Seniors face serious driving safety and mobility issues.

Self-Regulation of Driving by Older Adults

A LongROAD Study

December 2015

AAA Foundation for Traffic Safety

Title

Self-Regulation of Driving by Older Adults: A Synthesis of the Literature and Framework for Future Research. *(December 2015)*

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Acknowledgments

About the Sponsor

AAA Foundation for Traffic Safety
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Founded in 1947, the AAA Foundation in Washington, D.C. is a not-for-profit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report

About LongROAD

Safe mobility is essential to healthy aging. Recognizing that lifestyle changes, along with innovative technologies and medical advancements, will have a significant impact on the driving experiences of the baby boomer generation, the AAA Foundation for Traffic Safety has launched a multi-year research program to more fully understand the driving patterns and trends of older drivers in the United States. This multi-year prospective cohort study is being conducted at 5 sites throughout the country, with 3,000 participants, tracking 5+ years of driving behaviors and medical conditions. The multidisciplinary team assembled to investigate this issue is led by experienced researchers from Columbia University, University of Michigan Transportation Research Institute and the Urban Institute.

The LongROAD (Longitudinal Research on Aging Drivers) Study is designed to generate the largest and most comprehensive data base about senior drivers in existence and will support in-depth studies of senior driving and mobility to better understand risks and develop effective countermeasures. Specific emphasis is being placed on issues related to medications, medical conditions, driving patterns, driving exposure, self-regulation, and crash risk, along with mobility options for older Americans who no longer drive.

Abstract

Background

Self-regulation, or the modification of driving by driving less or avoiding challenging situations in response to declining abilities, is increasingly being studied as a way to help older drivers maintain independence and extend the period over which they can safely drive. However, considerable research gaps remain with respect to whether older drivers can accurately adjust their driving in response to their age-related declines, the extent to which older drivers engage in self-regulatory behaviors, the factors affecting self-regulation, and the extent to which it actually improves safety and mobility.

Objectives

The overall purpose of this paper is to report findings from an extensive synthesis of the literature on self-regulation of driving among older adults. The synthesis builds on earlier reviews of the literature by the authors, as well as extends literature findings on specific aspects self-regulation.

Methods

A set of search terms was developed that included combinations of three subsets of terms: self-regulation terms, driving terms, and aging terms. The search terms were used to target key journal articles, technical reports, conference papers and proceedings, white papers, books, and other documents on the topic. Inclusion criteria for the review included: 1) published primary quantitative or qualitative studies reporting results in English; 2) studies including older drivers as at least part of the sample; and 3) publications from 2009 onward, supplemented by our repository of relevant pre-2009 publications from earlier exhaustive reviews.

Results

Findings from the synthesis are presented with regard to prevalence and type of self-regulation, factors associated with self-regulation, and limitations of the self-regulation literature.

Conclusions

A framework for future research is needed that represents a more comprehensive, theoretically-informed, and uniform approach to understanding how older drivers self-regulate their driving at multiple levels of driver performance and decision making. A set of recommendations for such a framework is proposed.

Introduction

The issues around older driver safety and mobility have received considerable societal attention over the past several years due to the aging of the population (National Institute on Aging, 2011), trends toward increased licensure and driving by older adults (Sivak & Schoettle, 2011), and the overrepresentation of older drivers, at least after age 70, in fatal motor vehicle crashes (Insurance Institute for Highway Safety, 2010). Fragility and frailty may play an important role in current fatality rates (Langford & Koppel, 2006; Organization for Economic Co-operation and Development, OECD, 2001). However, safe driving can also be compromised by declines in driving-related cognitive, visual, and psychomotor abilities due to medical conditions that become more prevalent with aging, the medications used to treat these conditions, and the aging process itself (Eby, Molnar & Kartje, 2009; Molnar, Eby, St. Louis & Neumeyer, 2007).

Self-regulation, or the modification of driving by driving less or avoiding challenging situations in response to declining abilities, is increasingly being studied as a way to help older drivers maintain independence and extend the period over which they can safely drive (Gwyther & Holland, 2012; Wong, Smith & Sullivan, 2012). Strategies for helping balance the often conflicting needs for public safety and personal mobility are important for several reasons. First, older adults, like other age groups, prefer driving as their primary means of transportation in the community and consider driving to be vital to their well-being and independence (Carp, 1988; Hassan, King & Watt, 2015; Kaplan, 1995). Second, studies have identified a number of adverse consequences associated with driving cessation including: loss of independence and mobility (Adler & Rottunda, 2006; Al-Hassani & Alotaibi, 2014; Bauer, Rottunda & Adler, 2003; Dobbs & Dobbs, 1997); increased social isolation (Liddle, McKenna & Broome, 2004; Ragland, Satariano & MacLeod, 2004); increased depressive symptoms (Chihuri et al., 2015; Fonda, Wallace & Herzog, 2001; Marottoli et al., 1997; Ragland, Satariano & MacLeod, 2005); higher risk of nursing home placement (Freeman, Gange, Muñoz & West, 2006); and more general accelerated health declines (Edwards, Lunsman, Perkins, Rebok & Roth, 2009).

Third, to the extent that older drivers self-regulate appropriately, the burden on society to intervene with this population might be reduced. For example, voluntary self-restriction by older drivers could lessen the need for mandatory restriction by licensing agencies (which would still require compliance by drivers) such as prohibiting driving at night, during rush hour, on major highways, or long distances from home. Although such mandatory restrictions have shown promise as an approach for managing older driver safety, further research is needed to identify the overall safety benefits of such restrictions (Braitman, Chaudhary & McCartt, 2010; Hanson & Hildebrand, 2011) and which drivers are most likely to benefit from such restrictions (Nasvadi & Wister, 2009).

Purpose of Paper

As suggested above, appropriate self-regulation by older drivers might serve as a useful strategy that could not only benefit older adults directly, but also society at large. However, as noted by Hassan, King, and Watt (2015), "The question remains as to whether older drivers can accurately adjust their driving in response to their age-related declines"

(p. 26). The overall purpose of this paper is to report findings from an extensive synthesis of the literature on self-regulation of driving among older adults. The synthesis builds on earlier reviews of the literature by the authors (Molnar, 2013; Molnar & Eby, 2008), as well as extends literature findings on specific aspects of self-regulation (e.g., Molnar et al., 2013a, 2013b, 2014). Specifically, this report updates the set of publications reviewed by the authors, expands the set of factors thought to influence the self-regulation process and delves more deeply into some of them, and substantially reorganizes the presentation of information. It also presents a recommended framework for future research on self-regulation by older drivers.

The paper focuses on several topics related to self-regulation. First, it explores how self-regulation has been described, defined, and operationalized across the myriad of studies conducted in this area. This is important because the use of different constructs and measures of self-regulation may lead to very different findings. Second, it investigates the range of data collection approaches used by researchers. Third, it examines the current prevalence of self-regulation in the older driver population by identifying the extent and type of self-regulation found across the range of studies. Fourth, it describes the various sets of factors associated with self-regulatory behavior by older adults. Of interest were not only demographic factors such as age and sex, but also factors related to: health and functioning (both objective and subjective); awareness of and insight into functional declines; family and social support; and confidence, comfort with driving, and more general perceptions about one's capacities. Fifth, it identifies limitations of the current state of the literature on self-regulation. Finally, it lays out a framework for future research in this area to help address some of the challenges we currently face in interpreting study results and reaching meaningful conclusions that can be applied to the population of older drivers.

