrow set of driving avoidance situations that result largely from pre-trip decisions about the circumstances under which to drive or not drive; this level of decision making is termed "strategic" in Michon's hierarchical model of driving skills and control (Michon, 1979, 1985). Also of interest to research on self-regulation is Michon's tactical level of decision making which has to do with actual maneuvers made in traffic in response to conditions in the driving environment such as maintaining longer headways between the vehicle ahead or avoiding in-vehicle distractions while driving (e.g., chatting with passengers, grooming, talking on a mobile phone). Such tactical self-regulatory practices generally have not been investigated in studies on self-regulation.

The purpose of this study was to better understand how both strategic and tactical self-regulatory driving practices are influenced by various individual, social, and environmental factors. Specifically, the study investigated patterns of tactical and strategic self-regulation among a sample of Australian older drivers. Of special interest was the relative influence of several variables on the adoption of self-regulation, including self-perceptions of health, functioning, and abilities for safe driving, and driving confidence and comfort. In addition, the study was designed to disentangle self-regulatory practices from other types of driving modifications due to reasons related to lifestyle by focusing only on those driving behaviors motivated in some way by declining abilities associated with aging.

Method

This research was carried out at the Monash University Accident Research Centre (MUARC), as part of the latter's Ozcandrive study, a partnership with the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive) and in conjunction with the University of Michigan Transportation Research Institute (UMTRI). Candrive is an interdisciplinary, health-focused research program dedicated to improving the safety of older drivers (see Marshall et al., 2012). Candrive/Ozcandrive represents the first study to follow a large group of older drivers over several years, and collect comprehensive self-reported and objectively derived data on health, functioning, and driving.

Participants

This study used a subset of data from the Candrive/Ozcandrive study. Specifically, older drivers from the Ozcandrive Australian sample in the greater Melbourne area in Victoria were recruited for the study. The study was approved by the Monash University Human Research Ethics Committee. At the time of this study, 246 of the total 257 participants in the Ozcandrive Melbourne sample had been recruited and had completed the questionnaire; therefore, the sample size for this study was 246.

To be included in Ozcandrive, participants had to: have a general class driver license and be active drivers; be age 75 or older; drive at least 4 times per week; agree to undergo an annual physical and cognitive assessment and be contacted at least quarterly for vehicle data pickup and interview; reside in the local region of the study city for at least 10 months a year; have a regular family physician; plan to continue driving for the next 5 years; be fluent in English; consent to release driving information from the licensing authority; have access to a vehicle of model year 2002 or newer; and drive one vehicle for at least 70 percent of the time. Participants were excluded from Ozcandrive if they: planned to move out of the region; had a medical contraindication to driving within the previous 6 months (according to the Austroads guide; Austroads, 2006); or had a diagnosis of progressive conditions that could affect driving (e.g., Alzheimer's disease, macular degeneration).

Procedures

Upon enrolling in the study, participants underwent a comprehensive clinical assessment during which data on visual, cognitive, and psychomotor functioning were collected. Approximately 4 months after study enrollment, participants completed the Advanced Driving Decisions and Patterns of Travel (ADDAPT) questionnaire, a computer-based self-regulation instrument developed and pilot-tested at UMTRI (Molnar et al., 2009). ADDAPT was self-administered by study participants during a 30-45 minute session, with a member of the research team present in case assistance was needed. Naturalistic driving data were also collected during the 4 months prior to participants' completion of ADDAPT through in-car recording devices (ICRDs) installed in their personal vehicle (not reported in this paper).

Measures

ADDAPT was designed to examine self-regulation at multiple levels of driver performance and decision making. The questionnaire addresses not only the tactical and strategic levels of self-regulation discussed earlier, but also the life-goal level, a term coined by the UMTRI authors to take into account drivers' broader decisions in life that affect driving such as where to live in relation to frequent destinations or what kind of car to drive (Eby, Molnar & Kartje, 2009). Of interest for this study were self-regulatory practices at the strategic and tactical levels. Specific self-regulation measures are described below. Participants were also asked to respond to questions related to selected individual, social, and environmental factors that, based on review of the literature, were thought to be associated with the self-regulation process. There was also evidence linking some of these measures directly to poorer driving performance and in some cases to increased crash risk (e.g., Trail Making Test B and Rapid Pace Walk: Staplin, Gish & Wagner, 2003). In addition, the questionnaire included questions relating to sociodemographic variables which were used in the analyses to control for potential confounds. Sociodemographic variables included age, gender, and marital status, consistent with other studies that took one or more of these variables into account (e.g., see Braitman & McCartt, 2008; Kostyniuk & Molnar, 2008).

Self-regulatory practices

Measures of self-regulation for various driving situations at both the strategic and tactical levels were derived in a multi-step process. First, responses were taken from a set of questionnaire items asking participants if they tried to modify their driving by driving less, avoiding specific situations considered to be challenging, or engaging in other practices. For example, at the strategic level, participants were asked if they tried to avoid 10 specific driving situations: driving at night, in bad weather, on busy roads, in unfamiliar areas, alone, at night in bad weather, during rush hour traffic, or on the freeway, as well as reversing or making right turns across oncoming traffic at intersections without right hand turn arrows (keeping in mind that Australians drive on the left hand side of the road). They were also asked if they planned their route ahead of time, made a practice run to become familiar with their route, combined trips into a single outing, or brought passengers along to help navigate. At the tactical level, participants were asked if they tried to avoid various in-vehicle distractions while driving, including chatting with passengers, eating, reading a road map, changing radio stations, talking on a mobile phone, or personal grooming, as well as if they tried to leave more room than they used to between their car and the car ahead of them.

Participants who responded in the affirmative to any of questions about driving modification were asked about their reasons. Six of the response options related to what is commonly thought of as self-regulation; that is, difficulty seeing during the day or night; difficulty remembering things; difficulty concentrating on more than one thing at a time; reduced strength, flexibility, or general mobility; not feeling comfortable; not feeling safe relative to getting in a crash. Two response options were related to what would be considered lifestyle or preferences rather than self-regulation (i.e., have always tried to avoid the situation/engage in that practice; don't need to avoid the situation/engage in that practice) or other (with the respondent asked to provide the specific reason). Multiple reasons for each reported behavior were recorded where appropriate.

For each driving modification response, participants were classified into one of three groups: 1) non-modifiers (those who did not modify their driving); 2) self-regulators (those who modified their driving either by avoiding a particular situation or engaging in a particular practice for reasons related to self-regulation; and 3) others (those who modified their driving but for not for

reasons related to self-regulation). To be considered a self-regulator, participants had to choose at least one of the six self-regulatory reasons. The distributions of these three classifications across the various strategic and tactical situations can be found in Table A1 of the Appendix. In developing the measures of self-regulation at both the strategic and tactical levels for this study, only self-regulators were included.

Self-perceived health and functioning

To measure health and functioning, participants were asked to rate themselves (on a 7-point scale with 1 being "poor" and 7 being "excellent") on three separate items commonly used in surveys (e.g., Kostyniuk & Molnar, 2008): their overall health, their ability to walk one kilometer, and their ability to climb two flights of stairs. For the purposes of the analyses, the latter two items were averaged to develop an average functioning score (Cronbach's Alpha=0.86). The item on overall health was not included as it was not strongly correlated to the two measures of functioning.

Self-perceived abilities for safe driving

Participants were asked to rate themselves (on a 7-point scale with 1 being "poor" and 7 being "excellent") on four abilities for safe driving: their ability to see during the day or at night; their ability to remember things; their ability to concentrate on more than one thing at a time; and their strength, flexibility, or general mobility. For the purposes of the analyses, an average abilities score was developed by taking the mean of the four separate scores (Cronbach's Alpha=0.73).

Driving confidence, comfort, and safety

Participants were asked, in general, how confident they were that they could safely drive to places they needed to go to (on a 7-point scale with 1 being "not at all" and 7 being "completely"). For each of the 10 strategic driving avoidance situations asked about in the questionnaire, participants were asked to rate their feelings of comfort in that situation (on a 7-point scale with 1 being "not at all comfortable" and 7 being "completely comfortable"). For the purposes of the analyses, an average comfort score was developed for each participant by taking the mean of all 10 individual comfort ratings (Cronbach's Alpha=0.91). Similarly, participants were asked to rate their feelings of safety in each of the driving situations with safety defined in

terms of crash risk rather than personal security (on a 7-point scale with 1 being "not at all safe" and 7 being "completely safe"). For the purposes of the analyses, an average safety score was developed for each participant by taking the mean of all 10 safety ratings (Cronbach's Alpha=0.95).

Enabling factors and barriers to self-regulation

Participants were also asked several questions intended to identify factors that might encourage or discourage self-regulation. They were asked if they had family or friends available to give them a ride if they needed one (yes/no). They were also asked whether anyone inside or outside of their household depended on them to drive them (yes/no). In addition, they were asked how much they enjoyed driving (on a 7-point scale with 1 being "not at all" and 7 being "completely"), as this factor was considered to reflect a larger "life-goal" attribute that could affect an individual's driving-related choices (see Donorfio, Mohyde, Coughlin & D'Ambrosio, 2008; Eby et al., 2009).

Objectively-derived functioning

Several measures were included that came from in-person assessments conducted as part of the larger Candrive/Ozcandrive study. These included measures of: visual acuity of both eyes using the Snellen chart (Anderson & Holliday, 1995; Davey, 1981); contrast sensitivity as measured by the Pelli-Robson test (Pelli, Robson & Wilkins, 1988); cognitive functioning using the Trail Making Test B (Moses, 2004); Rapid Pace Walk (AMA, 2003), and visual perception as measured by the Motor Free Visual Perception (MVPT) test (Colarusso & Hammill, 2003). As described by Woolnough et al. (2012), these measures were operationalized in the Candrive protocol as follows: for Trail Making test Part B, the time to completion in seconds and the total number of errors were recorded; for the Rapid Pace Walk, the total number of seconds to walk 10 feet, turn around, and then walk another 10 feet was recorded; for the Visual Acuity (Snellen eye chart), scores were recorded as the smallest row of letters that could be accurately detected (no errors) while standing 10 feet from the Snellen chart, with the test being completed for the left eye, the right eye, and both eyes. For the MVPT test, participants were presented with a series of 13 target items. For each target item, they had to choose which one of four incomplete drawings, if completed, would match the target item (Vance et al., 2006). The total time to

complete the series in seconds was recorded. Contrast sensitivity was measured using the established protocol for the Pelli Robson sensitivity chart, with higher scores denoting better contrast sensitivity for the left eye, the right eye, and both eyes (Owsley, Stalvey, Wells, Sloane & McGwin, 2001).

Analysis

Given the impracticality of separately modeling each of the 14 strategic and 7 tactical driving situations, we developed two composite variables: one for strategic self-regulation and one for tactical self-regulation. That is, for each type, we summed each instance in which a participant was classified as a self-regulator to create a composite variable representing self-regulation. These variables provided useful insights into the collective behavior of self-regulation across the various situations in which it can occur. Thus, they were used, respectively, in two separate sets of regression analyses – one for strategic self-regulation and one for tactical self-regulation. Strategic and tactical self-regulation both represent over-dispersed count outcomes and negative binomial regressions are an appropriate statistical technique for dealing with count data (Faraway, 2006). As discussed above, the initial set of predictor variables was selected based on a review of the literature. Prior to developing the models, Spearman Ranked correlation analyses were conducted to provide a baseline understanding of the relationships between variables in the dataset (see Table A2 in Appendix). Negative binomial regression models were then developed to investigate the relationship of these variables on our outcomes of interest while controlling for other variables. All relationships with a p value < 0.05 were considered to be statistically significant.

Results

The mean age of participants was 79.7 years (SD=3.51, range=75-94). Other characteristics of study participants are shown in Table 1. The majority of participants were male and married. Most participants owned their residence (house, unit, or apartment) and had lived in it for more than 10 years. The majority of households consisted of the participant and at least one other individual. Over 45 percent of participants reported that someone else in the household also drove and over one-third reported that others were dependent on them to drive. Most

participants reported being retired, although a sizable number were in paid work and nearly two-thirds reported doing volunteer work in the community. Household income and education levels covered a broad range, although two-thirds reported an income of less than $AUD50,000 and over half had achieved at least a high school diploma.

Table 1. Sample Characteristics

Characteristic	Number*	Percent
Gender		
Male	171	71.5
Female	68	28.5
Marital Status		
Married/Common law	148	61.7
Separated/Divorced	18	7.5
Widowed	60	25.0
Single	14	5.8
Housing Arrangement		
Owned house, flat, apartment	185	77.1
Rented house, flat, apartment	9	3.8
Family member's house, flat, apartment	3	1.3
Senior/retirement community that provides transportation	29	12.1
Senior/retirement community not providing transportation	11	4.6
Other	3	1.3
Length at present location		
Less than 1 year	5	2.1
1-5 years	35	14.6
6-10 years	29	12.1
More than 10 years	171	71.3
Number of people in the household, including respondent		
1	92	38.3
2	135	56.3
3 or more	13	5.4
Number of drivers in the household, including respondent		
1	131	54.6
2	102	42.5
3 or more	7	2.9
Are you the primary driver	218	90.8
Does anyone in or outside the household depend on you to drive them	85	35.4
Do you have friends or family available to give you a ride if you need one	221	89.8
Are you retired	229	96.2
Do you currently do any paid work	25	11.7
Do you currently do any volunteer work in the community	154	65.3
Household income (Australian dollars; AUD)		
Less than $20,000	25	12.2
$20,000-$49,999	110	53.7
$50,000-$79,999	44	21.5
$80,000-$99,999	13	6.3
$100,000 or more	13	6.3
Education		
Less than high school completion	59	24.8
High school or technical school graduate	68	28.6
University degree	62	26.1
Some post graduate education	33	13.9
Post education degree or higher	16	6.7

*Numbers in each category may not add to 246 due to missing data.

Strategic and Tactical Self-Regulation Composite Variables

Values of the strategic self-regulation composite variable ranged from 0 to 9, with a mean of 1.3 and SD of 1.8. Values of the tactical self-regulation variable ranged from 0 to 7, with a mean of

2.0 and SD of 1.8. The full distributions of these composite variables are shown in Tables 2 and 3 below.

Table 2. Strategic Self-Regulation Count

Count	Frequency	Percent
0	120	48.8
1	48	19.5
2	25	10.2
3	21	8.5
4	16	6.5
5	6	2.4
6	3	1.2
7	5	2.0
8	1	.4
9	1	.4
Total	246	100.0

As shown in Table 2, close to half of participants were not considered strategic self-regulators in any of the situations; about 20 percent were considered strategic self-regulators in one situation only, 10 percent in two situations, and the remaining 20 percent in three or more situations. Although the total count possible for strategic self-regulation was 14, the highest count attained by any participant was 9.

Table 3. Tactical Self-Regulation Count

Count	Frequency	Percent
0	67	27.5
1	55	22.5
2	37	15.2
3	28	11.5
4	30	12.3
5	21	8.6
6	3	1.2
7	3	1.2
Total	244	100.0

The distribution for tactical self-regulators was noticeably different with fewer participants classified as non-self-regulators (27.5 percent) resulting in more participants being considered as self-regulators in at least one or more situations (Table 3). In addition, counts were distributed across all possible values (0-7).

Predictor Variables

Descriptive statistics are shown in Table 4 for all continuous predictor variables used in the models (see Table 1 for descriptive statistics for categorical variables). As a group, participants

rated themselves relatively highly in terms of their health and functioning, abilities for safe driving, and feelings of driving comfort and safety.

Table 4. Descriptive Statistics for Continuous Predictor Variables					
Predictor Variable	**N**	**Mean**	**S.D.**	**Minimum**	**Maximum**
Age	246	79.7	3.5	75	94
Overall health rating (1 being poor, 7 excellent)	245	5.8	0.8	3	7
Average functioning rating (1 being poor, 7 excellent)	246	5.7	1.4	1	7
Average abilities rating for safe driving (1 being poor, 7 excellent)	246	5.6	0.7	3.25	7
Average feelings of comfort (1 being not at all, 7 completely)	241	5.9	0.9	3.1	7
Average feelings of safety (1 being not at all, 7 completely)	239	5.9	1.1	1	7
Enjoyment of driving (1 being not at all, 7 completely)	240	6.2	1.0	3	7
Confidence that can drive to places (1 being not at all, 7 completely)	239	6.8	0.4	5	7
MVPT-3 (time taken in seconds)	246	142.4	57.1	67	448
Rapid pace walk (time taken in seconds)	246	6.9	1.4	4	14
Trail Making B Test (time taken in seconds)	246	114.7	51.0	41	407
Visual Acuity (both eyes)	246	13.4	5.8	6.5	75
Pelli-Robson contrast sensitivity (both eyes)	246	1.9	0.1	1.35	1.95

Multivariable model for strategic self-regulation

A series of negative binomial regression models were run to examine relationships between various factors and strategic self-regulation. Each model contained different combinations of factors of interest thought to be associated with self-regulation as the independent variables and the strategic self-regulation count variable as the dependent variable. The Akaike Information Criterion (AIC; Akaike, 1974) was used to compare models and the model summarized in Table 5 had the best statistical fit. Age was investigated in the model but it was not statistically significant nor did the inclusion of age change any of the substantive conclusions. Therefore the final model shown here with the best fit does not include age.

Table 5. Summary of Multivariable Negative Binomial Regression Model Statistics for Predicting Strategic Self-Regulation					
Variable	**Reference**	**Sig.**	**Incident Rate Ratio**	**95% CI for incident rate**	
				Lower	Upper
Gender	Female	0.026	0.665	0.464	0.953
Marital status	Not married	0.421	1.144	0.825	1.586
Family/friends available to give ride if needed	Yes	0.019	1.733	1.093	2.749
Someone dependent on participant to drive	Yes	0.159	1.254	0.915	1.718
Average self-perceived functioning		0.019	1.160	1.025	1.313
Average self-perceived abilities		<.001	0.572	0.439	0.744
Average Feelings of Comfort		<.001	0.600	0.477	0.753
Average Feelings of Safety		0.024	0.829	0.705	0.976
How much enjoy driving		0.430	1.067	0.908	1.255
How confident can drive safely to places		0.731	1.054	0.779	1.426
Rapid Pace Walk		0.040	1.117	1.005	1.242
Trail Making B Test		0.176	1.002	0.999	1.005
MVPT-3		0.032	0.996	0.993	1.000

As shown in Table 5, the estimated incident rate ratio comparing males to females is 0.665; that is, men are expected to have a rate for strategic self-regulation 0.665 times less than for women. Higher self-ratings of abilities for safe driving and feelings of driving comfort and safety were all associated with less self-regulation. Interestingly, higher ratings of functioning were associated with greater self-regulation. Study participants who did not have friends or family to drive them had an incident rate ratio 1.7 times that of other participants; that is, they engaged in strategic self-regulation across almost twice as many driving situations as those who had someone to drive them. Finally, higher scores on the Rapid Pace Walk (with higher scores meaning longer times in completing the walk) were associated with greater self-regulation, while higher scores on the MVPT (with higher scores also meaning longer completion times) were associated with less self-regulation. Marital status, having someone dependent for rides, enjoyment of driving, general driving confidence, and Trail Making Test Part B were not significantly associated with strategic self-regulation. It should also be noted that other functional abilities of interest (e.g., visual acuity and contrast sensitivity) dropped out in earlier models because of lack of statistical significance and were therefore not included in this final model.