Methods

This section describes the methods used to critically review studies published in the peer-reviewed literature focusing on self-regulation among older drivers.

Scope of Review

The review built on work already done on this topic by the authors as well as brought in new and updated information on relevant topics. As a starting point for identifying the appropriate scope, a set of overall inclusion and exclusion criteria was developed. Inclusion criteria included: 1) published primary quantitative or qualitative studies reporting results in English; 2) studies including older drivers as at least part of the sample; and 3) publications from 2009 onward. This time period was chosen because we have conducted extensive reviews of the literature up to 2009 and have all the relevant publications up to that year (e.g., Molnar & Eby, 2008. Molnar et al., 2009). Therefore, for this synthesis, an extensive review was conducted from 2009 onward and appropriate articles from the previous reviews were included. Exclusion criteria included: 1) documents that express the author's opinion rather than presenting evidence based on scientific data; and 2) studies in which the research results did not appear valid due to insufficient sample size, confounding variables, and inappropriate data analyses.

Scanning and Screening for Available Documents

The search for relevant documents was conducted by first developing a set of search terms based on the authors' knowledge of the self-regulation literature and past reviews of this literature (e.g., Molnar, 2013; Molnar & Eby, 2008). The set represented combinations of three subsets: self-regulation related words (self-regulation, self-regulatory, avoidance, compensation, modification, restriction, reduction); driving related words (driving, driver, drivers), and aging related words (aging, ageing, aged, older, senior, elderly). The search terms were used to target key journal articles, technical reports, conference papers and proceedings, white papers, books, and other documents on the topic. Databases included TRID (Transportation Research Board), Scopus, DeepBlue, Google Scholar, UM-MIRLYN, and the UMTRI Library. Most European literature (that coming from SWOV, TRL, INRETS, VTI, and BASt) is now indexed in TRID, which incorporates the ITRD database (OECD's International Transport Research Documentation).

The document search process was necessarily iterative in that as appropriate articles were found, we used subject and key word terms in those articles to refine our search, as well as follow up on relevant references included in those articles. In addition, we made use of systematic reviews that have been done in this area or subsets of the area to help us tailor our search.

Retrieval and Organization

The reference management software package Zotero was used to manage the literature review. Using Zotero facilitated the identification, retrieval, and storage of reference and other bibliographic information because of its capabilities to: directly import bibliographic information from most bibliographic databases; search library catalogs and free databases

from within the software program itself; and organize PDFs of the full articles on the UMTRI server.

Synthesis

Collected articles and data were reviewed for appropriateness and those deemed appropriate (based on inclusion and exclusion criteria) were collected and organized, so that information could be synthesized for this review. We then integrated this synthesis into previous review findings as appropriate or in the case of new findings, summarized them in a meaningful way. Collectively, the synthesis presented here should provide a summary of the current research on self-regulation of driving by older adults, as well as discuss limitations, weaknesses, and/or varying perspectives on the research to date. The search for publications, using the search terms and databases identified earlier, yielded a total of 596 publications from 2009 onward. After initial screening, 100 were considered to be relevant and underwent a detailed review for this synthesis. In addition, 71 publications from pre-2009 were included in the synthesis

Results

The research on self-regulation of driving among older adults has increased significantly in the past several years, leading to corresponding increases in the scientific literature. A careful review and synthesis of this literature requires detailed attention to how studies define and operationalize self-regulation, as well as findings with respect to the extent and type of self-regulation, and the various factors that influence the process.

Definitions of Self-Regulation

The research literature on driving self-regulation generally describes self-regulation as the process by which individuals modify or adjust their driving patterns by driving less or intentionally avoiding situations considered 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, self-regulation is considered to be a strategy for compensating for declining health or loss of functional abilities that can compromise driving (e.g., Hakamies-Blomqvist & Wahlström, 1998; Sullivan, Smith, Horswill, & Lurie-Beck, 2011). In this context, older drivers' 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 et al., 2006, p. 363); and as a process requiring "…an awareness of physical, cognitive, and sensory limitations" (Sargent-Cox, Windsor, Walker, & Anstey, 2011, p. 898).

Underlying theses various definitions is the notion that drivers have some insight into and awareness of their declining abilities and self-regulate their driving to continue driving in some capacity – that is, for safety or related reasons, they either reduce their overall driving or avoid certain situations that are challenging for them such as driving at night, in bad weather, during rush hour traffic, in unfamiliar areas, on the freeway, and so forth (e.g., Baldock et al., 2006; Jones, Cho, Abendschoen-Milani & Geilen, 2011; Sullivan et al., 2011).

However, most studies of self-regulation have simply asked older drivers if they modify their driving (e.g., by driving less or avoiding certain driving situations) without delving deeper into their motivations for these modifications. Therefore, it is difficult to know if these modifications constitute self-regulatory behavior as it is commonly defined, or if they simply represent changes in driving patterns that have little or nothing to do with self-regulation. A number of reasons have been advanced for driving modifications unrelated to self-regulation, such as changes in preferences or lifestyles resulting in greater flexibility in scheduling trips or simply less need to travel under certain conditions (e.g., Ball et al., 1998; Blanchard & Myers, 2010; Charlton, et al., 2006; Hassan, King & Watt, 2015; Myers et al., 2008). Recent findings that younger drivers also engage in avoidance behavior (e.g., Gwyther & Holland, 2012; Moták, Gabaude, Bougeant & Huet, 2014; Naumann, Dellinger, & Kresnow, 2011) also support the assertion that driving avoidance is not always related to declining abilities associated with aging. Thus, even though these avoidance behaviors by younger drivers are often described as self-regulation, it can be argued that they do not

meet the common definitions of self-regulation and should more properly be considered driving avoidance.

Recent results from Molnar and her colleagues (e.g., Molnar et al., 2013a) reinforce the idea that self-regulation is a complex process that cannot be defined simply by reported driving avoidance or other driving modification. They found that reasons for avoidance were varied and differed considerably across driving situations, often being more closely related to lifestyle changes or preferences than to self-regulation, consistent with the studies referenced above. Reasons considered to be associated with self-regulation included not only awareness of specific functional impairments (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/general mobility) but also a more general feeling of driving discomfort (i.e., don't feel comfortable or don't feel safe in terms of getting into a crash).

Similarly, in recent work comparing driving avoidance and self-regulatory patterns in younger and older drivers, Moták, Gabaude, Bougeant and Huet (2014) made a clear distinction between avoidance and self-regulation. Avoidance was described as the amount of self-reported avoidance in different driving situations, while self-regulation was described as the "correlation between the amount of self-reported avoidance and drivers' age, driving experience, perceptions of mental and physical health, and objectively assessed cognitive function" (p.26) and as "avoidance matched to one's cognitive abilities" (p. 18). They noted that older drivers might engage in behaviors that appear to suggest self-regulation but are in fact due to reasons other than age-related declines (e.g., reduced travel need, more free time and flexibility in scheduling, availability of alternative transportation options).

Meng and Siren (2015) conducted structured telephone interviews with 840 older drivers to identify reasons for driving self-regulation. Reduction in driving and avoidance of driving situations were considered to be separate types of self-regulation. Respondents were asked if they avoided, whenever possible,: (1) driving when feeling unwell; (2) driving on a motorway (highway); (3) driving when it is dark; or (4) driving in times and places with many cyclists. The most frequently reported reasons for avoiding driving in these four situations were associated with disliking or feeling insecure about driving in the particular situation. In contrast, the most frequent reason for reducing driving was having fewer activities to engage in. The authors concluded that self-regulation by older drivers may represent an automatic process in which they are unaware that they are compensating for functional loss. However, by asking the questions about driving avoidance within the context of feeling unwell, respondents may have limited their responses to a single and very special circumstance unrelated to broader reasons for self-regulation.

Findings from one year of data from a longitudinal study of current and former drivers found that reasons for restricting and stopping driving were varied and many participants reported multiple reasons (Kowalski et al., 2012). The most frequently cited reasons for restricting driving or preferring not to drive in certain driving situations included vision problems (32 percent), no longer needing to due to such things as retirement or availability of transportation (31 percent), feeling unsafe or nervous (19 percent), cost (15 percent), and lack of enjoyment (15 percent). In other work by some of these same authors, Kowalski, Jeznach and Tuokko (2014) conducted interviews and focus groups with a convenience

sample of 51 current and former drivers. Reasons given for avoiding difficult driving situations and other self-imposed driving restrictions were categorized as either internal (within the individual; e.g., declines in visual abilities, discomfort, concern about safety, lack of pleasure) or external (outside the individual; e.g., poor driving of others, less need to drive, lifestyle). The authors concluded that reasons for restricting or stopping driving are not always associated with awareness of declining abilities but also have to do with environmental, financial, and other factors.

Research findings also suggest that reasons may vary across different avoidance situations because the challenges associated with those situations may be very different. For example, people might avoid driving in unfamiliar areas because of the fear of getting lost or poor wayfinding abilities. In fact, in a study by Bryden, Charlton, Oxley and Lowndes (2013), drivers who reported that they regularly avoided unfamiliar areas were significantly more likely to be female and to report poorer wayfinding abilities. Other self-regulatory practices are linked to very different abilities (e.g., avoidance of nighttime driving and deficits in contrast sensitivity), which could lead to different self-reported motivations for engaging in those practices.

Prevalence of Self-Regulation

Examining the prevalence of self-regulation by older adults requires information not only on the extent to which older drivers self-regulate their driving, but also the types of self-regulatory practices they engage in. In this section, we classify self-regulatory behaviors into three distinct levels: strategic, tactical, and life-goal (Eby, Molnar & Kartje, 2009).

Strategic self-regulation has to do with decisions made by drivers before they actually embark on a driving trip; that is, the decision to not take a trip at all or to avoid driving situations considered challenging such as driving at night, in busy traffic, on the freeway, and so forth (e.g., Molnar et al., 2013a, 2013b, 2014). Strategic self-regulation occurs during the general planning stage of a trip, with most decisions taking place before the trip even begins (Smiley, 2004). These include high level decisions about trip goals, mode of transit, driving route, and conditions under which to drive (e.g., time of day, weather conditions, type of roadway, degree of familiarity of driving area), as well as evaluation of the costs and risks involved (Michon, 1985; Smiley, 2004).

Tactical self-regulatory practices are those that drivers engage in while they are actually on the road, such as maneuvering in traffic and avoiding in-vehicle distractions, often referred to as secondary tasks or activities (Molnar et al., 2013a, 2013b, 2014). Tactical self-regulation has to do with the actual maneuvers drivers make in traffic (e.g., obstacle avoidance, gap and headway acceptance, speed choice, and overtaking), as well as decisions about avoiding potentially distracting secondary activities in the vehicle while driving (e.g., using the radio, grooming, eating, talking on a mobile phone, and texting). An important reason for considering the avoidance of in-vehicle distractions as a self-regulatory behavior is the assumption that "… if older adults are aware of their difficulties in sharing attention between various tasks, they will probably be less inclined to combine driving with other non-driving related activities such as operating a radio or a CD player or having a telephone conversation" (p.647; Fofanova & Vollrath, 2011).

The life-goal level of self-regulation, a term coined by Eby et al. (2009), has to do with larger decisions in life such as 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). These types of larger decisions affect driving more indirectly than the strategic and tactical levels of self-regulation. The concept of life-goal self-regulation builds on young driver work by Keskinen and his colleagues (e.g., Hatakka, Keskinen, Gregersen, Glad & Hernetkoski, 2002; Keskinen, 1996, 2007; Keskinen, Hatakka, Laapotti, Katila & Peraaho, 2004; Laapotti & Keskinen, 2004) that extended Michon's hierarchical model of driver skills and control to include a higher level related to 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' personal characteristics and how they live their day-to-day lives also affect approaches to driving and specific driving behaviors (Berg, 2006). 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.

Collectively, these levels build on Michon's hierarchical model for driving skills and control (e.g., 1979, 1985), as well as the work to extend the hierarchical model to address the interplay between critical driving skills and motives (Keskinen, 2007). Michon's model included three levels of skills and control – strategic (planning), tactical (maneuvering), and operational (control). The operational level is not included here as it has to do with the details of driving that are largely automated (e.g., steering movements, braking; Berg, 2006) and therefore does not lend itself to self-regulation. Relevant study findings with regard to the strategic, tactical, and life-goal levels of self-regulation are discussed below.

Strategic self-regulation

Most studies to date on self-regulation have focused on strategic self-regulation. Molnar and Eby (2008), in an earlier review of the literature, found that many older drivers report self-regulating at the strategic level 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), or 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). More recent studies also provide evidence of such self-regulation by older adults, particularly avoidance of challenging driving and parking situations (e.g., Choi, Adams & Kahana, 2013; Meng & Siren, 2015; Molnar et al., 2013a, 2013b; 2013c; Siren & Meng, 2013).

However, there continues to be sizable variability across studies sampling various populations with regard to rates of self-regulation, making it difficult to reach meaningful conclusions on just how widespread such self-regulation is. For example, rates of self-reported avoidance of night driving vary from as low as 8 percent (Baldock et al., 2006), to 19 percent (Molnar & Eby, 2008), to 25 percent (Charlton et al., 2006), to 40 percent (Choi, Adams & Kahana, 2013; Siren & Meng, 2013), to 60 percent (Ruechel & Mann, 2005), to as

high as 80 percent (Ball et al., 1998). Other prevalence rates also vary considerably. For example, self-reported avoidance rates for driving in bad weather vary from 2 percent (Baldock et al., 2006), to 9 percent (Molnar & Eby, 2008), to 14 percent (Charlton et al., 2006) to about 20 percent (Ball et al., 1998) to 35 percent (Molnar et al., 2013b) to 65 percent (Molnar et al., 2013a).   Self-reported avoidance rates for driving on the freeway vary from less than 1 percent (Hanson & Hildebrand, 2011) to 5 percent (Baldock et al., 2006) to 8 percent (Molnar et al., 2013b) to close to 20 percent (e.g.,; Choi, Adams & Kahana, 2013; Meng & Siren, 2015; Molnar et al., 2013a), to about 60 percent (Ball et al.,1998). Self-reported avoidance rates for driving in unfamiliar areas vary from about 14 percent (Molnar et al., 2013b) to around 30 percent (Molnar et al., 2013a; Siren & Meng, 2013).