Multivariable model for tactical self-regulation

A separate series of negative binomial regression models were run to examine relationships between various factors and tactical self-regulation. Each model contained different combinations of factors of interest thought to be associated with self-regulation as the independent variables and the tactical self-regulation count variable as the dependent variable. AIC values were again used as the method for model selection and the model summarized in Table 6 had the best statistical fit.

Table 6. Summary of Multivariable Negative Binomial Regression Model Statistics for Predicting Tactical Self-Regulation					
Variable	**Reference**	**Sig.**	**Incident Rate Ratio**	**95% CI for Incident Rate**	
				Lower	Upper
Gender	Women	0.071	1.318	0.977	1.778
Marital status	Not married	0.462	1.105	0.847	1.442
Family/friends available to give ride if needed	Yes	0.546	1.124	0.768	1.646
Someone dependent on participant to drive	Yes	0.322	1.135	0.883	1.460
Age		0.042	0.965	0.932	0.999
Overall health		0.570	1.046	0.895	1.223
Average self-perceived functioning		0.891	1.007	0.917	1.105
Average self-perceived abilities		0.029	0.797	0.651	0.977
Average Feelings of Comfort		0.485	0.933	0.768	1.134
Average Feelings of Safety		0.266	0.925	0.807	1.061
How much enjoy driving		0.057	0.883	0.777	1.004
How confident can drive safely to places		0.332	0.879	0.677	1.141
Rapid Pace Walk		0.983	0.999	0.914	1.092
Trail Making B Test		0.333	0.999	0.996	1.001
Pelli-Robson contrast sensitivity		0.001	0.284	0.133	0.607

Results of the negative binomial models for tactical self-regulation were quite different from those for strategic self-regulation (Table 6). Factors found to be associated with tactical self-regulation were average ratings of abilities for safe driving and scores on the Pelli-Robson contrast sensitivity test. In addition, age was added to the final model and was found to be statistically significant, with a one year increase in age translating into a 0.965 decrease in the incident rate ratio. The incidence rate ratio for the Pelli-Robson contrast sensitivity test was 0.284, suggesting that a one point increase on this scale leads on average to a decrease in the number of tactical self-regulatory behaviors by about 70% (thus, in general, the lower one's contrast sensitivity, the more tactical self-regulation).

Discussion and Conclusions

This study examined various individual, social, and environmental factors associated with self-regulation by older drivers at the tactical and strategic levels of driver performance and decision making. An important finding from this study was that self-regulation is a multidimensional concept. In particular, strategic self-regulation and tactical self-regulation appear to represent separate constructs that are influenced by different sets of factors.

For strategic self-regulation, participants' self-perceived abilities and feelings of comfort (our main proxy measure for driving confidence across specific situations) were both strongly related to self-regulation at significance levels of $p < 0.001$, with higher self-ratings associated with less

self-regulation. Gender was also statistical significant, with women more likely to self-regulate than men. These findings extend previous research by demonstrating that self-perceived abilities, feelings of comfort, and gender were associated with a specific class of self-regulation – namely strategic self-regulation. They also provide some support for Kostyniuk and Molnar's (2008) proposition that gender effects may, in part, be explained by individuals' perceived level of confidence in various driving situations, given that women's average ratings of driving comfort in this study were significantly lower than men's (5.5 versus 6.1, respectively; p=0.002).

Kostyniuk and Molnar (2008) further speculated that future cohorts of women who have been driving most of their lives may exhibit driving behaviors more similar to men. This seems reasonable in light of study findings that the driving cessation of women who had an active driving history was more similar to what is known about the driving cessation of men, suggesting that decisions about stopping driving are related to personal driving history rather than gender per se (Hakamies-Blomqvist & Siren, 2003). As the baby boomers continue to age, there will be opportunities to follow their driving behaviors over time to examine these issues.

Age was not a significant predictor of strategic self-regulation, thus providing partial support to other studies in which adding a confidence variable resulted in a reduced contribution by such factors as age and gender in explaining driving avoidance (e.g., Charlton et al., 2006). The lack of a significant relationship between age and strategic self-regulation is also not surprising given the relatively small age range of participants in the study and the relatively high level of health among participants; this is consistent with findings from other studies that age alone may not be the best indicator of self-regulation. For example, Donorfio, D'Ambrosio, Coughlin, and Mohyde (2008) found that an individual's health status and the interaction with age and health were the essential considerations in decisions regarding self-regulation and driving; that is, while individuals tended to self-regulate more with age, the effect became more pronounced as health status declined.

At the same time, results of this study point to the importance self-perceptions of health and functioning, reinforcing conclusions from other studies on self-regulation among older drivers

that self-perceptions may be better predictors of self-regulation than actual functioning (e.g., Anstey et al., 2005). Our finding that participants' self-ratings of health and abilities were significantly related to self-regulation, while few of the objective measures of functioning were, is consistent with the broader health behavior change literature. For example, Strecher, DeVellis, Becker and Rosenstock (1986) argued that it is individuals' perception about their capabilities and not necessarily their true capabilities that influence behavior. They noted the consistency of their conclusions with Bandura's (1977) assertion that an individual's expectations about the ability to execute or engage in a behavior, an important precursor for behavior change, reflects the individual's perceived rather than actual capabilities and it is these perceptions and not one's true abilities that influence behavior. On the other hand, one would expect that where there is a wide mismatch between actual and perceived abilities, with actual abilities being quite low and perceived abilities being quite high, the chance of appropriate self-regulation is unlikely.

Participants who did not have family or friends available to drive them were considerably more likely to restrict their driving across various driving situations, which may seem counterintuitive. However, taking into account that greater self-regulation was also associated with higher self-ratings of physical functioning; this may reflect an awareness by participants who still have good mobility but lack options for getting around once they stop driving, that they need to actively manage their driving to extend the period over which they can safely drive and they do so through a gradual process of self-regulation. That is, what may be common to all of these relationships is the awareness that driving could become a problem in the future and there is a need to do what they can now to extend the time over which they can drive by lengthening the transition to non-driving. This interpretation fits with the observation by Donorfio, Mohyde et al. (2008) that self-regulation is not a one-dimensional concept; rather, at one end of the continuum, older adults may consider some amount of self-regulation as a positive strategy for extending safe driving, while at the other end, extensive self-regulation and driving cessation may undermine quality of life.

A different pattern emerged with regard to tactical self-regulation; an expected result, given the differences in the temporal and categorical nature of tactical versus strategic decision making.

Fewer variables overall were associated with tactical self-regulation although, similar to strategic self-regulation, higher self-ratings of abilities were associated with fewer self-regulatory practices. Unlike strategic self-regulation, gender was not a significant predictor of self-regulation. Age was a significant predictor with increasing age being associated with fewer self-regulatory practices at the tactical level. The only other significant predictor was contrast sensitivity, with better contrast sensitivity predicting less tactical self-regulation. Intuitively, better contrast sensitivity would be expected to be associated with less self-regulation. However, the explanation for why increasing age was also associated with less self-regulation is less clear. Further research on tactical self-regulation among older adults is clearly warranted. There may be opportunities to more objectively gather information on tactical self-regulation, such as refraining from adjusting radio controls or grooming, using instrumented vehicles to study driving under naturalistic conditions (e.g., see Charlton, Catchlove, Scully, Koppel & Newstead, 2013).

Overall, our study yielded statistically significant relationships for only some of the cognitive functioning variables and only in relation to strategic self-regulation. Several other studies on self-regulation have found that factors associated with cognitive function (e.g., problems with balance, memory, confusion, or concentration) were not frequently mentioned as reasons for restricting driving (e.g., Betz & Lowenstein, 2010; Ragland et al., 2004). The lack of significance in the models for many of the cognitive functioning variables may have been due to our sample being relatively healthy and cognitively intact.

These results may also reflect a lack of insight among participants with cognitive impairments into their cognitive limitations or a lack of awareness that cognitive impairment is a risk factor for crash involvement (Betz & Lowenstein, 2010). The latter explanation points to the complexity of the relationship between cognitive functioning and self-regulation. For some forms of progressive dementia such as Alzheimer's disease, we would expect that as the disease progresses, individuals will increasingly lack awareness or insight into their cognitive deficits, which will undermine their use of self-regulation as a compensatory strategy (e.g., Carr, Meuser & Morris, 2006; Cotrell & Wild, 1999; Gil et al., 2001). This is because dementia not only affects cognitive skills for driving (e.g., memory, executive functioning, visuospatial skills) but

also those skills necessary to benefit from self-regulation and planning for driving transition and cessation (e.g., insight, reasoning). Thus, some studies show that the driving performance of individuals with dementia is worse than drivers without cognitive impairment (Man-Son-Hing, Marshall, Molnar & Wilson, 2007) and those affected by dementia do not change their driving behaviors even after a crash (Lucas-Blaustein et al., 1988). Individuals with progressive dementia will inevitably need to stop driving at some point (Croston, Meuser, Berg-Weger, Grant & Carr, 2009). However, in the early stages of the disease, driving safety may not be seriously compromised, as evidenced by a recent study that used vehicle instrumentation to monitor the driving of adults with early-stage dementia under naturalistic driving conditions (Eby, Silverstein, Molnar, LeBlanc & Adler, 2012).

The study had some limitations. The sample was comprised of a convenience cohort of older drivers age 75 years and older. Thus, there was likely a bias towards a healthier sample, resulting possibly in less self-regulation being reported than might have been found in a more general population with a greater range of impairments. All self-regulatory practices were self reported and may not represent the actual behavior or decision of participants. However, an important strength of the study is that self-regulation was operationalized not simply as driving reduction or avoidance but was based on people's actual motivations for modifying their driving. It is important to disentangle self-regulation of driving from avoiding driving situations for other reasons. Older drivers who are avoiding certain situations because of current lifestyle preferences rather than the awareness that their driving abilities may be compromised in certain driving situations cannot necessarily be relied upon to continue avoiding those situations if their lifestyle preferences change.

This study used data collected early in the Ozcandrive/Candrive project and from only one point in time. It will be important to examine changes in participants' self-regulatory driving behaviors over time as they age and increasingly experience declines in health and functioning. Continuing efforts are underway by the Ozcandrive/Candrive research team to investigate changes over time using a large set of clinical and psychosocial measures. In addition, as the Ozcandrive/Candrive study progresses, there will be an opportunity to examine prospectively, the effects of participants' self-regulatory behaviors on their actual crash risk. This is especially

critical as few studies have examined the effects of self-regulation on crash risk, with most findings coming from retrospective studies, limiting the ability to infer cause and effect. The prospective design of Ozcandrive/Candrive affords the possibility to answer many of the unanswered questions that remain about the self-regulation process among older adults. More generally, continuing efforts to better understand the self-regulatory practices of older drivers at the tactical, strategic, and even life-goal levels should provide important insights into how the transition from driving to non-driving can be better managed to balance the interdependent needs of public safety and personal mobility. One important audience for this information is physicians and other health professionals who can play a supportive role with respect to the transition from driving to non-driving among their older adult patients (MacLean, Berg-Weger, Meuser & Carr, 2007) but often lack the knowledge or confidence to respond to driving-related concerns (Meuser, Carr, Berg-Wegman, Niewoehner & Morris, 2006). While there is still much to learn about the process of self-regulation, results from this and other studies can help to inform the practice of professionals working with older adults to maintain their safe mobility.

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Appendix

Table A1. Driver Groups at Strategic and Tactical Levels					
	Strategic Level		Tactical Level		
Situation	N	%	Situation	N	%
Driving at night			Chatting with passengers while driving		
Non-modifiers	191	77.6	Non-modifiers	174	71.3
Self-regulators	40	16.3	Self-regulators	34	13.9
Others	15	6.1	Others	36	14.8
Making unprotected right turns			Eating while driving		
Non-modifiers	220	89.4	Non-modifiers	51	20.9
Self-regulators	17	6.9	Self-regulators	84	34.4
Others	9	3.7	Others	109	44.7
Driving in bad weather			Reading a road map while driving		
Non-modifiers	160	65.0	Non-modifiers	19	7.8
Self-regulators	49	19.9	Self-regulators	101	41.4
Others	37	15.0	Others	124	50.8
Driving on busy roads			Changing radio stations while driving		
Non-modifiers	205	83.3	Non-modifiers	168	68.9
Self-regulators	12	4.9	Self-regulators	25	10.2
Others	29	11.8	Others	51	20.9
Driving in unfamiliar areas			Talking on a mobile phone while driving		
Non-modifiers	212	86.2	Non-modifiers	9	3.7
Self-regulators	21	8.5	Self-regulators	89	36.9
Others	13	5.3	Others	143	59.3
Driving alone			Personal grooming while driving		
Non-modifiers	242	98.8	Non-modifiers	10	4.2
Self-regulators	-	-	Self-regulators	58	24.2
Others	3	1.2	Others	172	71.7
Driving at night in bad weather			Leave more room between your car and car ahead		
Non-modifiers	136	55.7	Non-modifiers	140	58.1
Self-regulators	70	28.7	Self-regulators	86	35.7
Others	38	15.6	Others	15	6.2
Driving during rush hour traffic					
Non-modifiers	131	51.0			
Self-regulators	32	12.5			
Others	81	31.5			
Driving on the freeway					
Non-modifiers	224	91.8			
Self-regulators	10	4.1			
Others	10	4.1			
Reversing					
Non-modifiers	215	88.1			
Self-regulators	16	6.6			
Others	13	5.3			
Plan your route ahead of time					
Non-modifiers	74	30.7			
Self-regulators	48	19.9			
Others	119	49.4			
Make a practice run to become familiar with your route					
Non-modifiers	221	92.1			
Self-regulators	1	0.4			
Others	18	7.5			
Combine trips into a single outing					
Non-modifiers	76	31.5			
Self-regulators	5	2.1			
Others Does for other reasons	160	66.4			
Bring passengers along to help navigate					
Non-modifiers	238	98.9			
Self-regulators	1	0.4			
Others	2	0.8			
Reduced your driving in the past year					
Non-modifiers	227	92.3			
Self-regulators	3	1.2			
Others	16	6.5			

* Numbers may not add to 246 for each situation due to missing data.

Table A2. Spearman Correlations Between Self-Regulation and Individual, Social, and Environmental Factors																			
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**	**S**
A	1	.45*	-.13#	-.11	-.33*	-.06	-.55*	-.52*	-.25*	-.27*	.21+	.03	.15#	.20+	.09	-.08	.05	-.02	.09
B	.45*	1	-.14#	-.03	-.24*	-.02	-.22+	-.22+	-.25*	-.22+	-.08	-.02	-.05	-.02	.04	.08	.09	-.16#	-.05
C	-.13#	-.14#	1	.47*	.49*	.06	.24*	.24*	.20+	.27*	-.06	-.11	-.02	-.13#	-.12	-.13#	-.08	.05	-.05
D	-.11	-.03	.47*	1	.39*	.09	.22+	.22+	.10	.15#	-.20+	.04	-.11	-.25*	-.16#	-.03	-.05	.03	-.06
E	-.33*	-.24*	.49*	.39*	1	-.02	.44*	.36*	.35*	.38*	.00	-.06	-.05	-.08	-.16#	-.08	-.09	.03	-.09
F	-.06	-.02	.06	.09	-.02	1	-.01	.04	.04	-.08	.03	-.13#	-.08	-.04	.08	-.02	.01	-.01	.03
G	-.55*	-.22+	.24*	.22+	.44*	-.01	1	.85*	.44*	.39*	-.26*	-.13	-.21+	-.13#	-.07	-.03	-.08	-.03	-.08
H	-.52*	-.22+	.24*	.22+	.36*	.04	.85*	1	.41*	.39*	-.25*	-.14#	-.18+	-.14#	-.09	-.06	-.09	-.08	-.11
I	-.25*	-.25*	.20+	.10	.35*	.04	.44*	.41*	1	.34*	-.03	.01	-.07	.03	-.03	-.06	.06	-.01	-.13#
J	-.27*	-.22+	.27*	.15#	.38*	-.08	.39*	.39*	.34*	1	-.14#	-.04	-.05	.00	-.10	-.05	-.02	.03	-.04
K	.21+	-.08	-.06	-.20+	.00	.03	-.26*	-.25*	-.03	-.14#	1	.04	.42*	.16#	-.04	-.03	.01	-.02	-.11
L	.03	-.02	-.11	.04	-.06	-.13#	-.13	-.14#	.01	-.04	.04	1	-.17+	.03	.10	.02	-.01	.01	.04
M	.15#	-.05	-.02	-.11	-.05	-.08	-.21+	-.18+	-.07	-.05	.42*	-.17+	1	.19+	.01	.05	-.02	-.02	.09
N	.20+	-.02	-.13#	-.25*	-.08	-.04	-.13#	-.14	.03	.00	.16#	.03	.19+	1	.23*	.02	.04	-.06	.19+
O	.09	.04	-.12	-.16#	-.16#	.08	-.07	-.09	-.03	-.10	-.04	.10	.01	.23*	1	.35*	.14#	-.14#	.17+
P	-.08	.08	-.13#	-.03	-.08	-.02	-.03	-.06	-.06	-.05	-.03	.02	.05	.02	.35*	1	.06	-.20+	.18+
Q	.05	.09	-.08	-.05	-.09	.01	-.08	-.09	.06	-.02	.01	-.01	-.02	.04	.14#	.06	1	-.15#	.09
R	-.02	-.16#	.05	.03	.03	-.01	-.03	-.08	-.01	.03	-.02	.01	-.02	-.06	-.14#	-.20+	-.15#	1	-.04
S	.09	-.05	-.05	-.06	-.09	.03	-.08	-.11	-.13#	-.04	-.11	.04	.09	.19+	.17+	.18+	.09	-.04	1

*p<.001
+p<.01
#p<.05

A: Strategic self-regulation count
B: Tactical self-regulation count
C: Overall health rating
D: Average functioning rating (ability to walk 1 kilometers and climb 2 flights of stairs)
E: Average abilities rating for safe driving (ability to see clearly at night, remember things, concentrate on two or more things at a time, and strength, flexibility and general mobility).
F: Family or friends available to give rides if needed
G: Average feelings of comfort
H: Average feelings of safety
I: Enjoyment of driving
J: Confidence that can drive to places
K: Gender
L: Does anyone depend on participant for rides
M: Marital status
N: Rapid pace walk
O: Trail Making B Test
P: MVPT-3
Q: Visual Acuity
R: Pelli-Robson Contrast Sensitivity
S. Age

Chapter 8: Self-Regulation of Driving by Older Adults: Comparison of Self-Report and Objective Driving Data (Publication 4)

This paper addresses the researcher's third research question: How do self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors? The purpose of the exploratory work reported in the paper was to better understand the process of self-regulation among older adults by examining their trip-specific driving patterns using objective measures of driving, and comparing these patterns with drivers' self-reports. Specific aims were to: develop measures for examining driving patterns in older drivers using GPS data; and use those measures to examine relationships between real-world driving patterns and self-reported responses using the ADDAPT questionnaire on self-regulation of driving among older adults. At the time the thesis was submitted for examination, this paper was under review at Transportation Research: Part F. Included here is the submitted version of the paper. Subsequent to submitting the thesis for examination, the paper was revised and accepted for publication, and is now published (see Molnar, Charlton, Eby, Bogard, Langford, Koppel, Kolenic, Marshall & Man-Son-Hing, 2013).