These differences in rates of reported self-regulation may be due to differences across studies with respect to the individual characteristics of participants (e.g., sex, age, living arrangements, health and functional status), their driving patterns and the social and cultural context within which their driving takes place, and the extent to which 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, as well as the methods used to examine self-regulation and how self-regulation is defined and measured. For example, in a study of 246 older drivers in Australia, 22 percent reported that they tried to avoid driving at night (Molnar et al., 2013a). However, when motivations for this nighttime driving avoidance were taken into account, the proportion of the sample considered to be self-regulators dropped to 16 percent. Across all strategic avoidance situations, taking motivations for avoidance into account had varying effects depending on the driving situation. For most situations, the majority of avoiders were ultimately classified as self-regulators. However, after taking motivations into account for a few driving situations, over 50 percent of avoiders did not qualify as self-regulators (driving on busy roads, driving in rush hour traffic, planning out route ahead of time).

Tactical self-regulation

Few studies, at least until recently, have looked at tactical self-regulation. Tactical self-regulation, in various forms, has been the focus of several recent studies (e.g., LeBlanc, Bao, Sayer & Bogard, 2013; Charlton, Catchlove, Scully, Koppel & Newstead, 2013; Fofanova & Vollrath, 2011, 2012; Molnar et al., 2013a, 2013b; Reimer et al., 2013; Siren & Meng, 2013). For example, Fofanova and Vollrath (2012) conducted face-to-face interviews with a German sample of 205 older drivers and 209 middle-age drivers about their engagement in distracting activities during the last half hour of the driving trip (with over 90 percent of trips being less than half hour). The two most frequently reported activities among both groups were interaction with passengers and using in-car devices. The older driver group was less likely to report using an in-vehicle device, self-initiated internal tasks, eating or drinking, or smoking related tasks. None of the older drivers reported clothing/grooming or using a mobile phone or add-on device. They noted that their findings were consistent with earlier studies. In particular, Lerner (2008) examined drivers' willingness to engage in various secondary tasks while driving including eating, drinking, performing different functions with a mobile phone or navigation system. He found that in general, older (age 60 and older) and middle-age drivers (age 25-59) expressed less

willingness than younger drivers (age 16-24) to use in-vehicle technologies.

In structured telephone interviews with 888 Danish drivers age 75 and older, 50 percent of respondents reported that they avoided listening to the radio whenever possible while driving (Siren & Meng, 2013).   Of 17 overall self-regulatory behaviors asked about, this was the fourth overall avoidance situation reported (surpassed only by feeling unwell, when tired, and when it is slippery) and was more prevalent than avoiding driving when it is dark (40 percent). The two other tactical self-regulatory behaviors asked about were avoiding having conversations while driving (close to 35 percent) and avoiding overtaking (30 percent).

Charlton, Catchlove, Scully, Koppel and Newstead (2013) reported findings from a naturalistic study of 10 older drivers (collectively taking 371 trips) to identify secondary tasks or activities engaged in at intersections. The most frequently observed activities were scratching/grooming (43 percent), talking/singing (30 percent), and manipulating the vehicle control panel (12 percent). Drivers were less likely to engage in secondary activities under challenging conditions – that is, at uncontrolled intersections and when the car was moving. The authors concluded that this selective engagement in secondary activities according to roadway and driving situations supports the idea that "older drivers self-regulate by limiting their engagement in secondary activities when the driving task is more challenging compared with less demanding situations" (p.277).

Molnar et al. (2013a) surveyed 246 older drivers from a convenience sample in Australia, asking whether they tried to avoid a number of in-vehicle distractions while driving and if so, why. After taking into account motivations for avoidance (i.e., including only avoidance associated with common self-regulatory motivations), they found the following rates of tactical self-regulation: avoiding reading a map (41 percent); avoiding talking on a mobile phone (37 percent); avoiding eating (34 percent); avoiding personal grooming (24 percent); avoiding chatting with passengers (14 percent); and avoiding changing radio stations (10 percent). Thirty-six percent of study participants also reported self-regulating by leaving more room between their car and the car ahead of them than they used to. These rates point to the variability of self-regulation across specific driving situations that have been found for strategic self-regulatory behaviors. Across all tactical driving situations, self-regulators comprised about 28 percent.

The self-regulatory practice of accepting greater headways was examined in another naturalistic driving study of drivers, in this case, with drivers who had an integrated crash warning system in their vehicle (LeBlanc, Bao, Sayer & Bogard, 2013). Drivers were categorized as younger (age 20-30), middle-age (age 40-50), and older (age 60-70). Study findings indicated age-related self-regulation behavior when other vehicles were being followed, with older drivers tending to leave more space between their vehicle and the vehicle ahead than other age groups; that is, they maintained a safer distance when following other vehicles.

Another potential marker of tactical self-regulation relates to lane changing behavior. Reimer et al. (2013) used instrumented vehicles in actual highway conditions to examine lane choice and changing among a sample of 106 drivers age 20-29, 40-49, and 60-69, under varying levels of cognitive load. Drivers in the oldest age group drove at slower speeds and

were less likely to drive in the left-most lane than others, and were significantly less likely to make a lane change than middle-age drivers. The authors characterized these behaviors among older drivers as adopting a generally more conservative driving style but cautioned that they could have resulted from basic saturation of the drivers' cognitive capacities leading to limited engagement in other activities rather than intentional self-regulation of driving.

Findings from a simulator study of 10 older drivers and 10 middle-age drivers also provided some support for tactical self-regulation among older adults as measured by lane changing behavior (Fofanova & Vollrath, 2011). When engaging in a lane change task, the older adults appeared to maintain their performance by focusing their attention on that task and abandoning any secondary tasks.

Driving at slower speeds was identified as a way that older drivers may compensate for age-related deficits in a driving simulator study by Trick, Toxopeus and Wilson (2010). According to the authors, the 34 older adults in the sample reduced their driving speed substantially to compensate for poor visibility and navigational challenges, which had the effect of negating the impact of these variables in collisions and hazard response. There was also a tendency for drivers with worse scores on tests of sensory or attentional function to decrease their speeds more in the face of diving challenges.

Life-goal self-regulation

A study by Molnar et al. (2013a) was the first to examine life-goal self-regulation. Their exploratory study of life-goal self-regulation was part of a larger driving study using a convenience sample of 246 Australian drivers (Molnar, 2013; Molnar et al., 2013b). Findings indicated that few participants in this sample reported engaging in such practices (e.g., moving to a new location to be closer to common destinations or to have other additional options for getting around, buying a new car for safety-related reasons, starting an exercise or fitness program to help maintain driving skills). The authors speculated that because life-goal self-regulatory practices involve important decisions that affect many aspects of a person's life (of which driving is just one part), many people may not be prepared to face those decisions when they still consider themselves to be relatively high functioning, as was the study sample. However, more older adult communities are being established that provide transportation options and it is possible that life-goal self-regulation may become more common in the next few decades as our population continues to age.

Factors Associated with Self-Regulation

<u>Sociodemographic factors</u>

The two most commonly studied demographic factors examined within the context of self-regulation have been sex and age, and to a lesser extent household composition (or living status). These are highlighted below, along with a few other individual factors that have received limited attention in the literature.

Sex: Older women have been shown to self-regulate their driving more than older men and the evidence continues to grow (e.g., Charlton et al., 2006; Choi, Adams & Kahana, 2013; Classen, Wang, Crizzle, Winter & Lanford, 2013; D'Ambrosio, Donorfio, Coughlin, Mohyde & Meyer, 2008; Hakamies & Blomqvist, 1998; Kostyniuk & Molnar, 2008; Naumann, Dellinger & Kresnow, 2011; Rosenbloom, 2009; Rosenbloom & Santos, 2014; Sengupta et al., 2014; West et al., 2003). These findings are also consistent with evidence of a sex effect in driving cessation (as opposed to driving self-regulation), with a number of studies showing that women are more likely to be non-drivers or former drivers than men (e.g., Choi & Mezuk, 2012; Mezuk & Rebok, 2008) and that they have a higher probability of stopping driving when studied over time (Choi, Mezuk, Lohman, Edwards & Rebok, 2012).

There are, however, several studies that do not support the higher rates of self-regulation among older women (e.g., Blanchard & Myers, 2010; Gwyther & Holland, 2012; Molnar, Eby, Roberts, St. Louis & Langford, 2009, Ross et al., 2009; Unsworth, Wells, Browning, Thoman & Kendig, 2007). For example, while women, overall, were more likely than men to report avoidance of various driving situations among a sample of adults age 18 to 78, this relationship was only supported for younger and middle-age participants, not older participants (Gwyther & Holland, 2012). Similarly, in a study of the five-year driving habit trajectories among a sample of older adults, Ross et al. (2009) found that being female was 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). Findings from logistic regression analyses by Unsworth et al. (2007) indicated that men and women were equally likely to report modifying their driving, although women were more likely to report giving up driving altogether, taking into account individual health and vision problems.

In trying to explain these mixed findings on the relationship between sex and self-regulation, Kostyniuk and Molnar (2008) pointed to the important mediating role that perceived confidence in various driving situations might play. They also suggested that the driving behaviors of future cohorts of women might be more like those of men, to the extent that their life-long driving experience contributes to increased confidence in driving. This line of thinking is consistent with other studies in which some type of confidence variable was added in the analyses, resulting in decreasing the effects of such factors as sex and age in explaining driving avoidance (e.g., Charlton et al., 2006). It is also consistent with study findings that driving cessation among women with an active driving history was more similar to men's driving cessation, pointing to the importance of personal driving history rather than sex per se in decisions about stopping driving (Hakamies-Blomqvist & Siren, 2003). Although Unsworth et al.'s (2007) finding that women were more likely than men to stop driving is not consistent with these conclusions, their study did not appear to explicitly control for personal driving history.

Age: Findings from studies examining the effects of age on self-regulation have been mixed. Some studies support the conclusion that self-regulation increases 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). However, other studies have not supported this (e.g., Blanchard & Myers, 2010; Molnar, Eby, Roberts, St. Louis & Langford, 2009; Molnar et al., 2014). As noted in our earlier reviews, these mixed results may have been due to differences in study design such as differences in the age groups and ranges included in the sample, or other factors such as

differences in how self-regulation is operationalized and the extent to which motivations for avoidance are taken into account. Motivations for avoidance can be quite different for young and old adults; thus, it is not clear if studies including older and younger drivers are really getting at actual self-regulation across all age groups. Age is also likely to be associated with a number of factors that can also influence self-regulation including medical illness. For example, Gwyther and Holland (2012) found that self-regulation increased with age after they controlled for driving experience. Donorfio, D'Ambrosio, Coughlin and Mohyde (2008b) found that drivers tended to self-regulate more with age, but the effect became more pronounced as health status declined, thus pointing to the important interactions between age and health in self-regulatory decisions. Although the ability to recognize such interactions is enhanced by a longitudinal study design, most studies of self-regulation to date have been cross-sectional.

Household composition/living arrangements: Study results on the effect of household composition/living arrangements have been mixed. Some studies have found an association with self-regulation (Betz & Lowenstein, 2010; Braitman & McCartt, 2008; Choi, Adams & Kahana, 2013). For example, Betz and Lowenstein (2010) analyzed data from a national telephone survey and found that drivers who lived alone were more than twice as likely to report self-limiting their driving (as measured by tending to avoid driving in bad weather, at night, in congested traffic, on long trips, or on highways or high-speed roads). Choi, Adams, and Kahana (2013) also found that older drivers who lived alone were more likely to report modifying their driving by avoiding driving at night or on the highway. Other studies have not found an association between living arrangements and self-regulation (e.g., Ragland, Satariano & MacLeod, 2004). Household composition and living status are often intermingled with factors related to family and social support for transportation – these latter factors are addressed in the section on enabling factors and barriers to self-regulation later in the paper.

Other individual factors: Other individual factors that have been examined, albeit on a limited basis, and found to be associated with at least some self-regulatory driving behaviors include: negative attitudes toward driving (Tuokko et al., 2014); poor sense of direction or wayfinding abilities (Bryden, Charlton, Oxley & Lowndes, 2013; Turano et al., 2009); income (with self-regulation and income found to be inversely related; Rosenbloom & Santos, 2014). Gwyther and Holland (2012) identified anxious driving style and negative affective attitudes as independent predictors of self-regulation in a questionnaire study of 395 drivers, with results suggesting an association between anxiety and over-regulation. In more recent work by the authors (Gwyther & Holland, 2014), the association between feelings of vulnerability and driving behavior was explored through focus groups with 48 drivers age 18-75. Older participants were most likely to report that they felt vulnerable at night (in terms of getting into a crash rather than personal security).

Health and functioning factors

Overall health and functioning can be influenced by a host of medical conditions, particularly chronic medical conditions such as cardiovascular disease, dementia, arthritis, diabetes mellitus, stroke, glaucoma, cataract, and chronic pain (Anstey, Wood, Lord & Walker, 2005). However, the relationship between medical conditions and actual driving is complex. For example, in a systematic review on the effects of multiple chronic conditions on driving ability, Marshall and Man-Son-Hing (2011) identified two studies (Forrest,

Bunker, Songer, Coben & Cauley, 1997; Vance et al., 2006) suggesting that driving avoidance and self-restriction are each correlated with increasing number of medical conditions. In their overall study conclusions however, the authors cautioned that the myriad combinations of diseases with associated varying severity present a level of complexity that currently makes it very difficult to provide clear and relevant information to inform decisions relative to driving with multiple medical conditions. Rosenbloom and Santos (2014) analyzed data from two national surveys (National Household Travel Survey and National Health and Aging Trends Study) and found that the majority of people with medical conditions reported reducing their daily travel, and many restricted their driving to daytime hours. However, as noted by the authors, both surveys have limited information on medication use and therefore make it difficult to fully understand the complex relationship between health and self-regulation.

One reason for the complex influence of medical conditions on driving is that the medications used to treat various medical conditions can affect not only the disease and its symptoms but also driving. In addition, there are a host of other factors that may intervene or have confounding effects. For example, in a study of 928 active older drivers in Canada, subclinical sleep disturbances did not affect self-reported driving frequency, avoidance, or perceived abilities (Hickey et al., 2013). Rather, the driving behaviors of interest were better explained by mediating demographic, health, and cognitive factors. Collectively, these findings suggest that it is not medical conditions per se that affect driving but rather the resulting impact they have on functional abilities. Therefore, this review focuses on the effects of functional impairments on self-regulation rather than the effects of medical conditions per se.