Monash University

Declaration for Thesis Chapter 8:

Molnar, L.J., Charlton, J.L., Eby, D.W., Bogard, S.E., Langford, J., Koppel, S., Kolenic, G.E., Marshall, S. & Man-Son-Hing, M. (under review). Self-Regulation of Driving by Older Adults: Comparison of Self-Report and Objective Driving Data.

Declaration by candidate

In the case of the publication presented in Chapter 8, the nature and extent of my contribution to the work was the following:

Nature of contribution	**Extent of contribution (%)**
▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, drafting of text, preparation of figures/tables, revision/editing for intellectual content	80%

The following co-authors contributed to the work. None of the co-authors were students at Monash University (and therefore no indication of the extent of their contribution in percentage terms was required).

Name	
Dr. Judith L. Charlton	▪ Concept and design – initial concept, development of study design ▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. David W. Eby	▪ Concept and design – initial concept, development of study design ▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Mr. Scott Bogard	▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Jim	▪ Concept and design – initial concept, development of study design

Langford	▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Sjaan Koppel	▪ Acquisition of data – data collection, data management, supervision of data quality ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Ms. Giselle E. Kolenic	▪ Analysis and interpretation – statistical analysis, interpretation of analysis ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Shawn Marshall	▪ Concept and design – initial concept, development of study design ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content
Dr. Malcolm Man-Son-Hing	▪ Concept and design – initial concept, development of study design ▪ Publication preparation – paper outline, preparation of figures/tables, revision/editing for intellectual content

Candidate's Signature	[redacted]	**Date** 11-02-2013

Declaration by co-authors

The undersigned hereby certify that:

(19) the above declaration correctly reflects the nature and extent of the candidate's contribution to this work, and the nature of the contribution of each of the co-authors.
(20) they meet the criteria for authorship in that they have participated in the conception, execution, or interpretation, of at least that part of the publication in their field of expertise;
(21) they take public responsibility for their part of the publication, except for the responsible author who accepts overall responsibility for the publication;
(22) there are no other authors of the publication according to these criteria;
(23) potential conflicts of interest have been disclosed to (a) granting bodies, (b) the editor or publisher of journals or other publications, and (c) the head of the responsible academic unit; and
(24) the original data are stored at the following location(s) and will be held for at least five years from the date indicated below:

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Self-Regulation of Driving by Older Adults:
Comparison of Self-Report and Objective Driving Data

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Keywords: self-regulatory practices, mobility, older drivers, GPS

Abstract

Until recently, objective data have been lacking on the extent to which older adults modify their driving by driving less or avoiding situations considered challenging; a process commonly referred to as self-regulation. Advances in technology now make it possible to examine driving exposure, patterns, and habits using low-cost global positioning system (GPS) technology to record a vehicle's location on a continuous basis along with the date and time. The purpose of this exploratory study was to better understand the process of self-regulation among older adults by examining their trip-specific driving patterns using objectively-derived GPS measures of driving and comparing these patterns with drivers' self-reports. The study used a sample of 156 adults age 75 or older, recruited from the greater Melbourne area of Australia as part of the Ozcandrive project, a partnership between Monash University Accident Research Centre and the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive), a prospective cohort study of older drivers. Objective driving data were collected through equipment installed in participants' personal vehicles. Participants were asked to drive as they normally would with the equipment installed in their vehicle. After approximately the first 4 months of driving with the device, data were downloaded and participants completed a computer-based questionnaire on self-regulation of driving. Results suggest that there was correspondence, albeit not perfect, between some objective driving measures and their comparable self-reported measures, but a lack of correspondence for others. For avoidance of various driving situations, comparisons were statistically significant for driving at night, driving in unfamiliar areas, and on high speed roads. For each driving situation, participants' actual driving predicted the likelihood of reporting trying to avoid that situation, although perfect one-to-one correspondence between the self-reported and objective data on self-regulatory driving patterns was lacking. For measures of driving exposure, self-reported and objective driving exposure measures were correlated, but participants tended to underreport their average number of days per week and kilometers per week driven. This discrepancy between self-reported and objective measures is of concern as the ability to measure driving exposure not only contributes to a better understanding of the complex process of self-regulation, but is also a critical element in understanding crash risk.

1 Introduction

It has been estimated that more than 600,000 adults age 70 and older stop driving in the United States (US) each year and become dependent on others to meet their transportation needs (Foley, Heimovitz, Guralnik & Brock, 2002). The process of transitioning from driving to non-driving is complex and can have adverse consequences such as loss of independence, diminished self-worth, increased social isolation, increased depressive symptoms, and more general accelerated health declines (e.g., see Adler & Rottunda, 2006; Edwards, Lunsman, Perkins, Rebok & Roth, 2009; Fonda, Wallace & Herzog, 2001; Liddle, McKenna & Broome, 2004; Marottoli et al., 1997; Ragland, Satariano & MacLeod, 2004, 2005). Some drivers stop driving suddenly because of a medical condition or a motor vehicle crash. However, for many drivers, the transition to non-driving is a gradual process as they become increasingly more vulnerable to difficulties in traffic, limit their driving under certain conditions, and drive progressively less than before (Hakamies-Blomqvist & Wahlström, 1998).

While there is still much to learn about this process, we know there is considerable variation in how older drivers respond to driving-related problems, what steps they take in an attempt to continue driving safely, and how well they adapt if they have to stop driving. A review by Molnar and Eby (2008) found that many older drivers reduce their overall driving exposure or avoid specific driving situations such as driving at night, in bad weather, in heavy traffic, and making unprotected left turns. However, other drivers do not appear to appropriately modify their driving in situations considered to be challenging; this process of driving modification is commonly referred to as self-regulation (e.g., see Baldock, Mathias, McLean & Berndt, 2006; Ball et al., 1998; Charlton et al., 2006; Stalvey & Owsley, 2000).

Most studies of self-regulation have relied on self-report by drivers (e.g., Baldock et al., 2006; DeCarlo, Scilley, Wells & Owsley, 2003; Owsley, Stalvey, Wells & Sloane, 1999; Sargent-Cox, Windsor, Walker & Anstey, 2011; Sullivan, Smith, Horswill & Lurie-Beck, 2011). However, as noted by Huebner, Porter and Marshall (2006) and others, the validity and accuracy of self-reported data have generally not been examined. Thus, a major limitation in this area has been

that objective data are lacking about the extent to which older drivers reduce their driving overall or avoid specific driving situations.

Advances in technology now make it possible to examine driving exposure, patterns, and habits using low-cost global positioning system (GPS) technology to record a vehicle's location on a continuous basis along with the date and time (e.g., see Grengs, Wang & Kosyniuk, 2008; Porter & Whitton, 2002). The ability to collect these objective data represents a major step forward and helps address concerns that have been raised about the validity and accuracy of self-reported estimates of driving exposure (e.g., see Huebner, et al, 2006; Staplin, Gish & Joyce, 2008; Staplin, Gish & Wagner, 2003). Data collection using GPS has been favorably viewed in at least one study, with older drivers preferring in-vehicle technology to measure driving exposure over using travel diaries (Marshall et al., 2007). At the same time, there are also challenges associated with interpreting objective data collected through in-vehicle instrumentation, particularly when information about the context of the driving situation is unknown. For straightforward driving behaviors such as exposure variables (e.g., miles or kilometers driven in a given period of time), objective data may be superior to self-reports, although further empirical testing would be useful. However, for better understanding the context of driving and broader concepts of decision making, there may be a role for self-report, particularly when used in conjunction with objectively-derived data.

Despite the promise of in-car recording devices (ICRDs) using GPS technology, there has been limited research comparing GPS and self-reported data with regard to the trip-specific driving patterns of drivers, particularly for older drivers beginning to experience age-related declines that can affect driving. Only a handful of published studies were found that compared self-reported driving by older adults as a group with objectively derived driving data (e.g., Blanchard, Myers & Porter, 2010; Huebner et al., 2006; Marshall et al., 2007; Myers, Trang & Crizzle, 2011). Marshall et al. (2007) recruited 20 Canadian older drivers and compared self-reported driving data from travel diaries to two types of electronic data logging devices, the CarChip and FleetPulse™. They found moderate and strong correlations, respectively, between travel diaries and the CarChip and FleetPulse™ devices. In contrast, Huebner et al. (2006) and Blanchard et al. (2010), using Canadian samples of 20 and 61, respectively, found that older drivers both

under and over estimated their weekly driving distance, based on comparisons between self-reports of weekly driving distance and driving data from the CarChip device. Blanchard et al. (2010) discussed variations in protocols and analyses that may have accounted for the differences between their findings and those of Marshall et al. (2007).

Clearly, there is an opportunity to continue to advance knowledge in this area by examining self-regulatory practices among larger samples of older drivers and in other geographic locations, using objective data to examine actual driving behaviors, as well as self-reported data to better understand the context within which these driving behaviors occur and the intended behaviors of drivers both on and off the road. An essential part of this undertaking is to gain a better understanding of how objective and self-reported driving data compare by identifying specific areas of convergence and divergence.

2. Study Background

The purpose of this exploratory study was to better understand the process of self-regulation among older adults by examining their trip-specific driving patterns using objective measures of driving, and comparing these patterns with drivers' self-reports. The specific aims were to: 1) develop measures for examining driving patterns in older drivers using GPS data; and 2) use these measures to examine relationships between real-world driving patterns and self-reported responses using a questionnaire on self-regulation of driving among older adults.

The study is part of a larger program of research focusing on: the nature and extent of self-regulation by older drivers at multiple levels of driver performance and decision making; how self-regulation is influenced by various individual, social, and environmental factors; and how self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors. The research program is being carried out by the University of Michigan Transportation Research Institute (UMTRI) and Monash University Accident Research Centre (MUARC), as part of the Ozcandrive study which includes older drivers in both Australia and New Zealand. Ozcandrive is a partnership with the Canadian Driving Research Initiative for Vehicular Safety in the Elderly (Candrive), the first study to follow a large group of older drivers

over several years, and collect comprehensive data on health, functioning, and driving (see Marshall et al., 2012). A major focus of the Candrive study is to document the natural driving life course of older drivers, including any transition from driving to non-driving, using self-reported and objectively-derived driving and clinical data.

3. Methods

Participants in the Australian component of the Ozcandrive sample (i.e., those Ozcandrive participants recruited from the greater Melbourne area of Australia) completed a computer-based questionnaire on driving self-regulation about 4 months after being recruited into the study. Participants completed the questionnaire in addition to the standard protocol for the Candrive/Ozcandrive project. Objective driving data were also collected through equipment installed in participants' personal vehicles, as part of the Candrive/Ozcandrive project. Approval for the study was received from the Monash University Human Research Ethics Committee. Full detail on the Candrive/Ozcandrive study protocols can be found in Marshall et al. (2012) and Porter et al. (under review). Of special interest for this study are the protocols that relate to participant recruitment and collection of objective driving data.

3.1 Participant recruitment

Study participants were recruited between June 2010 and June 2011 through autoclub membership, community and city newspapers, newsletters, posters, and presentations and outreach to various senior-related associations. Those who expressed interest in the study were contacted via telephone by a research assistant from Ozcandrive and screened for eligibility and study commitment. The overall aim was to recruit older, active drivers who would potentially be able to participate in the study for up to 5 years.

Inclusion criteria for Ozcandrive were: having a general class driver license and having been actively driving for at least 1 year; being age 75 or older; driving at least 4 times per week; having agreed to undergo an annual physical, cognitive, and vision assessment, and be contacted at least quarterly for vehicle data pickup and interview; residing in the local region of the study city for at least 10 months a year; being followed actively by a family physician; intending to

continue driving for the next 5 years; fluent in English; consenting to release driving information from the licensing authority; access to a vehicle of model year 2003 or newer; and driving one vehicle for at least 70 percent of the time. Exclusion criteria were: a planned move out of the region; a medical contraindication to driving within the previous 6 months (according to the Austroads guide; Austroads, 2006); or a diagnosis of progressive conditions that could affect driving (e.g., Alzheimer's disease, macular degeneration).

3.2 Data Collection

3.2.1 In-car recording device

Objective data on the real-world naturalistic driving of study participants were collected through a custom-designed ICRD installed in their personal vehicle. The ICRD (OttoView-CD) plus software suite was developed for Candrive by Persentech Inc. in Winnipeg, Manitoba (Porter et al., under review; see Figure 1). The ICRD was installed in each participant's primary vehicle, with the power supply and data coming from the vehicle via the On Board Diagnostic (OBDII) port (present in all vehicle models later than 2003 in Australia). The ICRD automatically started when the vehicle ignition was turned on and shut down when the vehicle ignition was turned off; hence, each such ignition-on ignition-off cycle was considered to be a single trip. Vehicle location information was also collected, using a GPS antenna mounted on the dash and a receiver in the main device box. In cases in which the participant shared a vehicle with others, a radio frequency identifier system (antenna plus key chain fob used by the study participant) was used to identify the participant as the vehicle driver so that driving data for nonparticipants could be removed. Participants' data were stored on an SD memory card at a rate of 1 Hz.

Figure 1. Multiple Views of ICRD (key chain fob in upper left; OBDII connector in upper right; actual device with memory card, OBDII cable, GPS antenna, and RFID antenna in lower portion of figure; from Porter et al., under review)

Participants were asked to drive as they normally would with the ICRD installed in their vehicle. After approximately the first 4 months of driving with the device, data were downloaded and participants completed a questionnaire on self-regulation of driving. Participants reporting that they shared a vehicle also kept a driving log to record any trips made by another driver, if they did not have an RFID antenna and fob set up. Following the 4-month data download, all participants were interviewed to clarify any data issues that had arisen during the driving period, as well as provide information about other vehicles they may have driven in addition to their

primary vehicle, including the number of days per week and self-estimated total kilometers driven. Participants were also queried about whether they had driven the other vehicle on a regular basis or during a single block of time (e.g., a rental car during a vacation). At the time of this study, vehicle data collected during the first 4 months of the study had been processed for 220 of the total 257 Ozcandrive participants in the Melbourne area sample and therefore were included in the analyses.

3.2.2 Self-regulation questionnaire

The self-regulation instrument used in the study was the computer-based Advanced Driving Decisions and Patterns of Travel (ADDAPT) questionnaire developed at UMTRI (Molnar, Eby, Roberts, St. Louis & Langford, 2009). ADDAPT addresses the following topics: current driving patterns and changes over time; alternative transportation options; participant socio-demographic characteristics; general health and functioning; abilities for safe driving; self-regulatory driving practices at the life-goal, strategic, and tactical levels; life-goal preferences and activities; feelings of driving comfort and safety; and ability to self-regulate. ADDAPT was pilot tested with 132 adults age 70 and older residing in Michigan, USA. These participants were comprised of both older adults recruited from the general population and older adults with losses in vision, psycho-motor skills, or cognition recruited from specialty geriatric clinics at the University of Michigan (see Molnar et al. 2009 for further details). Based on the pilot study results and advice from the Australian authors, ADDAPT was revised and tailored for use with Australasian older drivers.

Participants completed the questionnaire approximately 4 months after they had enrolled in the Ozcandrive study and signed informed consent. The computer-based questionnaire was self-administered by study participants during a session in which a member of the research team was present in the room to provide assistance as necessary. Completion of the questionnaire took on average 30-45 minutes. It is important to note that completion of the questionnaire occurred AFTER the first 4 months of driving data had been collected by the ICRD; therefore, the self-reported ADDAPT data were compared to the 4 months of ICRD data on driving behaviors that had already occurred.

3.3 ICRD data processing

Downloaded data files from the SD card were sent by Ozcandrive project staff to the Winnipeg Candrive site using a file transfer protocol server at the University of Manitoba. The files were then processed and checked against follow-up interview data to verify that the ICRD was functioning properly. Data for drivers other than participants were identified so they could be removed from the dataset. Specific problems with the data were also identified (e.g., key fob not detected frequently enough, missing GPS data, problems with data downloads). Based on this review, participants were classified as having all or most, some, or none of their data being usable for analyses. In addition, specific trips were identified that needed to be filtered out at a later time (e.g., trips to/from the Ozcandrive study site).

Based on the information provided by the Winnipeg site, the ICRD data were cleaned at UMTRI during a multi-stage process. First, to be conservative, only participants classified as having all or most of their data usable for analyses were included in the study. This resulted in removing 57 participants from the set of 220 participants for whom ICRD data were available at the time of the analyses (leaving 163 participants). Second, all data were filtered for trips not made by the participant, either according to the RFID-identified trips or by the driving log. In addition, all trips of less than 200 meters (e.g., moving a vehicle into a garage) were deemed to be "non-trips" for the purpose of the analyses.

Finally, within the set of participants with usable data, there were also some participants who had driven another vehicle in addition to their primary vehicle during the 4-month driving period. For six of these participants, the estimated kilometers driven in the alternate vehicle amounted to 30 percent or more of their total kilometers driven during the period (exceeding the Ozcandrive study inclusion criterion that at least 70 percent of driving be done in participant's primary vehicle). These participants were removed, resulting in 157 participants remaining in the ICRD dataset. One additional participant was removed because corresponding questionnaire data were not available for that individual, resulting in a final dataset of 156 participants. Collectively, these 156 participants made a total of 69,981 vehicle trips, drove 495,111 kilometers, and drove for 14,392 hours during the 4-month driving period.

Raw GPS data do not allow examination of driving patterns directly. Thus, a number of algorithms were applied to derive the measures of interest for the study. Travel patterns were determined primarily based on GPS measurements that included location, time of day, vehicle speed, heading, and GPS quality indicators. The set of GPS-derived measures developed for the study, along with descriptions of these measures are included in Table 1. More detailed descriptions of some of these measures follow the table. Several measures were normalized by the exposure variable of trips undertaken by the driver. This was done to allow comparison of measures between drivers with different participation periods, and given that many decisions about self-regulation are made by drivers on a trip-by-trip basis (e.g., avoidance of nighttime driving is typically manifested as not taking a trip during nighttime hours rather than generally limiting the number of miles or days driven at night).

Table 1. List of Measures from ICRD Driving Data

Overall driving exposure	
Measure	**Description**
Days per week driving	Total number of days with at least one trip taken divided by total number of weeks available to drive during study participation.
Trips per week	Total number of trips taken divided by total number of weeks available to drive during study participation.
Kilometers per trip	Total number of kilometers driven divided by total numbers of trips made during study participation.
Kilometers per week	Total number of kilometers driven divided by total number of weeks available to drive during study participation.
Kilometers per trip chain	Total number of kilometers driven divided by total number of estimated trip chains. One trip chain was equal to the sum of trips that occurred between leaving home and returning home.
Self-regulatory patterns	
Percent of trips at night	Percent of all trips during which at least 80 percent of the trip was during nighttime (solar angle greater than 96 degrees).
Percent of trips during rush hour traffic	Percentage of trips taken during weekday rush hours (6:30-9:00 AM or 4:00- 6.30 PM).
Percent of trips on high speed roads	Percent of all trips traveled at speeds of 85 kilometers/hour or higher. Used as a proxy for freeways.
Percent of trips within 5 kilometers of home	Kilometers traveled while within 5 miles of the driver's residence divided by total kilometers traveled by that driver. Proxy for driving in familiar areas.
Percent of trips within 10 kilometers of home	Kilometers traveled while within 10 miles of the driver's

	residence divided by total kilometers traveled by that driver. Proxy for driving in familiar areas.
Percent of trips within 15 kilometers of home	Kilometers traveled while within 15 miles of the driver's residence divided by total kilometers traveled by that driver. Proxy for driving in familiar areas.
Ratio of left hand to right hand turns	Ratio of all left-hand to right-hand turning events identified for driver, with increasing ratios indicating greater self-regulation.
Average number of trips per trip chain	Total number of trips taken by driver as part of identified trip chains divided by total number of trip chains identified.

Information on solar angle (based on latitude/longitude coordinates and GPS time) was used to determine daylight, twilight, and nighttime. Daylight was defined as 0-89 degree solar angle, civil twilight as 90-96 degree solar angle, and nighttime as solar angle greater than 96 degrees. Percent of trips during nighttime was determined based on the percent of trips during which at least 80 percent of the trip was during nighttime. Rush hour driving was defined as driving between the hours of 6:30-9:00 AM or 4:00-6:30 PM. Three separate measures of distance from home were examined (within 5, 10, and 15 kilometers of home) as proxies for driving in familiar areas, given individual differences likely found in what constitutes a familiar area. High speed driving (a proxy for freeway driving) was defined as speeds of 85 kilometers per hour and faster. We considered using 100 kilometers per hour and faster as the proxy measure for high speed, given that speed limits on Australian freeways are typically 100 kilometers per hour. However, there were so few trips taken at these speeds that it was not meaningful to use this measure in the analyses and it was decided to retain the proxy measure of 85 kilometers per hour and faster.

The process of determining the ratio of left to right turns involved several steps. The first step was to identify turns by taking the vehicle heading data from the GPS and developing a yaw measure. Yaw rate was derived from the GPS heading data at times when the vehicle was moving and GPS fixed quality was considered good (i.e., at least three satellites) The yaw rate was then smoothed using a binomial filter over a 5-second period. Yaw rate was used to identify periods when a vehicle was turning or in a curve; these were defined by having an absolute value of yaw greater than 0.09 degrees/second. Vehicle speed was then divided by yaw rate to obtain instantaneous turn radius. Turning events were defined as those with a heading change of between 70 and 110 degrees with the sign of the heading indicating the direction of the turn.

A trip chain has been described as a sequence of trips beginning from a location and returning to that location after some number of intermediate stops (Golob & Hensher, 2007); it is operationalized in the analyses as all trips occurring between the time the participant left home and returned home. Trip chaining behavior is of interest in studying self-regulatory behavior because of the possibility that older adults may combine several trips into one outing to reduce the magnitude of driving challenges. This idea is supported by the findings from at least one study that although the generation of non-work trip chains decrease with age, simple chains (those involving a single away-from-home destination) decrease at a faster rate than complex chains (Golob & Hensher, 2007).

3.4 Analysis

All data analyses were conducted using IBM SPSS Statistics version 19. Separate sets of descriptive statistics were generated for the ICRD driving data and the questionnaire data. It should be noted that the objective driving data analyzed for this study represent the everyday driving of participants in their primary vehicle.

To examine the relationship between the objectively derived driving data and self-reported questionnaire data, simple logistic and simple linear regressions were run for a set of independent/dependent variable combinations that related to either overall driving exposure (e.g., kilometers driven) or self-regulatory driving patterns (avoidance of challenging situations). Logistic regressions were used for categorical (binary) dependent variables and linear regression for continuous dependent variables. For each independent/dependent combination of interest, the independent variable was the objectively-derived driving measure and the dependent variable was the comparable self-report measure. This was done not only because of how the data were collected (i.e., participants first drove for 4 months before being asked to reflect on their driving in the questionnaire), but also because it makes sense that actual behavior would predict a survey response rather than the other way around. The regression framework was used rather than simple correlation analysis or t-tests because it not only allows for the correlation (or association) between driving and self-report data to be assessed, but it also yields predictions about the

expected change in the dependent variable given a change in the independent variable (Gelman & Hill, 2007).

4 Results

4.1 Participant characteristics

The mean age of participants was 79.2 (SD=3.2, range 75-88). Other characteristics of study participants are shown in Table 2. The majority of participants were male and married. All but two considered themselves to be urban residents. Most participants owned their residence (i.e., house, flat, or apartment). Regardless of residence type, most had lived there for more than 10 years. The majority of households consisted of the participant and at least one other individual, with over a third of participants reporting that someone else in the household also drove. One third also reported that others were dependent on them to drive. Most reported being retired, although over two-thirds reported doing volunteer work in the community. Household income and education levels covered a broad range, although two-thirds reported an income of less than $AUD50,000 and over half had completed high school or technical school.

Table 2. Sample Characteristics		
Characteristic	**Number***	**Percent**
Gender		
Male	109	69.9
Female	47	30.1
Marital Status		
Married/Common law	85	57.8
Separated/Divorced	13	8.9
Widowed	37	25.2
Single	12	8.2
Do you consider yourself an urban or rural resident		
Urban	154	98.7
Rural	2	1.3
Housing Arrangement		
Owned house, flat, apartment	116	78.9
Rented house, flat, apartment	4	2.7
Family member's house, flat, apartment	2	1.4
Senior/retirement community that provides transportation	18	12.2
Senior/retirement community not providing transportation	5	3.4
Other	2	1.4
Length at present location		
Less than 1 year	4	2.7
1-5 years	21	14.3
6-10 years	17	11.6
More than 10 years	105	71.4
Number of people in the household, including respondent		
1	61	41.5
2	79	53.7
3 or more	7	4.8
Number of drivers in the household, including respondent		
1	90	61.2
2	55	37.4
3 or more	2	1.4
Are you the primary driver – yes	133	90.5
Does anyone in or outside the household depend on you to drive them - yes	54	36.7
Are you retired – yes	141	96.6
Do you currently do any paid work – yes	13	10.1
Do you currently do any volunteer work in the community - yes	95	65.5
Household income (Australian dollars; AUD)		
Less than $20,000	18	14.0
$20,000-$49,999	70	54.3
$50,000-$79,999	23	17.8
$80,000-$99,999	8	6.2
$100,000 or more	10	7.8
Education		
Primary School	37	23.7
High school	15	9.6
Trade/Technical Certificate	31	19.6
Diploma	45	28.8
Degree	21	13.5
Post-graduate	7	4.5

* Numbers in each category may not add to 156 due to missing data.

4.2 Descriptive analyses for ICRD driving data and questionnaire data

The ICRD driving data are summarized in Table 3. Over the course of the 4-month driving period, participants drove an average of 5.7 days per week, making an average of 25.4 trips per week. In terms of distance, they drove, on average, 7.1 kilometers per trip and 179.6 kilometers per week. The average driving distance for each trip chain identified was 39.3 kilometers. The selected driving patterns highlighted in the table are those for which there were comparable questionnaire measures. Among participants as a group, relatively few trips were taken at night or on high speed roads (4.8% and 6.0%, respectively). Close to 25% of trips were taken during rush hour traffic, over 75% were within 5 kilometers of home, and over 90% were within 15 kilometers of home. Participants made, on average, about the same number of right hand as left hand turns across all of their trips. When engaging in trip chaining, they completed an average of 2.8 trips within each chain (i.e., 2.8 separate ignition-on/ignition-off cycles from the time they left home to the time they returned home).

Table 3. Measures from ICRD Driving Data

Measure	Mean	SD	Min	Max
Overall driving exposure				
Days per week driving	5.7	1.1	2.0	7.0
Trips per week	25.4	9.3	8.0	74.0
Kilometers per trip	7.3	3.5	2.0	22.7
Kilometers per week	179.6	96.1	41.0	666.0
Kilometers per trip chain	39.3	40.3	5.6	309.2
Self-regulatory patterns				
Percent of trips at night	4.8	4.8	0	33.1
Percent of trips on high speed roads (>85 km)	6.0	6.6	0	37.1
Percent of trips during rush hour	23.4	7.7	6.0	54.6
Percent of trips within 5 kilometers of home	77.9	12.1	45.9	100
Percent of trips within 10 kilometers of home	87.3	10.6	52.2	100
Percent of trips within 15 kilometers of home	91.3	9.6	52.2	100
Ratio of left hand to right hand turns	1.0	0.2	0.6	2.1
Average trips per trip chain	2.8	0.6	1	5.3

Questionnaire data on overall driving exposure and self-regulatory driving patterns are summarized in Table 4. As a group, participants reported driving 5.9 days per week on average and 155.9 kilometers per week. When asked about the driving distance of most of their out and back trips (defined as trip chains for the purposes of this study) about half of participants reported these trips to be 1-10 kilometers in distance and about 18% reported them to be greater than 15 kilometers in distance. In terms of self-regulatory patterns, the greatest percentages of participants reported combining trips into a single outing (66.9), trying to avoid driving rush hour traffic (48.3), driving at night (20.3), and driving in unfamiliar areas (15.7). Less than 10% of participants reported either trying to avoid making unprotected right hand turns, trying to avoid driving on the freeway, or reducing their driving in any way over the past year. Only 10 participants reported reducing their driving either by reducing the number of days, trips, or kilometers per week, or the distance of their trips.

Table 4. Self-Reported Driving Behaviors from the Questionnaire

Overall driving exposure	**Mean Number**	**SD**
How many days per week do you normally drive?	5.9	1. 2
How many kilometers do you drive in a normal week?	155.9	118.4
	Number	**Percent**
Thinking just of your out-and-back trips from home – that is, starting from home, driving to one or more places, and returning home – how many kilometers would you say most of these trips are?		
1-10 kilometers	76	50.0
11-15 kilometers	48	31.6
More than 15 kilometers	28	18.4
Self-regulatory patterns (participants reporting yes)	**Number**	**Percent**
Do you try to avoid driving at night?	31	20.3
Do you try to avoid making unprotected right turns?	13	8.5
Do you try to avoid driving in unfamiliar areas?	24	15.7
Do you try to avoid driving during rush hour traffic?	73	48.3
Do you try to avoid driving on the freeway?	13	8.6
Do you combine trips into a single outing?	99	66.9
Have you reduced your driving in the past year in any way?	10	6.5
Reduced the number of days per week you normally drive?	4	2.6
Reduced the number of trips per week you normally take?	4	2.6
Reduced the number of kilometers you drive in a normal week?	6	3.9
Reduced the distance of your trips?	8	5.2

4.3 Comparative analyses of ICRD driving data and questionnaire data

Simple logistic regressions were used to model the relationship between several of the comparable ICRD and questionnaire combinations that had to do with self-regulatory driving patterns (e.g., percent of trips at night versus whether tries to avoid driving at night). In each case, the ICRD driving measure was used as the independent variable and the corresponding questionnaire measure was used as the dependent variable. The purpose of the modeling was to predict, for each combination, the outcome of the questionnaire, based on the corresponding ICRD driving behavior measure. Summary information for the logistic regressions are presented in Table 5, including for each comparison, the dependent and independent variables, significance (p value), odds ratio, and 95% confidence intervals.

Table 5. Simple Logistic Regression Results for Each Comparison

Independent Variable (from driving data)	Dependent Variable (from questionnaire data)	Sig.	Exp(b) (Odds Ratio)	95% CI for Odds Ratio
Percent trips at night	Do you try to avoid driving at night?	.007	.792	.669, .938
Ratio of left turns to right turns	Do you try to avoid making unprotected right turns?	.396	1.013	.983, 1.045
Percent trips within 5 kilometers of home	Do you try to avoid driving in unfamiliar areas?	.289	1.021	.982, 1.061
Percent trips within 10 kilometers of home	Do you try to avoid driving in unfamiliar areas?	.054	1.056	.999, 1.116
Percent trips within 15 kilometers of home	Do you try to avoid driving in unfamiliar areas?	.013	1.119	1.024, 1.222
Percent of trips during rush hour traffic	Do you try to avoid driving in rush hour?	.379	1.019	.977, 1.063
Percent of trips on high speed roads (>85km)	Do you try to avoid driving on the freeway?	.019	.760	.604, .956
Average number of trips per trip chain	Do you combine trips into a single outing?	.303	1.360	.758, .2.443

As can be seen from the table, results were statistically significant for three of the dependent/independent combinations including: avoidance of night driving/percent of trips at night; avoidance of driving in unfamiliar areas/percent of trips within 15 kilometers of home; and avoidance of freeway driving/percent of high speed trips. The odds ratios for the combinations related to avoidance of night driving and on high speed roads were less than one, while the odds ratio for avoiding driving in unfamiliar areas were greater than one. This implies that as the percentage of nighttime trips by a participant increased by 1 percentage point, the odds of him or

her reporting trying to avoid driving at night *decreased* by a factor of about 0.79. Similarly, as the percentage of a participant's trips on high speed roads increased by 1 point, the odds of him or her reporting trying to avoid driving on freeways *decreased* by a factor of 0.76. By contrast, as the percentage of a participant's trips within 15 kilometers of home increased by 1 point, the odds of him or her reporting trying to avoid driving in unfamiliar areas *increased* by a factor of 1.1. Results were not statistically significant for combinations related to avoiding right hand turns, driving in rush hour traffic, and trip chaining; that is, there was no significant relationship between the questionnaire responses and the actual driving data.

Two of the questionnaire measures of overall driving exposure were continuous rather than categorical, and were therefore examined using simple linear regression modeling. Results are shown in Table 6. As can be seen, results were statistically significant for both days driven per week and kilometers per week. Specifically, for each day per week increase in actual driving, there was a 0.49 increase on the questionnaire response for days driven. Similarly, for each kilometer increase in actual driving, there was a .44 increase on the questionnaire response for the number of kilometers driven. What this implies is that as the objective driving measures for days per week and kilometers per week increased, so too did the corresponding self-reported measures; however, participants responses on the questionnaire represented an underestimate of their actual driving by factors of 0.49 and 0.44, respectively.

Table 6. Simple Linear Regression Results for Each Comparison

Independent Variable (from driving data)	Dependent Variable (from questionnaire data)	Sig.	Coefficient Estimate	95% CI for Odds Ratio
Days per week driving	How many days per week do you normally drive?	p<.000	0.485	0.244, 0.576
Kilometers per week driving	How many kilometers do you drive in a normal week?	p<.000	0.444	0.232, 0.605

5 Discussion and Conclusions

This exploratory study examined the driving exposure and self-regulatory driving patterns of older adults, using objective measures of driving and comparing them to drivers' self-reports. An important strength of the study was its increased sample size relative to the few studies of

this type that have been conducted to date, providing us with more statistical power to discern relationships. Results suggest that there was correspondence, albeit not perfect, between some objective driving measures and their comparable self-reported measures, but a lack of correspondence for others. For avoidance of various driving situations, comparisons were statistically significant for driving at night, driving in unfamiliar areas, and on high speed roads. For each driving situation, participants' actual driving predicted the likelihood of reporting trying to avoid that situation.

However, it is not surprising that perfect one-to-one correspondence between the self-reported and objective data on self-regulatory driving patterns was lacking. The questionnaire asked participants if they tried to avoid certain driving situations – thus, the questionnaire items were intended to measure general behavioral intent. There are many reasons why actual behavior may deviate from intention. For example, Baldock et al. (2006) explored the concept of self-regulatory self-efficacy – the ability to actually self-regulate if one so chooses. Further analyses of the questionnaire data are underway to examine this issue more closely, including multivariate analyses to take into account factors that may interfere with a person's ability to carry out his or her intent such as lack of available alternatives to driving oneself or having others who are dependent on the driver for rides. Lack of perfect correspondence may have also been due to the necessity of using proxy measures for some of the self-regulatory practices. For example, trips further than 15 kilometers of home were used as a proxy measure for driving in unfamiliar areas and the ratio of left to right hand turns was used a proxy measure for making unprotected right hand turns across oncoming traffic, based on the idea that drivers who tried to avoid such turns would be more like to have a higher ratio of left to right hand turns. However, we were not able to identify whether right hand turns occurred at protected or unprotected intersections, although the algorithm did limit turns to intersections and not roundabouts.

The correspondence between self-reported and objective measures for avoidance of driving at night, in unfamiliar areas, and on high speed roads suggests an opportunity to use both types of data in combination to better understand these particular self-regulatory practices among older adults. The objective data could be useful in determining the rates of driving that actually occur in these situations that are often targeted for self-regulation. Corresponding self-reported data

could be useful in providing additional insights into the context of driving or non-driving in these situations. In particular, self-reported data could help uncover the motivations of older adults for driving or not driving in these situations. Such knowledge is important for the development of effective interventions to promote appropriate self-regulation. Self-reported data could also be useful in examining the extent to which individuals' driving behavior is in line with their intentions, and if not, what factors undermine their ability to carry out their intentions.