Visual impairment: As people age, they undergo anatomical changes in vision, some of which result from diseases that become more prevalent with aging and some of which result from the aging process itself (Gruber, Mosimann, Muri & Nef, 2013). These changes may compromise safe driving because of the critical role that vision plays in the driving task (Owsley & McGwin, 2010). A number of studies have explored the effects of visual impairment on driving in general and more specifically driving self-regulation. In fact, visual impairment has been arguably the most frequently studied functional decline vis-à-vis self-regulation among older drivers.

Findings from many studies support an association between visual impairment and increased self-regulation (e.g., Ball et al., 1998; Charlton et al., 2006; Choi, Adams & Kahana, 2013; Fraser, Meuleners, Ng & Morlet, 2013; Lotfipour et al., 2010; Sengupta et al., 2014; Unsworth, Wells, Browning, Thomas & Kendig, 2007; West et al., 2003). For example, in a study by Ball et al. (1998), individuals with clinically-determined visual and/or attentional impairments reported avoiding several challenging situations, while those with impaired mental status did not appear to engage in self-regulation. Similarly, findings from a study by Charlton et al. (2006) indicated that self-reported vision problems were associated with driving avoidance. The latter study used a telephone survey to examine the prevalence and type of self-regulation among drivers age 55 and older in Victoria, Australia.

Findings from work by Lotfipour et al. (2010) indicated that poor vision as measured by the Snellen Visual Acuity Test and Visual Function Index was correlated with self-reported voluntary driving restrictions. Fraser et al. (2013) found that among 99 bilateral cataract

patients awaiting surgery, those who reported self-regulating their driving (avoiding at least one challenging situation because of their vision) had significantly poorer contrast sensitivity (ability to detect differences in contrast between an object and its background) than those not reporting self-regulation.

More recently, van Landingham and her colleagues (2013) found that drivers with glaucoma were more likely to have ceased driving at night than a comparison group. The glaucoma group also reported a greater mean number of driving limitations overall (e.g., not driving beyond the neighborhood, in the rain, in unfamiliar areas). Driving limitations were also more common among those with severe visual field loss, demonstrating greater driving limitations with increasing disease severity. However, to get at driving limitations, study participants were asked whether they had performed the particular driving activities at all during the time frame of interest, not whether they avoided the activities or were prohibited legally from doing them.

Some of these same investigators examined the effects of central visual loss on driving restrictions in a sample of 64 adults with bilateral visual loss or severe unilateral visual loss from age-related macular degeneration (AMD) and normally sighted controls age 60-80 (Sengupta et al., 2014). They found that drivers with AMD-related vision loss were more likely to report avoiding driving over longer distances beyond one hour, at night, and in unfamiliar conditions. Self-regulation was greatest among those with more severe visual acuity and contrast sensitivity.

Contrast sensitivity impairment also emerged in another recent study as a predictor of self-regulation, as measured by reduced driving exposure (Sandlin, McGwin & Owlsey, 2014). Among a population-based sample of older adults age 70 and older, drivers with impaired contrast sensitivity reported less annual mileage and a lower number of places and trips driven per week than drivers with normal contrast sensitivity, even after adjusting for other factors including cognitive status. However, visual acuity deficit was not associated with any reductions in driving.

Not all studies support an association between visional impairment and increased self-regulation. Some studies have found that relatively large proportions of drivers with visual impairment do not appear to self-regulate appropriately (e.g., Okonkwo, Crowe, Wadley & Ball, 2007; Stalvey & Owsley, 2000). For example, Stalvey and Owsley (2000) examined self-regulation among a sample of drivers age 65 and older defined as high risk (i.e., having visual acuity and/or visual processing deficits, a high level of driving exposure, and a history of crash involvement). Findings from a telephone survey administered to these participants indicated that most of them 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. Finally, following up with older drivers who had been interviewed about self-regulation five years earlier, Baldock, Thompson and Mathias (2008) found few changes in self-reported driving confidence and avoidance of difficult driving situations despite the finding that participants had worsening visual acuity and contrast.

Psychomotor impairment: The effects of physical mobility measures on self-regulation have been less studied than other areas of functioning and findings are inconclusive. Braitman and Williams (2011) examined changes in self-regulation of driving over a three-year period

in a longitudinal sample of 12,650 older drivers in three states in the US (with 1,437 completing the full complement of four surveys). They assessed physical mobility using three items measuring the capacity to do certain activities such as turning one's head or climbing up and down a flight of stairs. Participants with worsening physical mobility were found to self-regulate their driving by avoiding more driving situations, although changes over time were modest. The authors noted that sample attrition and the relatively short study period may have contributed to the modest changes over time.

Physical functioning (relative to lower extremity function and falls) was unrelated to self-reported driving avoidance or exposure in a study by Vance et al. (2006). The authors used structural equation modeling techniques to analyze data from 815 drivers age 55 and older interviewed by telephone about their health and mobility three to six months following an in-person assessment. Lower extremity function was measured by a composite variable averaging scores for two clinical tests assessing lower limb mobility (Rapid Pace Walk and Foot Tap). The authors surmised that the lack of a relationship between physical functioning and driving habits may have been due to the restricted age range in the sample or the possibility that the measures of lower limb mobility did not fully capture physical functioning.

Molnar et al. (2014) also used the Rapid Pace Walk as a possible predictor of self-regulation, but as a stand-alone measure of general mobility rather than in combination with the Foot Tap or other measures. They reported study findings from the first year of a longitudinal cohort study of 246 older drivers in Australia. Results of a series of multivariable regression models indicated that poorer performance on Rapid Pace Walk was associated with greater strategic self-regulation but not tactical self-regulation. Strategic self-regulation was also influenced by self-reported ability to climb two flights of stairs and walk one kilometer, but in the opposite direction. That is, greater strategic self-regulation was associated with higher self-reported ratings of physical functioning. The authors attributed this latter finding to the possibility that participants who are still mobile but lack transportation options may have heightened awareness of the need to actively manage their driving to extend the period over which they can drive. These participants do this through a gradual process of self-regulation.

Cognitive impairment: While many of the earlier studies on functional decline tended to focus on visual impairment, there has been a proliferation of studies on cognitive impairment and self-regulation. Findings from these studies have been mixed, however. Several studies have found that many drivers with cognitive impairment such as dementia do in fact restrict their driving or stop driving altogether within a few years (e.g., Adler, 2010; Drachman & Swearer, 1993; Festa, Ott, Manning, Davis & Heindel, 2013; Ross et al., 2009; Talbot et al., 2005; Vance et al., 2006). For example, cognitive deficits, as measured by poorer scores on the Useful Field of View (UFOV) test (an assessment tool of visual attention), have been found to be associated with decreased driving exposure or increased driving avoidance in at least two studies (Ross et al., 2009; Vance et al., 2006).