The discrepancy between self-reported and objective measures of driving exposure is of greater concern. The ability to measure driving exposure not only contributes to a better understanding of the complex process of self-regulation, it is also a critical element in understanding crash risk (Marshall et al., 2007). Although the self-reported and objective driving exposure measures in this study were correlated, participants tended to underreport their average number of days per week and kilometers per week driven. That is, as the objective driving measures increased by one unit, the self-reported driving measures also increased, but by a factor less than one unit. These findings are consistent with other work showing that older drivers may misestimate their actual driving frequency (e.g., Blanchard, et al., 2010; Huebner, et al., 2006), although the misestimating in this study was confined to underreporting, on average, rather than both overreporting and underreporting.

The study had some limitations. The sample was comprised of a convenience cohort of older drivers age 75 years and older. A convenience rather than random sampling approach was used because a truly random and representative sample can only be achieved through mandatory participation, which would have been neither possible nor desired. The reasons which prevented a random sample included: concern for possible negative impact on licensure that almost certainly lead to a level of volunteer bias; and 'cold calling' potential recruits is unlikely to yield a high response rate for a study requiring a 5-year commitment from participants. Thus, there was likely a bias towards a healthier sample, resulting possibly in less self-regulation being reported than might have been found in a more general population with a greater range of impairments, particularly since at enrollment, drivers were only eligible if they drove at least 4 days per week. However, given the high level of functioning, especially with regard to cognition, one might expect better correspondence between self-reported and objective measures

of driving exposure. Further, some participants drove another vehicle during the study period in addition to their primary vehicle; hence their underestimation of driving is likely even greater than what was found in these analyses which only used driving data from the ICRD installed in their primary vehicle.

Another limitation had to do with the relatively large amount of GPS-derived data considered unusable and therefore not available for analyses. Nevertheless, the final dataset of 156 participants represented an extensive amount of data to analyze (69,981 vehicle trips, 495,111 kilometers driven, and 14,392 hours of driving), especially given the exploratory nature of the study. Further refinements in using ICRDs to capture objective driving are underway and should result in improved data retention for future studies. In addition, continued efforts to derive meaningful driving measures from the ICRD data should yield valuable insights into driving exposure and self-regulatory driving patterns among older adults.

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Chapter 9: Discussion and Conclusions

The purpose of this thesis research was to advance knowledge and understanding of self-regulation among older adults by answering three research questions: What is the nature and extent of self-regulation by older drivers? How is self-regulation influenced by various individual, social, and environmental factors? How do self-reports of self-regulatory practices compare with objective data on driving patterns and behaviors?

Important and distinctive contributions of the thesis research included: 1) disentangling reported self-regulation from simple avoidance of various driving situations by examining the motivations people report for modifying their driving; 2) examining self-regulation at multiple levels of driver performance and decision making using Michon's (1979, 1985) hierarchical model as a starting point, specifically the tactical and strategic levels; 3) extending Michon's model to include the life-goal level which takes into account people's broader motives and decisions in life that can affect driving; and 4) taking advantage of advances in technology to examine the naturalistic driving of a relatively large sample of Australian older drivers with regard to self-regulatory behaviors and comparing these objective driving data with participants' self-report data.

In this research, tactical self-regulation included decisions that drivers make about maneuvers in traffic or while driving in response to conditions in the driving environment (e.g., gap and headway acceptance, whether to engage in various secondary tasks inside the vehicle). Strategic behavior included higher level decisions about trip goals, mode of transit, driving route, and circumstances under which to drive (e.g., time of day, type of roadway, traffic conditions). The life-goal level was adapted from work on young drivers to address older drivers' general motives and attitudes in life that can affect driving more indirectly (e.g., decisions about where to live in relation to frequented destinations or what type of vehicle to purchase).

Findings from the research provide valuable insights into the self-regulatory process among older adults. First, self-regulation is not simply the avoidance of certain driving situations or the modification of one's driving behavior. Drivers report many reasons for modifying their driving,

only some of which relate to what is commonly considered self-regulation. Understanding the motivations for these modifications is necessary and the PhD research showed that these motivations are varied and differ considerably across driving situations. Reasons for driving avoidance or other practices were often more closely related to lifestyle or preferences than to self-regulation, consistent with findings by others (e.g., Charlton et al., 2006; Myers et al., 2008; Blanchard & Myers, 2010). Thus, to better understand self-regulation among older adults, it is important to understand the reasons that people have for avoiding driving situations or engage in other practices.

To this end, three distinct groups of older adults were identified for each driving situation of interest in the research, based on participants' reported motivations for modifying their driving. These groups were: non-modifiers, self-regulators, and others. Non-modifiers did not report trying to change their behavior in any way. Self-regulators reported trying to avoid a particular situation or engaging in a particular driving practice for reasons related to what is commonly considered self-regulation (i.e., difficulty seeing during the day or night; difficulty remembering things; difficulty concentrating on more than one thing at a time; reduced strength, flexibility, or general mobility; not feeling comfortable driving in the driving situation/not engaging in that practice; not feeling safe driving in the situation/not engaging in that practice). The group termed "others" reported trying to avoid a particular situation or engaging in a particular practice only for reasons other than self-regulation (e.g., they had always tried to avoid the situation/engage in that practice; thus it was related to driving-related challenges). Across all driving situations, non-modifiers ranged from 3.7 to 98.9 percent, self-regulators ranged from 0 to 41.4 percent, and others ranged from 0.8 to 71.7 percent.

It is possible that some participants who reported only non-self-regulatory reasons for making driving modifications were actually self-regulators who either failed to recognize it or chose not to acknowledge this. However, further analyses of these three groups revealed that they significantly differed from one another across a number of health, functioning, and driving dimensions, supporting the conclusion that they represent distinct groups. The distinction between self-regulators and others is particularly important, and has implications for promoting appropriate self-regulation of driving. Older drivers who are avoiding certain driving situations

because of lifestyle preferences rather than an awareness that their driving abilities may be compromised, cannot necessarily be relied on to continue avoiding those situations if their lifestyle needs or preferences change.

A second insight that came from the PhD research is that self-regulation is clearly a multi-dimensional concept, with self-regulation tied closely to specific driving situations, as well as level of decision making. Rates of reported strategic self-regulation were relatively low for most situations with the greatest rates reported for night time and bad weather (2 percent or less for avoiding driving alone, making a practice run, combining trips into a single outing, bringing a passenger along to help navigate, or reducing overall driving in the past year; 4.1 percent for avoiding the freeway; 4.9 percent for avoiding driving on busy roads; 6.6 percent for avoiding reversing; 6.9 percent for avoiding making unprotected right turns; 8.5 percent for avoiding driving in unfamiliar areas; 12.5 percent for avoiding driving during rush hour; 16.3 percent for avoiding driving at night; 19.9 percent for avoiding driving in bad weather; 28.7 percent for avoiding driving at night in bad weather). Rates of reported tactical self-regulation were generally higher, ranging from 10.2 percent for avoiding changing the radio station while driving, to 13.9 percent for avoiding chatting with passengers, to 24.2 percent for avoiding personal grooming, to 34.4 percent for avoiding eating, to 35.7 percent for leaving more room between the car ahead, to 36.9 percent for avoiding talking on a mobile phone, to 41.4 percent for avoiding reading a road map.

In addition to the notable differences between the reported strategic and tactical levels of self-regulation with regard to the extent of self-regulation, the research indicated that they are influenced by different sets of individual, social, and environmental factors. Strategic self-regulation was strongly related to participants' self-perceived abilities for safe driving and feelings of comfort ($p < .001$), with higher self-ratings associated with less self-regulation. Gender was also statistically significant, with women more likely to self-regulate than men. These findings extend previous research by demonstrating that self-perceived abilities, feelings of comfort, and gender were associated with a specific class of self-regulation – namely strategic self-regulation. They also provide some support for Kostyniuk and Molnar's (2008) proposition that gender effects may, in part, be explained by individuals' perceived level of confidence in

various driving situations. Kostyniuk and Molnar (2008) further speculated that future cohorts of women who have been driving most of their lives may exhibit driving behaviors more similar to men. This seems reasonable in light of study findings that the driving cessation of women who had an active driving history was more similar to what is known about the driving cessation of men, suggesting that decisions about stopping driving are related to personal driving history rather than gender per se (Hakamies-Blomqvist & Siren, 2003). As the baby boomers continue to age, there will be opportunities to follow their driving behaviors over time to examine these issues.

One possible explanation for the lack of a significant relationship between age and reported strategic self-regulation is the relatively small age range of participants in the study and the relatively high level of health among participants. This explanation seems reasonable in light of findings from other studies that age appears to interact significantly with health status in decisions about self-regulation (e.g., Donorfio, D'Ambrosio, Coughlin & Mohyde, 2008a).

Another finding relative to reported strategic self-regulation was that participants who did not have family or friends available to drive them were considerably more likely to restrict their driving across various driving situations. Similarly, higher self-ratings of physical functioning were also associated with more self-regulation. Collectively, these findings may reflect an awareness by participants who still have good mobility but lack options for getting around once they stop driving that they need to actively manage their driving through a gradual process of self-regulation. That is, what may be common to all of these relationships is that individuals are aware that their driving could become a problem in the future and that they need to do what they can in the present to extend the period over which they can drive by lengthening the transition from driving to non-driving. This interpretation fits with the observation by Donorfio et al. (2008b) that self-regulation is not a one-dimensional concept; rather, at one end of the continuum, older adults may consider some amount of self-regulation as a positive strategy for extending safe driving, while at the other end, extensive self-regulation and driving cessation may undermine quality of life.

The pattern was quite different with regard to individual, social, and environmental factors that influence reported tactical self-regulation. Given the differences in the temporal and categorical nature of tactical versus strategic decision making, this is not unexpected. Fewer variables overall were associated with tactical self-regulation although, similar to strategic self-regulation, higher self-ratings of abilities were associated with fewer self-regulatory practices. Increasing age was associated with fewer self-regulatory practices at the tactical level. The only other significant predictor was contrast sensitivity, with worse contrast sensitivity predicting more tactical self-regulation. Given the highly visual nature of the driving task, it is understandable that as individuals' capacity to attend to visual demands (at least in the realm of contrast sensitivity) declines, they might be more inclined to try to reduce distractions inside the vehicle, in order to keep attention free for driving. Charlton et al.'s (2013) findings that drivers engaged in fewer secondary activities (thus, greater self-regulation) when negotiating turns at high complexity intersections compared with low complexity fully-controlled intersections is consistent with this. It is not clear why increasing age did not result in a similar pattern. Further research on tactical self-regulation among older adults is clearly warranted.

Taken together, results on reported strategic and tactical self-regulation suggest that these levels of self-regulation represent separate constructs and further research in this area should take this into account. At the same time, the one theme that cut across both levels of self-regulation was that self-perceptions of abilities are important and possibly superior predictors of self-regulation than actual functioning, consistent with other studies (e.g., Anstey et al., 2005). The finding that participants' self-ratings of health and abilities were significantly related to self-regulation in general, while few of the objective measures of functioning were, is also consistent with the broader health behavior change literature. For example, Strecher, DeVellis, Becker and Rosenstock (1986) argued that it is individuals' perception about their capabilities and not necessarily their true capabilities that influence behavior. They noted the consistency of their conclusions with Bandura's (1977) assertion that an individual's expectations about the ability to execute or engage in a behavior, an important precursor for behavior change, reflects the individual's perceived rather than actual capabilities and it is these perceptions and not one's true abilities that influence behavior.

The lack of statistically significant results for most of the measures of cognitive functioning are consistent with other studies in which factors associated with cognitive function (e.g., problems with balance, memory, confusion, or concentration) were not frequently mentioned as reasons for restricting driving (e.g., Betz & Lowenstein, 2010; Ragland et al., 2004). These findings may have been due to the high level of health and cognitive functioning of the sample, but they may also reflect a lack of insight among participants with cognitive impairments into their cognitive limitations or a lack of awareness that cognitive impairment is a risk factor for crash involvement (Betz & Lowenstein, 2010).

The relationship between cognitive functioning and self-regulation is complex. Those individuals with some form of progressive dementia such as Alzheimer's disease will increasingly lose awareness or insight into their cognitive deficits as the disease progresses. Thus, they will be less likely to use self-regulation as a compensatory strategy (e.g., Carr, Meuser & Morris, 2006; Cotrell & Wild, 1999; Gil et al., 2001) because dementia not only affects cognitive skills for driving (e.g., memory, executive functioning, visuospatial skills) but also those skills necessary to benefit from self-regulation and planning for driving transition and cessation (e.g., insight, reasoning; strategy). There is evidence that driving performance of individuals with dementia is worse than drivers without cognitive impairment (Man-Son-Hing, Marshall, Molnar & Wilson, 2007) and they do not change their driving behaviors even after a crash (Lucas-Blaustein et al., 1988). Although driving safety may not yet be compromised in the early stages of progressive dementia, ultimately everyone will have to stop driving at some point (Croston, Meuser, Berg-Weger, Grant & Carr, 2009).

The third insight from the research is that despite the relative infrequency of 121life-goal self-regulation, it warrants further research because of the opportunity that life-goal decisions afford for enhancing older adult safety and mobility. For example, there is mounting evidence that improving physical fitness can extend safe driving (e.g., Marottoli et al., 2007). Similarly, although the trend of aging in place is firmly entrenched among many older adults, there may be opportunities to create more livable communities with more accessible housing options to foster continued mobility. Finally, efforts to make vehicles safer and more accessible for older adults, as well as to better educate older consumers about the safety features in vehicles, are increasingly

being recognized as an important part of a multi-faceted approach to keeping older adults safely mobile (e.g., Eby & Molnar, 2012).

This research was the first to address self-regulation at the life-goal level. Relatively few respondents reported engaging in life-goal self-regulatory practices; for example, only one person reported moving to a new location in the past year to be closer to frequent destinations, nine reported having bought a different vehicle because they were uncomfortable driving their old vehicle or for other safety-related reasons, and 69 having begun a regular exercise program or fitness regime, mainly for reasons related to maintaining or improving their health (but with few actual mentions of driving). Because life-goal self-regulation involves important decisions that affect most aspects of a person's life (of which driving is just one part), many people may not be ready to face those decisions when they still consider themselves to be functionally intact as was the Ozcandrive sample. Further work is needed to follow drivers over longer periods of time to collect information on life-goal self-regulatory practices and the factors that influence them. In addition, other ways in which life-goal self-regulation could be operationalized should be explored beyond the three questions posed in the PhD thesis.

The fourth insight gleaned from the research is that although self-report appears to be a poor measure of driving exposure, it nevertheless may have a role to play in providing a context for understanding and helping interpret naturalistic driving data with regard to some specific self-regulatory driving practices. The research made exploratory comparisons between objective measures of driving and drivers' self-reports with regard to both driving exposure and self-regulatory driving practices. An important strength of the research was that it used an increased sample size relative to the few studies of this type that had been conducted previously, providing more statistical power to discern relationships. Findings suggested that there was correspondence, although modest, between some objective driving measures and their comparable self-reported measures, but a lack of correspondence for others. For avoidance of various driving situations, comparisons were statistically significant for driving at night, driving in unfamiliar areas, and on high speed roads. For each driving situation, participants' actual driving predicted the likelihood of reporting trying to avoid that situation.

The lack of perfect one-to-one correspondence between the self-reported and objective data on self-regulatory driving patterns was not surprising given that the questionnaire measured more general behavioral intent rather than actual behavior. There are many reasons why actual behavior may deviate from intention. For example, Baldock et al. (2006) explored the concept of regulatory self-efficacy – the ability to actually self-regulate if one so chooses. Social or environmental factors that may interfere with a person's ability to carry out his or her intent (i.e., barriers to self-regulation) include such things as lack of available alternatives to driving oneself or having others who are dependent on the driver for rides. The lack of correspondence for some pairs and only modest correspondence for others may have also been due to the necessity of using proxy measures for many self-regulatory practices. For example, the ratio of left to right hand turns was used as a proxy for measure for making unprotected right hand turns across oncoming traffic, based on the idea that drivers who tried to avoid such turns would be more likely to have a higher ratio of left to right hand turns. However, it was not possible to identify whether right hand turns occurred at protected or unprotected intersections. It may be possible to refine some of the driving measures to increase the likelihood that they are capturing the same underlying patterns of behavior as the corresponding self-report measures.

Although this exploratory work should clearly be followed up, the correspondence between self-reported and objective measures for avoidance of driving at night, in unfamiliar areas, and on high speed roads suggests there might be an opportunity to use both types of data in combination to better understand these particular self-regulatory practices among older adults. The objective data could be useful in determining the rates of driving that actually occur in these situations that are often targeted for self-regulation. Corresponding self-reported data could be useful in providing additional insights into the context of driving or non-driving in these situations. In particular, self-reported data could help uncover the motivations of older adults for driving or not driving in these situations to determine whether self-regulation was actually occurring. Self-reported data could also be useful in examining the extent to which individuals' driving behavior is in line with their intentions, and if not, what factors undermine their ability to carry out their intentions. For some types of self-regulatory practices such as tactical level avoidance of in-vehicle distractions, gathering objective data would require more than simple GPS technology

and therefore may not be feasible. In these cases, self-report may currently be the best option for data collection, despite its shortcomings.

The discrepancy found between self-reported and objective measures of driving exposure raises concerns however. Accurate measures of driving exposure not only contribute to a better understanding of the complex self-regulatory process, but they are a critical element in understanding crash risk (Marshall et al., 2007). Although the self-reported and objective driving exposure measures in this study were correlated, participants tended to underreport their average number of days per week and kilometers per week driven. These findings are consistent with other work showing that older drivers may misestimate their actual driving frequency (e.g., Blanchard et al., 2010; Huebner et al., 2006), although the misestimating in this study was confined to underreporting, on average, rather than both overreporting and underreporting. Thus, caution should be exercised in reaching conclusions about self-report with regard to driving exposure.

The study had some limitations. The sample was comprised of a convenience cohort of older drivers age 75 years and older. A convenience rather than random sampling approach was used because a truly random and representative sample can only be achieved through mandatory participation, which would have been neither possible nor desired. The reasons which prevented a random sample included: concern for possible negative impact on licensure that almost certainly lead to a level of volunteer bias; and 'cold calling' potential recruits is unlikely to yield a high response rate for a study requiring a 5-year commitment from participants. Thus, there was likely a bias towards a healthier sample, resulting possibly in less self-regulation being reported than might have been found in a more general population with a greater range of impairments, particularly since at enrollment, drivers were only eligible if they drove at least 4 days per week. All self-regulatory practices were self reported and may not represent the actual behavior or decision of participants. However, an important strength of the study is that self-regulation was operationalized not simply as driving reduction or avoidance but was based on people's actual motivations for modifying their driving.

Another limitation had to do with the relatively large amount of GPS-derived data considered unusable and therefore not available for analyses. Nevertheless, the final dataset of 156 participants represented an extensive amount of data to analyze (69,981 vehicle trips, 495,111 kilometers driven, and 14,392 hours of driving), especially given the exploratory nature of the study. Refinements in using ICRDs to capture objective driving should result in improved data retention for future studies. In addition, continued efforts to derive meaningful driving measures from the ICRD data should yield valuable insights into driving exposure and self-regulatory driving patterns among older adults. Future research might be able to use more sophisticated technology and/or incorporate geographical information systems (GIS) to yield better measures. However, there is always a tradeoff between costs and it may be prohibitive to follow a large cohort with more sophisticated technology.

A final limitation was that even though the data for the research came from a longitudinal cohort study, the thesis research itself was necessarily cross sectional in nature given that only one wave of data was available at the time the research was undertaken. Thus, the researcher was not able to assess changes over time. Longitudinal research is critical to be able to examine how individuals change over time as they age, especially the baby boomers who are just beginning to enter older age so that insights into this process can be used to guide practice and policy to further advance safe mobility for older adults.

Continuing efforts to better understand the self-regulatory practices of older drivers at the tactical, strategic, and life-goal levels should provide additional insights into how the transition from driving to non-driving can be better managed to balance the interdependent needs of public safety and personal mobility. One important audience for this information is physicians and other health professionals. These groups can play an important role in supporting their older adult patients as they transition from driving to non-driving (MacLean, Berg-Weger, Meuser & Carr, 2007). However these professionals often lack the knowledge or confidence to respond to driving-related concerns (Meuser, Carr, Berg-Wegman, Niewoehner & Morris, 2006). While there is still much to learn about the process of self-regulation, results from this research can help to inform the practice of professionals working with older adults to maintain their safe mobility.

Chapter 10: References

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Chapter 11: Appendices

This chapter contains four appendices referenced in the thesis document:

- Appendix A: Ethics Approval Certificates
- Appendix B: ADDAPT Questionnaire Codebook
- Appendix C: Molnar, et al. (2012) Australasian Road Safety Research, Policing, and Education Conference Proceedings Paper, 4-6 October, 2012, Wellington, New Zealand
- Appendix D: Results from t-tests with Bonferroni corrections

Appendix A: Ethics Approval Certificates

Behavioral Sciences Institutional Review Board • 540 East Liberty Street, Suite 202, Ann Arbor, MI 48104-2210 • phone (734) 936-0933 • fax (734) 998-9171 • irbhsbs@umich.edu

To: Dr. David Eby

From:

James Sayer
Colleen Seifert

Cc:

Scott Roberts
David Eby
Renee St Louis
Jeri Stroupe
Lisa Molnar
Judy Settles

Subject:Initial Study Approval for [HUM00023771]

SUBMISSION INFORMATION:
Study Title: A New Approach to Assessing Self-Regulation by Older Drivers: Development and Testing of a Questionnaire Instrument
Full Study Title (if applicable):
Study eResearch ID: HUM00023771
Date of this Notification from IRB:10/23/2008
Initial IRB Approval Date: 9/29/2008
Current IRB Approval Period:**9/29/2008 - 9/28/2010**
Expiration Date: Approval for this expires at **11:59 p.m. on 9/28/2010**
UM Federalwide Assurance (FWA): FWA00004969 expiring on 4/18/2011
OHRP IRB Registration Number(s): IRB00000246

NOTICE OF IRB APPROVAL AND CONDITIONS:
The IRB Behavioral Sciences has reviewed and approved the study referenced above. The IRB determined that the proposed research conforms with applicable guidelines, State and federal regulations, and the University of Michigan's Federalwide Assurance (FWA) with the Department of Health and Human Services (HHS). You must conduct this study in accordance with the description and information provided in the approved application and associated documents.

APPROVAL PERIOD AND EXPIRATION:
The approval period for this study is listed above. Please note the expiration date. If the approval lapses, you may not conduct work on this study until appropriate approval has been re-established, except as necessary to eliminate apparent immediate hazards to research subjects. Should the latter occur, you must notify the IRB Office as soon as possible.

IMPORTANT REMINDERS AND ADDITIONAL INFORMATION FOR INVESTIGATORS

APPROVED STUDY DOCUMENTS:
You must use any date-stamped versions of recruitment materials and informed consent documents available in the eResearch workspace (referenced above). Date-stamped materials are available in the "Currently Approved Documents" section on the "Documents" tab.

RENEWAL/TERMINATION:
At least two months prior to the expiration date, you should submit a continuing review application either to renew or terminate the study. Failure to allow sufficient time for IRB review may result in a lapse of approval that may also affect any funding associated with the study.

AMENDMENTS:
All proposed changes to the study (e.g., personnel, procedures, or documents), must be approved in advance by the IRB through the amendment process, except as necessary to eliminate apparent immediate hazards to research subjects. Should the latter occur, you must notify the IRB Office as soon as possible.

AEs/ORIOs:
You must inform the IRB of all unanticipated events, adverse events (AEs), and other reportable information and occurrences (ORIOs). These include but are not limited to events and/or information that may have physical, psychological, social, legal, or economic impact on the research subjects or other.

Investigators and research staff are responsible for reporting information concerning the approved research to the IRB in a timely fashion, understanding and adhering to the reporting guidance (http://www.med.umich.edu/irbmed/ae_orio/index.htm), and not implementing any changes to the research without IRB approval of the change via an amendment submission. When changes are necessary to eliminate apparent immediate hazards to the subject, implement the change and report via an ORIO and/or amendment submission within 7 days after the action is taken. This includes all information with the potential to impact the risk or benefit assessments of the research.

SUBMITTING VIA eRESEARCH:
You can access the online forms for continuing review, amendments, and AEs/ORIOs in the eResearch workspace for this approved study (referenced above).

MORE INFORMATION:
You can find additional information about UM's Human Research Protection Program (HRPP) in the Operations Manual and other documents available at: www.research.umich.edu/hrppp.

[redacted]

James Sayer
Co-chair, IRB Behavioral Sciences

Colleen Seifert
Co-chair, IRB Behavioral Sciences

MONASH University

Monash University Human Research Ethics Committee (MUHREC)
Research Office

Human Ethics Certificate of Approval

Date:	**30 July 2009**
Project Number:	**2009001183**
Project Title:	**A new approach to assessing self-regulation by older drivers**
Chief Investigator:	**Dr Judith Charlton**
Approved:	**From: 30 July 2009 To: 30 July 2014**

Terms of approval

1. The Chief investigator is responsible for ensuring that permission letters are obtained, if relevant, and a copy forwarded to MUHREC before any data collection can occur at the specified organisation. **Failure to provide permission letters to MUHREC before data collection commences is in breach of the National Statement on Ethical Conduct in Human Research and the Australian Code for the Responsible Conduct of Research**.
2. Approval is only valid whilst you hold a position at Monash University.
3. It is the responsibility of the Chief Investigator to ensure that all investigators are aware of the terms of approval and to ensure the project is conducted as approved by SCERH.
4. You should notify MUHREC immediately of any serious or unexpected adverse effects on participants or unforeseen events affecting the ethical acceptability of the project.
5. The Explanatory Statement must be on Monash University letterhead and the Monash University complaints clause must contain your project number.
6. **Amendments to the approved project (including changes in personnel):** Requires the submission of a Request for Amendment form to MUHREC and must not begin without written approval from SCERH. Substantial variations may require a new application.
7. **Future correspondence:** Please quote the project number and project title above in any further correspondence.
8. **Annual reports:** Continued approval of this project is dependent on the submission of an Annual Report. This is determined by the date of your letter of approval.
9. **Final report:** A Final Report should be provided at the conclusion of the project. MUHREC should be notified if the project is discontinued before the expected date of completion.
10. **Monitoring:** Projects may be subject to an audit or any other form of monitoring by MUHREC at any time.
11. **Retention and storage of data:** The Chief Investigator is responsible for the storage and retention of original data pertaining to a project for a minimum period of five years.

[redacted]

Professor Ben Canny
Chair, SCERH

cc: Ms Lisa J Molnar

Appendix B: ADDAPT Questionnaire Codebook

VAR #

ID Five digit number with first number being site number and last being survey wave

Q1 How many days per week do you normally drive?

Number between 0-7

Q2 How many kilometres do you drive in a normal week?

Number starting at 0

Q3 Thinking just of your out-and-back trips from home – that is, starting from home, driving to one or more places, and returning home – how many kilometers would you say most of these trips are?

1	Less than 1 kilometre
2	1-10 kilometres
3	11-15 kilometres
4	More than 15 kilometres
9	Missing

[Q4] Are the following transport options AVAILABLE in your neighborhood, regardless of whether or not you personally use them?

Q4a Public transport such as trains or buses

1	Yes
0	No
9	Missing

Q4b Private transport such as taxis

1	Yes
0	No
9	Missing

Q4c Special community transport such as a bus/minibus that picks you up at home and delivers you to your destination?

1	Yes
0	No
9	Missing

Q5 Do you have family or friends available to give you a ride if you need one?

1	Yes
0	No
9	Missing

[Q6] How would you rate the following in general?

Q6a Your overall health

1	Poor
2	
3	
4	
5	
6	
7	Excellent
9	Missing

Q6b Your ability to walk one kilometre

1	Poor
2	

3
4
5
6
7 Excellent

9 Missing

Q6c Your ability to climb two flights of stairs

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

Q7a During the past year, have you had a fall which caused you to feel pain afterward?

1 Yes
0 No

9 Missing

Q7b How many times?

Number between 1-?

[Q8] How would you rate the following FOR YOUR SAFE DRIVING?

Q8a Your ability to see during the day or at night?

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

Q8b Your ability to remember things

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

Q8c Your ability to concentrate on more than one thing at a time

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

Q8d Your strength, flexibility, or general mobility

1	Poor
2	
3	
4	
5	
6	
7	Excellent
9	Missing

Q9a During the past year, have you moved to a new location?

1	Yes
0	No
9	Missing

Was the move influenced by any of the following?

Q9a1 Wanted to be closer to the places you normally drive

1	Yes
0	No (not checked)

Q9a2 Wanted more options for getting around

1	Yes
0	No (not checked)

Q9a3 Other driving related reason

1	Yes
0	No (not checked)

Q9a4 Please specify_____

Q9a5 Had nothing to do with driving

1	Yes
0	No (not checked)

Q9b During the past year, have you begun a regular exercise program or fitness routine?

1	Yes
0	No
9	Missing

Q9b1 What influenced your decision to begin a regular exercise program or fitness routine?

NEED TO CODE OPEN ENDED RESPONSES

Q9c During the past year, have you bought a different car?

1	Yes
0	No
9	Missing

Was your decision influenced by any of the following?

Q9c1 Not feeling comfortable driving your previous car

1	Yes
0	No (not checked)

Q9c2 Not feeling safe driving your previous car

1 Yes
0 No (not checked)

Q9c3 Other driving related reason

1 Yes
0 No (not checked)

Q9c4 Please specify_____

Q9c5 Had nothing to do with driving

1 Yes
0 No (not checked)

Q10a During the past year, have you reduced the amount of driving you do in any way?

1 Yes
0 No
9 Missing

[Q10b] HOW have you reduced the amount of driving you do?

Q10b1 Reduced the number of days per week you normally drive

1 Yes
0 No (unchecked)

Q10b2 Reduced the number of trips per week you normally take

1 Yes
0 No (unchecked)

Q10b3 Reduced the number of kilometres you drive in a normal week

1 Yes
0 No (unchecked)

Q10b4 Reduced the distance of your trips

1 Yes
0 No (unchecked)

[Q10c] Why have you reduced the amount of driving you do?

Q10c1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q10c2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q10c3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q10c4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q10c5 Don’t feel comfortable driving everyday

1 Yes
0 No (unchecked)

Q10c6 Don’t feel safe driving everyday

1 Yes
0 No (unchecked)

Q10c7 Financial reasons (e.g., cost of petrol)

1 Yes
0 No (unchecked)

Q10c8 Environmental reasons (e.g., auto emissions)

1 Yes
0 No (unchecked)

Q10c9 Don’t need to drive everyday

1 Yes
0 No (unchecked)

Q10c10 Other

1 Yes
0 No (unchecked)

Q10c11 Please specify_____

Q11a Do you try to avoid driving at night?

1 Yes
0 No

9 Missing

Why?

Q11a1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q11a2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11a3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11a4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11a5 Don’t feel comfortable driving at night

1 Yes
0 No (unchecked)

Q11a6 Don’t feel safe driving at night

1 Yes
0 No (unchecked)

Q11a7 Have always tried to avoid driving at night

1 Yes
0 No (unchecked)

Q11a8 Don’t need to drive at night

1 Yes
0 No (unchecked)

Q11a9 Other

1 Yes
0 No (unchecked)

Q11a10 Please specify_____

Q11b At intersections where there is no right turn arrow, do you try to avoid making right turns across oncoming traffic?

1 Yes
0 No

9 Missing

Why?

Q11b1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q11b2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11b3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11b4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11b5 Don’t feel comfortable making unprotected right turns

1 Yes
0 No (unchecked)

Q11b6 Don’t feel safe making unprotected right turns

1 Yes
0 No (unchecked)

Q11b7 Have always tried to avoid making such turns

1 Yes
0 No (unchecked)

Q11b8 Don’t need to drive places requiring such turns

1 Yes
0 No (unchecked)

Q11b9 Other

1 Yes
0 No (unchecked)

Q11b10 Please specify_____

Q11c Do you try to avoid driving in bad weather (heavy rain, fog, etc.)?

1	Yes
0	No
9	Missing

Why?

Q11c1 Difficulty seeing during the day or night

1	Yes
0	No (unchecked)

Q11c2 Difficulty remembering things

1	Yes
0	No (unchecked)

Q11c3 Difficulty concentrating on more than one thing at a time

1	Yes
0	No (unchecked)

Q11c4 Reduced strength, flexibility, or general mobility

1	Yes
0	No (unchecked)

Q11c5 Don’t feel comfortable driving in bad weather

1	Yes
0	No (unchecked)

Q11c6 Don’t feel safe driving in bad weather

1	Yes
0	No (unchecked)

Q11c7 Have always tried to avoid driving in bad weather

1	Yes
0	No (unchecked)

Q11c8 Don’t need to drive in bad weather

1	Yes
0	No (unchecked)

Q11c9 Other

1	Yes
0	No (unchecked)

Q11c10 Please specify_____

Q11d Do you try to avoid driving on busy roads?

1	Yes
0	No
9	Missing

Why?

Q11d1 Difficulty seeing during the day or night

1	Yes
0	No (unchecked)

Q11d2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11d3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11d4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11d5 Don't feel comfortable driving on busy roads

1 Yes
0 No (unchecked)

Q11d6 Don't feel safe driving on busy roads

1 Yes
0 No (unchecked)

Q11d7 Have always tried to avoid driving on busy roads

1 Yes
0 No (unchecked)

Q11d8 Don't need to drive on busy roads

1 Yes
0 No (unchecked)

Q11d9 Other

1 Yes
0 No (unchecked)

Q11d10 Please specify_____

Q11e Do you try to avoid driving in unfamiliar areas?

1 Yes
0 No

9 Missing

Why?

Q11e1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q11e2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11e3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11e4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11e5 Don’t feel comfortable driving in unfamiliar areas

1 Yes
0 No (unchecked)

Q11e6 Don’t feel safe driving in unfamiliar areas

1 Yes
0 No (unchecked)

Q11e7 Have always tried to avoid driving in unfamiliar areas

1 Yes
0 No (unchecked)

Q11e8 Don’t need to drive in unfamiliar areas

1 Yes
0 No (unchecked)

Q11e9 Other

1 Yes
0 No (unchecked)

Q11e10 Please specify_____

Q11f Do you try to avoid driving alone?

1 Yes
0 No

9 Missing

Why?

Q11f1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q11f2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11f3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11f4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11f5 Don’t feel comfortable driving alone

1 Yes
0 No (unchecked)

Q11f6 Don’t feel safe driving alone

1 Yes
0 No (unchecked)

Q11f7 Have always tried to avoid driving alone

1 Yes

0 No (unchecked)

Q11f8 Don’t need to drive alone

1 Yes
0 No (unchecked)

Q11f9 Other

1 Yes
0 No (unchecked)

Q11f10 Please specify_____

Q11g Do you try to avoid driving at night in bad weather?

1 Yes
0 No

9 Missing

Why?

Q11g1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q11g2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11g3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11g4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11g5 Don’t feel comfortable driving at night in bad weather

1 Yes
0 No (unchecked)

Q11g6 Don’t feel safe driving at night in bad weather

1 Yes
0 No (unchecked)

Q11g7 Have always tried to avoid driving at night in bad weather

1 Yes
0 No (unchecked)

Q11g8 Don’t need to drive at night in bad weather

1 Yes
0 No (unchecked)

Q11g9 Other

1 Yes
0 No (unchecked)

Q11g10 Please specify_____

Q11h Do you try to avoid driving in rush hour traffic?

1	Yes
0	No
9	Missing

Why?

Q11h1 Difficulty seeing during the day or night

1	Yes
0	No (unchecked)

Q11h2 Difficulty remembering things

1	Yes
0	No (unchecked)

Q11h3 Difficulty concentrating on more than one thing at a time

1	Yes
0	No (unchecked)

Q11h4 Reduced strength, flexibility, or general mobility

1	Yes
0	No (unchecked)

Q11h5 Don’t feel comfortable driving in rush hour traffic

1	Yes
0	No (unchecked)

Q11h6 Don’t feel safe driving in rush hour traffic

1	Yes
0	No (unchecked)

Q11h7 Have always tried to avoid driving in rush hour traffic

1	Yes
0	No (unchecked)

Q11h8 Don’t need to drive in rush hour traffic

1	Yes
0	No (unchecked)

Q11h9 Other

1	Yes
0	No (unchecked)

Q11h10 Please specify_____

Q11i Do you try to avoid driving on the freeway?

1	Yes
0	No
9	Missing

Why?

Q11i1 Difficulty seeing during the day or night

1	Yes
0	No (unchecked)

Q11i2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11i3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11i4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11i5 Don't feel comfortable driving on the freeway

1 Yes
0 No (unchecked)

Q11i6 Don't feel safe driving on the freeway

1 Yes
0 No (unchecked)

Q11i7 Have always tried to avoid driving on the freeway

1 Yes
0 No (unchecked)

Q11i8 Don't need to drive on the freeway

1 Yes
0 No (unchecked)

Q11i9 Other

1 Yes
0 No (unchecked)

Q11i10 Please specify_____

Q11j Do you try to avoid reversing?

1 Yes
0 No

9 Missing

Why?