In a more recent study, Festa, Ott, Manning, Davis, and Heindel (2013) analyzed in-car video recordings from a naturalistic driving study of 18 participants with Alzheimer's disease and 20 age-matched controls to identify self-regulatory driving behaviors among the two groups. Both groups had been deemed "safe" to drive, based on a standardized road test. One of the strengths of the study was that it was able to characterize the driving

behavior based on data representing participants' real life driving. Both groups limited their driving to conditions that minimize risk including daytime hours, absence of passengers, sunny weather, light traffic, and residential rather than commercial environments. However, self-regulation was higher among the Alzheimer's disease group than the control group, with the exception of daytime hours and no passengers. The authors attributed the self-regulation to an awareness of clinical diagnosis rather than impaired driving per se, but cautioned that the increased restrictions observed among the Alzheimer's group could have been imposed by a caregiver rather than resulting from participants' own awareness and subsequent intentional decision to self-regulate. This highlights the importance of knowing people's motives for driving modifications so that meaningful interpretation of the data can be made.

The role that family members and caregivers can play in imposing driving restrictions on older drivers was highlighted in findings from focus groups of adult children of older drivers (Connell, Harmon, Janevic & Kostyniuk, 2012). Some participants described a process of negotiating options with their parent or taking a more direct approach by establishing specific guidelines and rules. In the words of one adult child, "And my husband sat him down and gave him a list of ten rules….One of them was that he couldn't drive outside town anymore" (p. 981).

In a recent study by Mauri, Sinforiani, Cuzzoni, Bono and Zucchella (2014) of 198 current and former drivers with dementia, structured interviews were conducted with participants with the assistance of their caregivers. Most participants were still driving and many (30-65 percent) reported having modified their driving in some way (e.g., reducing time or mileage, avoiding driving at night and during rush hour, staying with familiar routes). Driving restriction increased with age and increasing worsening of cognitive functioning. However, participants' own ratings of their driving ability were significantly higher than corresponding ratings from their caregivers, and caregivers played a key role in the decision to adopt self-regulatory behaviors.

Given the important role that cognition plays in recognizing the need for driving modification, one might expect that impaired older drivers would lack insight into the need to regulate their driving in response to their declining abilities. Findings from structured face-to-face interviews with 25 cognitively impaired older drivers (Meng, Siren & Teasdale, 2013) provide some support for this. While the cognitively impaired older drivers did recognize cognitive problems, they did not feel their driving was affected. In addition, driving-related discomfort played a role in self-regulatory behavior, but it was less clear what triggered this feeling among the driver group. The authors concluded that "while older drivers in general show good self-monitoring skills, cognitively impaired older drivers may show less reliable self-monitoring skills and a different pattern of change in their driving skills" (p.159). Findings from earlier work by the authors with a general sample of older drivers representing a range of cognitive functioning indicated that older drivers who recognized problems with cognitive functions were able to realistically assess changes in their driving skills, and that driving-related discomfort was an important factor affecting self-regulation and appeared to function as an indirect monitoring of their driving ability (Meng & Siren, 2012).

In another cross-sectional analysis of data from a large national cohort of 928 healthy older drivers in Canada, Rapoport et al. (2013) found statistically significant but only modest

associations between completion times on the Trail Making Test (a widely used cognitive test measuring psychomotor speed, mental flexibility, and executive functioning) and driving avoidance. The authors suggested that the modest nature of the associations may have been due to the fairly minor degree of cognitive impairment in the sample as a whole, potential reduced self-awareness of driving capabilities among those with cognitive impairment, or a combination of both.

Other studies have also found either weak associations between cognitive function and self-regulation or no evidence at all that older drivers with cognitive impairment restrict their driving (e.g., Baldock et al., 2008; Betz & Lowenstein, 2010; Braitman & Williams, 2011; Charlton et al., 2006; Kowalski et al., 2012; O'Connor, Edwards & Bannon, 2013; Ragland et al., 2004; Sandlin et al., 2004; Wong, Smith & Sullivan, 2012). For example, factors associated with cognitive function (memory, confusion, or concentration) were not frequently mentioned as reasons for restricting driving in some self-report studies (e.g., Betz & Lowenstein, 2010; Ragland et al., 2004). Although results from a longitudinal cohort study indicated that older drivers with worsening memory avoided more driving situations, changes during the three-year period were modest (Braitman and Williams, 2011). Okonkwo et al. (2007) found that rates of reported nighttime driving avoidance did not differ between high and low risk drivers. However, the high risk drivers (defined based on an objective measure of visual attention from which crash risk was estimated) reported more driving avoidance overall. In another study, declines in visual attention did not lead to increased driving avoidance (Baldock et al., 2008).

O'Connor, Edwards and Bannon (2013) examined not only older adults with mild dementia and those with normal cognition, but also those with mild cognitive impairment (MCI; considered to be a transitional syndrome between normal cognition and dementia) to assess self-regulatory behavior. Findings provided some evidence that MCI and dementia participants avoided a small number of specific situations significantly more than participants with normal cognition. However, large proportions of each group still drove frequently, suggesting that either they were still competent to drive, or able to recognize declining abilities and modify their driving in some challenging situations, or conversely, that they lacked insight into their declining capabilities.

In a cross-sectional study examining the influence of cognitive impairment on driving status and driving habits and intentions, Kowalski et al. (2012) classified 215 participants into three cognitive status groups based on performance on five cognitive benchmark measures. The groups ranged from cognitively intact to mildly impaired but not yet demented. Among current drivers, there were no differences between the cognitive groups in terms of driving reduction, preference not to drive in or restricting driving in certain driving situations, or average number of driving restrictions. In addition, none of the current drivers, regardless of cognitive status, were thinking of restricting or stopping driving in the near future.

In a recent study by Wong, Smith and Sullivan (2012), the relationship between self-regulation, driving confidence, and cognitive ability (measured by the Clock Drawing Test) was explored among a convenience sample of 72 older drivers in Australia. Findings indicated that participants who failed the Clock Drawing Test were significantly less likely to report self-regulating their driving, compared to those who successfully completed the test. Regardless of their outcome on the test, participants in the study reported good health

and driving abilities, confidence in their driving across a range of challenging situations, and similar intentions to continue driving.

All of the studies described above focused on some type of strategic self-regulatory behavior as their outcome variable. Adrian, Postal, Moessinger and Charles (2010) studied the implications of cognitive functions (and personality traits), as well as age and sex effects on "tactical compensation" which they described as "adaptive regulations while driving that become relevant in complex situations involving high mental or physical demands" (p. 3). A total of 126 drivers from age 20-82 drove a road course and completed several cognitive and personality assessments. Findings indicated that older drivers had lower mean road speeds than younger drivers and following distance increased with age. However, as a group, older women did not engage in tactical self-regulation, with older women driving faster with shorter following distances than older men. There were individual differences between men and women who did engage in tactical self-regulation, with the women having lower scores on some cognitive tests measuring attentional and executive processes, and the men having higher scores on measures of externality (versus internality which has been associated with overconfidence and optimism bias; Ozkan & Lajunen, 2005) and avoidance coping.