Q11j1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q11j2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q11j3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q11j4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q11j5 Don’t feel comfortable reversing

1 Yes
0 No (unchecked)

Q11j6 Don’t feel safe reversing

1 Yes
0 No (unchecked)

Q11j7 Have always tried to avoid reversing

1 Yes
0 No (unchecked)

Q11j8 Don’t need to reverse

1 Yes
0 No (unchecked)

Q11j9 Other

1 Yes
0 No (unchecked)

Q11j10 Please specify_____

Q12a While driving, do you try to avoid chatting with passengers?

1 Yes
0 No

9 Missing

Why?

Q12a1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q12a2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q12a3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q12a4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q12a5 Don’t feel comfortable chatting with passengers

1 Yes
0 No (unchecked)

Q12a6 Don’t feel safe chatting with passengers

1 Yes
0 No (unchecked)

Q12a7 Have always tried to avoid chatting with passengers

1 Yes

0 No (unchecked)

Q12a8 Other

1 Yes
0 No (unchecked)

Q12a9 Please specify_____

Q12b While driving, do you try to avoid eating?

1 Yes
0 No

9 Missing

Why?

Q12b1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q12b2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q12b3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q12b4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q12b5 Don't feel comfortable eating while driving

1 Yes
0 No (unchecked)

Q12b6 Don't feel safe eating while driving

1 Yes
0 No (unchecked)

Q12b7 Have always tried to avoid eating while driving

1 Yes
0 No (unchecked)

Q12b8 Other

1 Yes
0 No (unchecked)

Q12b9 Please specify_____

Q12c While driving, do you try to avoid reading a road map?

1 Yes
0 No

9 Missing

Why?

Q12c1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q12c2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q12c3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q12c4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q12c5 Don't feel comfortable reading a road map

1 Yes
0 No (unchecked)

Q12c6 Don't feel safe reading a road map

1 Yes
0 No (unchecked)

Q12c7 Have always tried to avoid reading a road map

1 Yes
0 No (unchecked)

Q12c8 Don't need to read a road map

1 Yes
0 No (unchecked)

Q12c9 Other

1 Yes
0 No (unchecked)

Q12c10 Please specify_____

Q12d While driving, do you try to avoid changing the radio stations?

1 Yes
0 No

9 Missing

Why?

Q12d1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q12d2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q12d3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q12d4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q12d5 Don’t feel comfortable changing the radio stations

1 Yes
0 No (unchecked)

Q12d6 Don’t feel safe changing the radio stations

1 Yes
0 No (unchecked)

Q12d7 Have always tried to avoid changing the radio stations

1 Yes
0 No (unchecked)

Q12d8 Don’t play the radio

1 Yes
0 No (unchecked)

Q12d9 Other

1 Yes
0 No (unchecked)

Q12d10 Please specify_____

Q12e While driving, do you try to avoid talking on a mobile phone?

1 Yes
0 No

9 Missing

Why?

Q12e1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q12e2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q12e3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q12e4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q12e5 Don’t feel comfortable talking on a mobile phone

1 Yes
0 No (unchecked)

Q12e6 Don’t feel safe talking on a mobile phone

1 Yes
0 No (unchecked)

Q12e7 Don’t have a mobile phone

1 Yes
0 No (unchecked)

Q12e8 Other

1 Yes
0 No (unchecked)

Q12e9 Please specify_____

Q12f While driving, do you try to avoid personal grooming (such as putting on makeup or shaving)?

1 Yes
0 No

9 Missing

Why?

Q12f1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q12f2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q12f3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q12f4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q12f5 Don’t feel comfortable grooming

1 Yes
0 No (unchecked)

Q12f6 Don’t feel safe grooming

1 Yes
0 No (unchecked)

Q12f7 Have always tried to avoid personal grooming

1 Yes
0 No (unchecked)

Q12f8 Don’t need to groom while driving

1 Yes
0 No (unchecked)

Q12f9 Other

1 Yes
0 No (unchecked)

Q12f10 Please specify_____

Q13a Do you usually plan your trip ahead of time, including writing down your route?

1 Yes
0 No

9 Missing

Why?

Q13a1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q13a2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q13a3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q13a4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q13a5 Don’t feel comfortable going out without planning trip

1 Yes
0 No (unchecked)

Q13a6 Don’t feel safe going out without planning trip

1 Yes
0 No (unchecked)

Q13a7 Have always planned trip

1 Yes
0 No (unchecked)

Q13a8 Other

1 Yes
0 No (unchecked)

Q13a9 Please specify_____

Q13b Do you usually make a practice run ahead of time to become familiar with your route?

1 Yes
0 No

9 Missing

Why?

Q13b1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q13b2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q13b3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q13b4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q13b5 Don't feel comfortable without making a practice run

1 Yes
0 No (unchecked)

Q13b6 Don't feel safe without making a practice run

1 Yes
0 No (unchecked)

Q13b7 Have always made a practice run

1 Yes
0 No (unchecked)

Q13b8 Other

1 Yes
0 No (unchecked)

Q13b9 Please specify_____

Q13c Do you reduce your overall travel by combining several trips into a single outing?

1 Yes
0 No

9 Missing

Why?

Q13c1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q13c2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q13c3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q13c4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q13c5 Don't feel comfortable not combining trips

1 Yes
0 No (unchecked)

Q13c6 Don't feel safe not combining trips

1 Yes
0 No (unchecked)

Q13c7 Financial reasons (e.g., cost of petrol)

1 Yes
0 No (unchecked)

Q13c8 Environmental reasons (e.g., auto emissions)

1 Yes
0 No (unchecked)

Q13c9 Have always combined trips

1 Yes
0 No (unchecked)

Q13c10 Other

1 Yes
0 No (unchecked)

Q13c11 Please specify_____

Q13d Do you now leave greater distances between your car and the car ahead of you than you used to?

1 Yes
0 No

9 Missing

Why?

Q13d1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q13d2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q13d3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q13d4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q13d5 Don’t feel comfortable leaving smaller distances

1 Yes
0 No (unchecked)

Q13d6 Don’t feel safe leaving smaller distances

1 Yes
0 No (unchecked)

Q13d7 Other

1 Yes
0 No (unchecked)

Q13d8 Please specify_____

Q13e Do you bring along a passenger specifically to help you navigate?

1 Yes

0 No

9 Missing

Why?

Q13e1 Difficulty seeing during the day or night

1 Yes
0 No (unchecked)

Q13e2 Difficulty remembering things

1 Yes
0 No (unchecked)

Q13e3 Difficulty concentrating on more than one thing at a time

1 Yes
0 No (unchecked)

Q13e4 Reduced strength, flexibility, or general mobility

1 Yes
0 No (unchecked)

Q13e5 Don't feel comfortable without a passenger to help

1 Yes
0 No (unchecked)

Q13e6 Don't feel safe without a passenger to help

1 Yes
0 No (unchecked)

Q13e7 Have always brought a passenger to help

1 Yes
0 No (unchecked)

Q13e8 Other

1 Yes
0 No (unchecked)

Q13e9 Please specify_____

[Q14] During the past year, have you made any of the following changes to your car?

Q14a Added special mirrors

1 Yes
0 No

9 Missing

Q14b Added steering knobs

1 Yes
0 No

9 Missing

Q14c Added hand controls to work the brake or the accelerator

1 Yes
0 No

9 Missing

Q14d Added an in-vehicle navigation system

1	Yes
0	No
9	Missing

Q15 When the roads were wet, how often did that fact alone make you modify your driving plans?

1	Never
2	
3	
4	
5	
6	
7	Always
9	Missing

How did you modify your driving plans?

Q15a Drove slower

1	Yes
0	No (unchecked)

Q15b Drove more cautiously

1	Yes
0	No (unchecked)

Q15c Reduced distractions inside your car

1	Yes
0	No (unchecked)

Q15d Changed your driving route

1	Yes
0	No (unchecked)

Q15e Started trip earlier to allow more time

1	Yes
0	No (unchecked)

Q15f Got someone else to drive

1	Yes
0	No (unchecked)

Q15g Delayed or canceled trip

1	Yes
0	No (unchecked)

Q15h Other

1	Yes
0	No (unchecked)

Q15i Please specify_____

Q16 When the most direct way to your destination required driving on the freeway, how often did that fact alone make you take an alternate route?

1	Never
2	
3	

4
5
6
7 Always

9 Missing

Q17 When the most direct way to your destination required driving on busy roads, now often did that fact alone make you take an alternate route?

1 Never
2
3
4
5
6
7 Always

9 Missing

Q18 When the most direct way to your destination required making right hand turns across oncoming traffic where there were no right turn arrows, now often did that fact alone make you take an alternate route?

1 Never
2
3
4
5
6
7 Always

9 Missing

Q19 When the roads were safe and the weather was good, how often did your desire to save petrol, and that fact alone, make you modify your driving plans?

1 Never
2
3
4
5
6
7 Always

How did you modify your driving plans?

Q19a Drove slower

1 Yes
0 No (unchecked)

Q19b Drove more cautiously

1 Yes
0 No (unchecked)

Q19c Changed your driving route

1 Yes
0 No (unchecked)

Q19d Got a ride with someone else

1 Yes
0 No (unchecked)

Q19e Delayed or canceled trip

1 Yes
0 No (unchecked)

Q19f Other

_____

1 Yes
0 No (unchecked)

Q19g Please specify_____

Q20 When the roads were safe and the weather was good, how often did your desire to save the wear and tear of your car, and that fact alone, make you modify your driving plans?

_____

1 Never
2
3
4
5
6
7 Always

How did you modify your driving plans?

Q20a Drove slower

_____

1 Yes
0 No (unchecked)

Q20b Drove more cautiously

_____

1 Yes
0 No (unchecked)

Q20c Changed your driving route

_____

1 Yes
0 No (unchecked)

Q20d Got a ride with someone else

_____

1 Yes
0 No (unchecked)

Q20e Delayed or canceled trip

_____

1 Yes
0 No (unchecked)

Q20f Other

_____

1 Yes
0 No (unchecked)

Q20g Please specify_____

Q21 When the roads were safe and the weather was good, how often did your concern about your ability to see clearly during the day make you modify your driving plans?

_____

1 Never
2
3
4
5
6
7 Always

9 Missing

How did you modify your driving plans?

Q21a Drove slower

_____

1 Yes
0 No (unchecked)

Q21b Drove more cautiously

1 Yes
0 No (unchecked)

Q21c Reduced distractions inside your car

1 Yes
0 No (unchecked)

Q21d Changed your driving route

1 Yes
0 No (unchecked)

Q21e Started trip earlier to allow more time

1 Yes
0 No (unchecked)

Q21f Got someone else to drive

1 Yes
0 No (unchecked)

Q21g Delayed or canceled trip

1 Yes
0 No (unchecked)

Q21h Other

1 Yes
0 No (unchecked)

Q21i Please specify_____

Q22 When the roads were safe and the weather was good, how often did your concern about your ability to see clearly at night make you modify your driving plans?

1 Never
2
3
4
5
6
7 Always

9 Missing

How did you modify your driving plans?

Q22a Drove slower

1 Yes
0 No (unchecked)

Q22b Drove more cautiously

1 Yes
0 No (unchecked)

Q22c Reduced distractions inside your car

1 Yes
0 No (unchecked)

Q22d Changed your driving route

1 Yes
0 No (unchecked)

Q22e Started trip earlier to allow more time

1 Yes
0 No (unchecked)

Q22f Got someone else to drive

1 Yes
0 No (unchecked)

Q22g Delayed or canceled trip

1 Yes
0 No (unchecked)

Q22h Other

1 Yes
0 No (unchecked)

Q22i Please specify_____

Q23 When the roads were safe and the weather was good, how often did your concern about possible problems with your ability to remember things make you modify your driving plans?

1 Never
2
3
4
5
6
7 Always

9 Missing

How did you modify your driving plans?

Q23a Drove slower

1 Yes
0 No (unchecked)

Q23b Drove more cautiously

1 Yes
0 No (unchecked)

Q23c Reduced distractions inside your car

1 Yes
0 No (unchecked)

Q23d Changed your driving route

1 Yes
0 No (unchecked)

Q23e Started trip earlier to allow more time

1 Yes
0 No (unchecked)

Q23f Got someone else to drive

1 Yes
0 No (unchecked)

Q23g Delayed or canceled trip

1 Yes
0 No (unchecked)

Q23h Other

1 Yes
0 No (unchecked)

Q23i Please specify_____

Q24 When the roads were safe and the weather was good, how often did your concern about possible problems with your ability to concentrate on more than one thing at a time make you modify your driving plans?

1 Never
2
3
4
5
6
7 Always

9 Missing

How did you modify your driving plans?

Q24a Drove slower

1 Yes
0 No (unchecked)

Q24b Drove more cautiously

1 Yes
0 No (unchecked)

Q24c Reduced distractions inside your car

1 Yes
0 No (unchecked)

Q24d Changed your driving route

1 Yes
0 No (unchecked)

Q24e Started trip earlier to allow more time

1 Yes
0 No (unchecked)

Q24f Got someone else to drive

1 Yes
0 No (unchecked)

Q24g Delayed or canceled trip

1 Yes
0 No (unchecked)

Q24h Other

1 Yes
0 No (unchecked)

Q24i Please specify_____

Q25 When the roads were safe and the weather was good, how often did your concern about reduced strength, flexibility, or general mobility make you modify your driving plans?

1	Never
2	
3	
4	
5	
6	
7	Always
9	Missing

How did you modify your driving plans?

Q25a Drove slower

1	Yes
0	No (unchecked)

Q25b Drove more cautiously

1	Yes
0	No (unchecked)

Q25c Reduced distractions inside your car

1	Yes
0	No (unchecked)

Q25d Changed your driving route

1	Yes
0	No (unchecked)

Q25e Started trip earlier to allow more time

1	Yes
0	No (unchecked)

Q25f Got someone else to drive

1	Yes
0	No (unchecked)

Q25g Delayed or canceled trip

1	Yes
0	No (unchecked)

Q25h Other

1	Yes
0	No (unchecked)

Q25i Please specify_____

Q26 How much do you enjoy driving?

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q27 How important is driving to you?

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q28 How important is it to you that you continue driving?

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q29 How confident are you that you can safely drive to places you need to go?

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q30 How involved in the community do you consider yourself to be?

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

[Q31] How important are the following activities to you?

Q31a Shopping

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q31b Volunteer work/community service

1	Not at all
2	
3	
4	
5	
6	

7 Completely

9 Missing

Q31c Social or recreational activities

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q31d Exercise or fitness activities

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q31e Time with family and friends

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32a Were you involved in purchasing the car you presently drive?

1 Yes
0 No

9 Missing

[Q32b] When you bought your present car, how important were the following features in your decision?

Q32b1 Comfort

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32b2 Cost of operating (e.g., petrol, care)

1 Not at all
2
3
4
5
6

7 Completely

9 Missing

Q32b3 Environmental impact (e.g., auto emissions)

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32b4 Makes you feel good about yourself

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32b5 Performance (e.g., power, handing)

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

[Q32c] When you bought your present car, how important were the following features in your decision?

Q32c1 Price

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32c2 Safety

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32c3 Size

1 Not at all
2

3
4
5
6
7 Completely

9 Missing

Q32c4 Status

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q32c5 Styling/look

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q33 How would you rate your ability to drive safely compared to other drivers your age?

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

Q34 How would you rate your ability to drive safely compared to yourself 5 years ago?

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

Q35 How would you rate your ability to drive safely compared to yourself 1 year ago?

1 Poor
2
3
4
5
6
7 Excellent

9 Missing

[Q36a] How COMFORTABLE do you feel in the following situations?

Q36a1 Driving at night

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q36a2 Making right hand turns across oncoming traffic where there are no right turn arrows

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q36a3 Driving in bad weather (e.g., heavy rain, fog)

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q36a4 Driving on busy roads

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q36a5 Driving in unfamiliar areas

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

[Q36b] How COMFORTABLE do you feel in the following situations?

Q36b1 Driving alone

1	Not at all
2	
3	
4	
5	

6
7 Completely

9 Missing

Q36b2 Driving at night in bad weather

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q36b3 Driving in rush hour traffic

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q36b4 Driving on the freeway

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q36b5 Reversing

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

[Q37a] How SAFE do you feel in the following situations (fear of getting in a crash)?

Q37a1 Driving at night

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q37a2 Making right hand turns across oncoming traffic where there are no right turn arrows

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q37a3 Driving in bad weather (e.g., heavy rain, fog)

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q37a4 Driving on busy roads

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q37a5 Driving in unfamiliar areas

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

[Q37b] How SAFE do you feel in the following situations (fear of getting in a crash)?

Q37b1 Driving alone

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q37b2 Driving at night in bad weather

1 Not at all
2
3
4
5
6
7 Completely

9 Missing

Q37b3 Driving in rush hour traffic

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q37b4 Driving on the freeway

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q37b5 Reversing

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

[Q38a] If you wanted to avoid the following situations, could you usually do so?

Q38a1 Driving at night

1	Yes
0	No
9	Missing

Q38a2 Making right hand turns across oncoming traffic where there are no right turn arrows

1	Yes
0	No
9	Missing

Q38a3 Driving in bad weather (e.g., heavy rain, fog)

1	Yes
0	No
9	Missing

Q38a4 Driving on busy roads

1	Yes
0	No
9	Missing

Q38a5 Driving in unfamiliar areas

1	Yes
0	No
9	Missing

[Q38b] If you wanted to avoid the following situations, could you usually do so?

Q38b1 Driving alone

1	Yes
0	No
9	Missing

Q38b2 Driving at night in bad weather

1	Yes
0	No
9	Missing

Q38b3 Driving in rush hour traffic

1	Yes
0	No
9	Missing

Q38b4 Driving on the freeway

1	Yes
0	No
9	Missing

Q38b5 Reversing

1	Yes
0	No
9	Missing

Q39 In your opinion, how acceptable is it for a woman to drive when a man is available to drive?

1	Not at all
2	
3	
4	
5	
6	
7	Completely
9	Missing

Q40 What is your birthday?

mm/dd/yyyy

Q41 Are you?

1	Male
2	Female
9	Missing

Q42 Are you currently?

	1	Married
	2	Common law/defacto
	3	Separated
	4	Divorced
	5	Widowed
	6	Single (never married)
	9	Missing

Q43 Please describe where you live

	1	In a house, flat, or apartment you rent
	2	In a house, flat, or apartment you own
	3	In a family member's house, flat, or apartment
	4	In a senior or retirement community that provides transportation
	5	In a senior or retirement community that does NOT provide transportation
	6	Other
	9	Missing

Q44 How long have you lived at your present location?

	1	Less than 1 year
	2	1-5 years
	3	6-10 years
	4	More than 10 years
	9	Missing

Q45 How long have you lived in Australia?

	1	Have always lived in Australia
	2	Less than 1 year
	3	1-5 years
	4	6-10 years
	5	More than 10 years
	9	Missing

Q46 Would you describe the area you live in as urban, rural, or other?

	1	Urban
	2	Rural
	3	Other
	9	Missing

Q47 How many people, INCLUDING YOURSELF, live in your household?

	1	1
	2	2
	3	3
	4	4
	5	5
	6	6
	7	7
	8	8
	9	9
	10	10
	11	More than 10
	99	Missing

Q48 How many people in your household drive, INCLUDING YOURSELF?

	1	1
	2	2
	3	3
	4	4

5	5
6	6
7	7
8	8
9	9
10	10
11	More than 10
99	Missing

Q49 Are you the primary driver?

1	Yes
2	No
9	Missing

Q50 Does anyone in or outside of your household depend on you to drive them?

1	Yes
2	No
9	Missing

Q51 Are you retired?

1	Yes
2	No
9	Missing

[Q52] Do you currently?

Q52a Do any paid work?

1	Yes
0	No
9	Missing

Q52b Do volunteer work in your community?

1	Yes
0	No
9	Missing

Q53 Which best describes your TOTAL HOUSEHOLD INCOME last year before taxes?

1	Less than $20,000
2	$20,000 - $49,999
3	$50,000 - $79,999
4	$80,000 - $99,999
5	$100,000 or more
9	Missing

Q54 What is the highest grade or level of school you completed?

1	Primary school or less
2	Some high school or technical school
3	Completed high school or technical school
4	University degree
5	Some post graduation education
6	Post graduate degree or higher
9	Missing

Appendix C: Proceedings Paper

Australasian Road Safety Research, Policing, and Education Conference 2012
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Findings from the Candrive/Ozcandrive Study: Self-Regulatory Driving Practices among Older Adults

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Abstract

As people age, they may experience declines in visual, cognitive, or psychomotor skills that can compromise safe driving. Many drivers are aware of these changes and self-regulate their driving to extend the period over which they can safely drive – that is, they avoid certain driving situations that they find challenging such as driving at night, during rush hour, or on the freeway, or making turns across oncoming traffic at intersections without protected turn arrows. However, study findings are mixed with regard to the extent and type of self-regulation occurring among older adults.

The purpose of this study was to better understand the process of driving self-regulation among older adults. The study used a subset of data from the Candrive/Ozcandrive prospective study of older drivers to investigate the extent and type of several self-regulatory practices, as well as possible associations between these practices and various sociodemographic, health, and driving-related factors. Study participants (n=246) completed a computer-based questionnaire on driving self-regulation about 4 months after being recruited into the study.

Study participants reported self-regulating their driving in several situations. A total of 46.3% reported trying to avoid driving in rush hour traffic, 44.3% in bad weather at night, 35.0% in bad weather, 22.4% at night, 16.7% on busy roads, 13.8% in unfamiliar areas, and 8.2% on freeways. In addition, 11.9% reported trying to avoid reversing and 10.6% reported trying to avoid making right turns across oncoming traffic at intersections with no right turn arrow. Only three participants reported trying to avoid driving alone. Differences in self-regulation by age, gender, self-perceived abilities for safe driving, and feelings of driving comfort across various driving situations were also examined and are discussed.

Keywords: self-regulation, mobility, older drivers, driving comfort, abilities.

1. Introduction

As people age, they may experience declines in visual, cognitive, or psychomotor skills that can compromise safe driving (Eby, Molnar & Kartje, 2009). Many drivers are aware of these changes and self-regulate their driving to extend the period over which they can safely drive – that is, they avoid certain driving situations that they find challenging such as driving at night, during rush hour, or on the freeway, or making turns across oncoming traffic at intersections without protected turn arrows (e.g., see e.g., Baldock, Mathias, McLean & Berndt, 2006; Ball, et al., 1998; D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008; Stalvey & Owsley, 2000).

However, study findings are mixed with regard to the extent and type of self-regulation occurring among older adults, and considerable knowledge gaps remain about the self-regulation process and the individual, social, and environmental factors that influence it (see Molnar and Eby, 2008 for a review of this literature). The lack of conclusive results in this area is due in large measure to considerable differences across studies in terms of how self-regulation is conceptualized and measured, the characteristics of study participants such as age, sex, and functional status, and the extent to and way in which studies have included measures that seem to influence the adoption of self-regulatory practices such as insight into functional declines and confidence in driving ability.

The purpose of this study was to better understand the process of driving self-regulation among older adults. Specifically, the study investigated the extent and type of several self-regulatory practices, as well as possible associations between these practices and various sociodemographic, health, and driving-related factors. Of particular interest were differences in reported self-regulatory practices by age, gender, self-perceived abilities for safe driving, and feelings of comfort with driving across various driving situations.

2. Methods

The study used a subset of data from the Candrive/Ozcandrive prospective study of older drivers. Specifically, participants in the Australian cohort of the Ozcandrive sample (i.e., those Ozcandrive participants recruited from the greater Melbourne area in Victoria, Australia) completed a computer-based questionnaire on driving self-regulation about 4 months after being recruited into Candrive/Ozcandrive and completing informed consent. The questionnaire was completed at one of the study sites, with a member of the study team available to answer questions and provide assistance. Participants completed the questionnaire in addition to their regular obligations as participants in Candrive/Ozcandrive. Full detail on the Candrive/Ozcandrive study protocols can be found in Marshall et al. (under review). At the time of this study, 246 of the total 261 participants in the Ozcandrive Melbourne area sample had been recruited and their questionnaire data were available for inclusion in the analyses.

3. Findings

The mean age of participants was 79.7 (SD=3.51). The majority of participants were male (72.8%) and married (61.7%). All but three considered themselves to be urban residents. Most participants (77.1%) lived in a residence (i.e., house, flat, or apartment) that they owned and

most had lived at that residence for more than 10 years (71.3%). The majority of households consisted of the participant and at least one other individual (61.7%). Close to one-half of participants reported that someone else in the household also drove and over one-third reported that others were dependent on them to drive. Most reported being retired (96.2%), although a sizable number were in paid work (11.7%) and nearly two-thirds reported doing volunteer work in the community. Household income and education levels covered a broad range, although two-thirds reported an income of less than $AUD50,000 and one-half had completed at least high school or technical school.

Table 1 provides summary information on the self-regulatory practices reported by participants. A total of 46.3% participants reported trying to avoid driving in rush hour traffic, 44.3% in bad weather at night, 35.0% in bad weather, 22.4% at night, 16.7% on busy roads, 13.8% in unfamiliar areas, and 8.2% on freeways. In addition, 11.9% reported trying to avoid reversing and 10.6% reported trying to avoid making right turns across oncoming traffic at intersections with no right turn arrow. Only three participants reported trying to avoid driving alone.

Table 1. Reported Self-Regulation Across Various Driving Situations

	Total N	Percent Responding Yes
Do you try to avoid driving at night?	246	22.4
Do you try to avoid making unprotected right turns?	246	10.6
Do you try to avoid driving in bad weather?	246	35.0
Do you try to avoid driving on busy roads?	246	16.7
Do you try to avoid driving in unfamiliar areas?	246	13.8
Do you try to avoid driving alone?	245	1.2
Do you try to avoid driving at night in bad weather?	244	44.3
Do you try to avoid driving during rush hour traffic?	244	46.3
Do you try to avoid driving on the freeway?	244	8.2
Do you try to avoid reversing?	244	11.9

Differences in self-regulation across the various driving situations were examined by age, gender, self-ratings of abilities for safe driving, and self-ratings of driving comfort (Tables 2-5). As shown in Table 2, there were statistically significant differences by gender for several of the self-regulatory practices including trying to avoid driving at night, in bad weather, in unfamiliar areas, at night in bad weather, and on the freeway, as well as trying to avoid reversing. In all cases, women were more likely than men to report trying to avoid these situations. As shown in Table 3, there were no differences in self-regulatory practices by age. There were, however, several differences by self-ratings of abilities for safe driving (Table 4). As shown in the table, there were statistically significant associations between mean ability rating and trying to avoid driving at night, in bad weather, on busy roads, in unfamiliar areas, alone, at night in bad weather, and during rush hour traffic. In each case, participants who reported trying to avoid driving situations had lower mean ability ratings than participants who did not report such avoidance behavior. Similarly, there were statistically significant associations between mean ratings of driving comfort and avoidance behavior for all driving situations except for trying to avoid unprotected turns and driving alone. For each statistically significant association,

participants who reported trying to avoid driving situations had lower mean driving comfort ratings than participants who did not report such avoidance behavior.

Table 2. Self-Regulatory Practices by Gender: Pearson Chi-Square Results			
Self-Regulatory Practice	**Value**	**df**	**Sig.**
Try to avoid driving at night	5.824	1	0.016
Try to avoid making unprotected right turns	0.183	1	0.669
Try to avoid driving in bad weather	8.274	1	0.004
Try to avoid driving on busy roads	0.496	1	0.481
Try to avoid driving in unfamiliar areas	16.337	1	p<.001
Try to avoid driving alone	0.055	1	1.00*
Try to avoid driving at night in bad weather	11.696	1	0.001
Try to avoid driving during rush hour traffic	0.550	1	0.458
Try to avoid driving on the freeway	8.625	1	0.003
Try to avoid reversing	5.272	1	.022

* Fisher's Exact Test used instead of Chi-Square Test due to fewer than 5 cases in one or more cells.

Table 3. Self-Regulatory Practices by Age: Independent Samples T-Test Results					
Self-Regulatory Practice	**Yes Mean (SD)**	**No Mean (SD)**	**t**	**df**	**Sig.**
Try to avoid driving at night	80.4 (3.7)	79.5 (3.5)	1.609	244	0.109
Try to avoid making unprotected right turns	80.2 (3.4)	79.7 (3.5)	0.651	244	0.516
Try to avoid driving in bad weather	80.2 (3.7)	79.5 (3.4)	1.383	244	0.168
Try to avoid driving on busy roads	80.2 (3.7)	79.6 (3.5)	0.881	244	0.379
Try to avoid driving in unfamiliar areas	79.5 (3.4)	79.8 (3.5)	-0.405	244	0.686
Try to avoid driving alone	78.0 (1.0)	79.8 (3.5)	-0.861	243	0.390
Try to avoid driving at night in bad weather	80.1 (3.6)	79.5 (3.5)	1.258	242	0.210
Try to avoid driving during rush hour traffic	79.9 (3.9)	79.6 (3.2)	0.670	218	0.504
Try to avoid driving on the freeway	81.2 (4.0)	79.62 (3.5)	1.931	242	0.055
Try to avoid reversing	79.5 (2.6)	79.8 (3.6)	-0.482	45	0.632

Table 4. Self-Regulatory Practices by Self-Ratings of Driving Abilities: Independent Samples T-Test Results					
Self-Regulatory Practice	**Yes Mean (SD)**	**No Mean (SD)**	**t**	**df**	**Sig.**
Try to avoid driving at night	5.3 (.7)	5.7 (.7)	-3.663	244	p<.001
Try to avoid making unprotected right turns	5.5 (.6)	5.6 (.7)	-.840	244	0.402
Try to avoid driving in bad weather	5.5 (.7)	5.7 (.7)	-2.446	244	0.015
Try to avoid driving on busy roads	5.3 (.7)	5.7 (.7)	-2.909	244	0.004
Try to avoid driving in unfamiliar areas	5.4 (.7)	5.7 (.7)	-2.017	244	0.045
Try to avoid driving alone	4.8 (1.3)	5.6 (.7)	-2.205	243	0.028
Try to avoid driving at night in bad weather	5.5 (.7)	5.7 (.6)	-2.284	242	0.023
Try to avoid driving during rush hour traffic	5.5 (.6)	5.7 (.7)	-2.631	242	0.009
Try to avoid driving on the freeway	5.7 (.7)	5.6 (.7)	0.201	242	0.841
Try to avoid reversing	5.4 (.9)	5.7 (.7)	-1.598	33	0.120

Table 5. Self-Regulatory Practices by Self-Ratings of Driving Comfort: Independent Samples T-Test Results					
Self-Regulatory Practice	**Yes Mean (SD)**	**No Mean (SD)**	**t**	**df**	**Sig.**
Try to avoid driving at night	5.1 (.9)	6.1 (.7)	-.8.270	71	p<.001
Try to avoid making unprotected right turns	5.6 (1.1)	5.9 (.8)	-1.669	29	0.106
Try to avoid driving in bad weather	5.4 (.9)	6.2 (.7)	-7.387	239	p<.001
Try to avoid driving on busy roads	5.3 (1.0)	6.0 (.8)	-4.437	49	p<.001
Try to avoid driving in unfamiliar areas	5.0 (.9)	6.1 (.8)	-7.385	239	p<.001
Try to avoid driving alone	6.1 (1.1)	5.9 (.9)	0.233	239	0.816
Try to avoid driving at night in bad weather	5.5 (.9)	6.3 (.7)	-7.526	194	p<.001
Try to avoid driving during rush hour traffic	5.6 (.9)	6.2 (.8)	-5.038	239	p<.001
Try to avoid driving on the freeway	5.0 (.9)	6.0 (.8)	-5.239	239	p<.001
Try to avoid reversing	5.3 (1.1)	6.0 (.8)	-3.356	32	0.002

4. Discussion

Sizable numbers of participants reported trying to avoid various driving situations. Participants were most likely to report (in descending order) trying to avoid driving during rush hour traffic, in bad weather at night, in bad weather, and at night. They were least likely to report trying to avoid driving on the freeway or alone. Women were likely than men to report trying to avoid all driving situations except making unprotected turns, driving on busy roads, and driving during rush hour traffic. There were no differences by age. In general, lower self-ratings of abilities for both safe driving and driving comfort were associated with greater likelihood of avoidance behavior. These findings suggest that self-regulation is a complex process influenced by various individual factors. Specifically, when examined separately, gender, self-perceived abilities, and feelings of driving comfort were all found to play a role in influencing self-regulatory behaviors. Further analyses, using multivariate methods, are underway to examine the interactive effects of these factors. Further analyses are also being conducted to examine participants' motivations for trying to avoid various driving situations to disentangle avoidance for reasons commonly associated with self-regulation from other avoidance for other reasons such as lifestyle or preferences that have little to do with self-regulation.

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Appendix D: One-Way Analysis of Variance (ANOVA) Results

Significant differences between groups (at $p < .05$) are identified by shaded cells in the following tables. Significant differences between non-modifiers and self-regulators are shown in blue. Significant differences between non-modifiers and others are shown in green. Significant differences between self-regulators and others are shown in purple.

	Health, Functioning, and Abilities for Safe Driving							
	Overall health	Walk 1 kilometre	Climb stairs	See day or night	Remember things	Concentrate	Strength/flex. mobility	Safe driving confidence
Strategic Level								
At night								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Making turns								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Bad weather								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Busy roads								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Unfamiliar areas								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Driving alone								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
At night in bad weather								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Rush hour traffic								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
On the freeway								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Reversing								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Plan route								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Combining trips								

	Health, Functioning, and Abilities for Safe Driving							
	Overall health	Walk 1 kilometre	Climb stairs	See day or night	Remember things	Concentrate	Strength/flex. mobility	Safe driving confidence
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Reduced driving								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Tactical Level								
Chatting								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Eating								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Reading map								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Changing radio								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Talking on phone								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Personal grooming								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								
Leave more room								
Non-modifier vs. Self-regulators								
Non-modifier vs. Others								
Self-regulators vs. Others								

Importance of Driving and Lifestyle Activities									
	Enjoy driving	Driving importance	Continued driving	Involved in community	Shopping	Volunteer service	Social/ recreational	Exercise/ fitness	Family/ friends
Strategic Level									
At night									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Making turns									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Bad weather									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Busy roads									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Unfamiliar areas									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Driving alone									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
At night in bad weather									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Rush hour traffic									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
On the freeway									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Reversing									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Plan route									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Combining trips									

Importance of Driving and Lifestyle Activities									
	Enjoy driving	Driving importance	Continued driving	Involved in community	Shopping	Volunteer service	Social/ recreational	Exercise/ fitness	Family/ friends
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Reduced driving									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Tactical Level									
Chatting									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Eating									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Reading map									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Changing radio									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Talking on phone									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Personal grooming									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									
Leave more room									
Non-modifier vs. Self-regulators									
Non-modifier vs. Others									
Self-regulators vs. Others									

Overall Ability to Drive Safely			
	Compared to Others	Compared to self 5 years ago	Compared to self 1 year ago
Strategic Level			
At night			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Making turns			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Bad weather			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Busy roads			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Unfamiliar areas			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Driving alone			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
At night in bad weather			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Rush hour traffic			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
On the freeway			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Reversing			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Plan route			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Combining trips			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Reduced driving			

Overall Ability to Drive Safely			
	Compared to Others	Compared to self 5 years ago	Compared to self 1 year ago
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Tactical Level			
Chatting			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Eating			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Reading map			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Changing radio			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Talking on phone			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Personal grooming			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			
Leave more room			
Non-modifier vs. Self-regulators			
Non-modifier vs. Others			
Self-regulators vs. Others			

Feelings of Comfort										
	At night	Making turns	Bad weather	Busy roads	Unfamiliar areas	Driving alone	At night bad weather	Rush hour	Freeway	Reversing
Strategic Level										
At night										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Making turns										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Bad weather										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Busy roads										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Unfamiliar areas										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Driving alone										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
At night in bad weather										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Rush hour traffic										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
On the freeway										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Reversing										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Plan route										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Combining trips										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										

Feelings of Comfort										
	At night	Making turns	Bad weather	Busy roads	Unfamiliar areas	Driving alone	At night bad weather	Rush hour	Freeway	Reversing
Reduced driving										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Tactical Level										
Chatting										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Eating										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Reading map										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Changing radio										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Talking on phone										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Personal grooming										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Leave more room										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										

Feelings of Safety										
	At night	Making turns	Bad weather	Busy roads	Unfamiliar areas	Driving alone	At night bad weather	Rush hour	Freeway	Reversing
Strategic Level										
At night										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Making turns										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Bad weather										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Busy roads										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Unfamiliar areas										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Driving alone										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
At night in bad weather										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Rush hour traffic										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
On the freeway										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Reversing										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Plan route										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Combining trips										

Feelings of Safety										
	At night	Making turns	Bad weather	Busy roads	Unfamiliar areas	Driving alone	At night bad weather	Rush hour	Freeway	Reversing
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Reduced driving										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Tactical Level										
Chatting										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Eating										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Reading map										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Changing radio										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Talking on phone										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Personal grooming										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										
Leave more room										
Non-modifier vs. Self-regulators										
Non-modifier vs. Others										
Self-regulators vs. Others										