Researchers have suggested that the lack of significant effects for many cognitive-functioning variables may be due to limited numbers of participants with impairment in many samples and varying definitions or samplings of the degree, severity, or type of cognitive impairment. Results may also reflect some individuals' lack of insight into their cognitive limitations and the impact such limitations can have on crash risk (Betz & Lowenstein, 2010). Lack of insight into declining abilities is addressed more fully in the next section; however, it is important to highlight its contribution to the complexity of the relationship between cognitive functioning and self-regulation. As some forms of progressive dementia (e.g., Alzheimer's disease) evolve, it is likely that individuals will increasingly lack awareness or insight into their cognitive deficits, thus undermining their ability to self-regulate (e.g., Carr, Meuser & Morris, 2006; Cotrell & Wild, 1999; Gil et al., 2001). The reason for this is that dementia not only affects cognitive abilities related to driving (e.g., memory, executive functioning, visuospatial skills) but also abilities necessary to benefit from self-regulation and planning for driving transition and cessation (e.g., insight, reasoning). Support for this comes from studies demonstrating worse driving performance among drivers with dementia than among drivers without cognitive impairment (Man-Son-Hing, Marshall, Molnar & Wilson, 2007) and those suggesting that drivers with dementia do not change their driving behaviors even after a crash (Lucas-Blaustein et al., 1988).

Clearly, drivers with progressive dementia will have to stop driving eventually (Croston, Meuser, Berg-Weger, Grant & Carr, 2009). However, at least in the early stages of the disease, driving safety may not be seriously compromised, as suggested by a naturalistic driving study that monitored drivers with early-stage dementia (Eby, Silverstein, Molnar, LeBlanc & Adler, 2012). Studies have shown that up to 45 percent of individuals with dementia may still drive (e.g., Carr, Jackson & Alquire, 1990; Logsdon, Teri & Larson, 1992). Increasing research attention is warranted, particularly given our gaps in knowledge about whether older drivers with early cognitive decline or very mild dementia have insight into any impairments in their driving related abilities and have the capability to self-regulate their driving (Kowalski et al., 2012).

Awareness and insight

Evidence continues to build in the literature that awareness of and insight into declining functional abilities is a necessary first step in driving self-regulation (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). Pachana and Petriwskyj (2006) noted that the terms awareness of deficits, insight, anosognosia, self-awareness, and ability to self-monitor are often used interchangeably in this literature.

Based on review of the literature on cognitive, sensory, motor, and physical factors associated with safe driving, Anstey et al. (2005) concluded that it is individuals' awareness of, insight into, and self-perceptions about their abilities that influence their decisions to drive in challenging situations such as peak travel times and nighttime driving, or adverse weather conditions. Further, they suggested that accurate self-monitoring of functional ability and driving capacity is necessary for safe driving and lack of insight may be a risk factor for poor driving performance and crash risk.

More recent work by some of these same investigators addressed the issue of how accurate drivers' self-monitoring might be with regard to one specific aspect of driving ability – hazard perception – and how this might affect self-regulation (Horswill, Anstey, Hatherly, Wood & Pachana, 2011; Horswill, Sullivan, Lurie-Beck & Smith, 2013). Horswill et al. (2011) studied 307 older drivers and found that confidence ratings for performance on a hazard perception test as well as self-ratings of driving ability predicted self-reported self-regulation or preferences for self-regulation of driving. However, they also found that participants' self-monitoring judgements on hazard perception performance had little or no correspondence to objective measures of hazard perception skills, suggesting that self-regulation was driven by other factors. These findings point to the importance of being able to self-monitor accurately to ensure that self-regulatory behavior is appropriately matched to driving abilities. Horswill et al. (2013) alluded to this in their follow-up study with similar results. They concluded that "relying on older drivers to self-regulate their driving to offset age-related declines could be problematic because these drivers (like all drivers) have little insight into their own driving ability, given that some level of insight is required for effective self-regulation" (p.135).

Personality factors might also influence peoples' self-perceptions about their driving ability. For example, McPeek, Nichols, Classen and Breiner (2011), using a convenience sample of older drivers, found preliminary evidence that participants identified as having a "sensing" preference (more likely to attend to facts and data perceivable by the five senses) on the Meyer Briggs Type Indicator Instrument, were more likely to exhibit self-bias than those with a preference for Intuition (organizing perceptions in terms of patterns, relationships, and possibilities beyond the immediate). The authors noted that such self-bias serves to undermine one's awareness of limitations in abilities.

The findings relative to insight and awareness 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. Similarly, Carmel et al. (2013) found support for the argument that self-

limitation of driving is more often an outcome of drivers' subjective evaluations of their capability to drive than objective functioning. As noted by Molnar (2013), these conclusions are consistent with the broader health behavior change literature, including: Strecher, DeVellis, Becker, and Rosenstock (1986) who argued that behavior is influenced by individuals' perception about their capabilities and not necessarily their true capabilities; and Bandura (1977) who argued that individuals' expectations about their ability to execute or engage in a behavior are a function of their perceived rather than actual capabilities, and that it is these perceptions that influence behavior.

There have been several promising efforts to increase awareness and insight among older drivers through feedback and other information, with the goal of encouraging or facilitating appropriate self-regulation (e.g., Ackerman et al., 2010; Eby, Molnar, Shope, Vivoda & Fordyce, 2003; Holland & Rabbit, 1992; Jones, Cho, Abendschoen-Milani & Geilen, 2011; Molnar, Eby, Kartje & St. Louis, 2010; Owsley, Stalvey & Phillips, 2003; Porter & Tuokko, 2011; Tuokko et al., 2007). For example, Ackerman et al. (2010) examined the impact of feedback on self-rated driving ability and self-regulation among a sample of 129 community dwelling older drivers. The feedback had to do with whether participants qualified for the discount, based on their performance on the Useful Field of View test. Failure to qualify was a significant predictor of increased driving avoidance over a three-month period but not of lower self-rated driving ability or reduced driving exposure. Holland and Rabbit (1992) also found that providing feedback on clinical results of functioning was associated with self-reported changes in driving to avoid challenging situations.

Approaches for giving feedback often rely on self-screening and/or more general education programs. For example, Owsley et al. (2003) assessed the effectiveness of an educational curriculum for older drivers at high risk of crashing due to vision impairment, previous recent crash involvement, and high frequency of driving. These drivers were more likely to rate their vision as less than excellent and report avoidance of visually challenging driving situations than a control group.

Rosenbloom (2009) reported on the effects of three safety education and training interventions that emphasized the value of different types of self-regulation mechanisms. She examined the extent to which participation in the programs resulted in more self-regulation one year later in response to driving problems. Results were quite mixed. Across the three interventions, participants in the intervention group were more likely to self-regulate than members of the control group for some of the problem situations presented but less likely for others, although results did suggest differing impact by intervention.

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.

Health motives or motivational dispositions toward health have also been examined with regard to whether intentions to self-regulate behavior were translated into action plans by a sample of older adults (Schüz, Wurm, Warner, Wolff & Schwarzer, 2014). The study

focused on physical activity as a self-regulatory behavior. Findings suggested that health motivations (operationalized as the importance of health relative to other domains) moderated the degree to which the effects of intentions on behavior are mediated by planning. Specifically, health motives determined how well intentions were translated into plans but not how well plans predicted behavior. The authors pointed out the significance of their findings for not only research on physical activity but also on practical interventions aimed at changing health behavior more generally.

<u>Driving confidence and comfort</u>

As noted by Hassan, King and Watt (2015), "the age-related declines in peoples' visual/sensory, motor, or cognitive functions are often subtle and gradual which can make it difficult for older people to draw the link between these changes and the impact on their driving ability" (p. 27). This points to the potentially important role of driving comfort as a mediating factor in self-regulation, especially for mild and gradual loss in functional abilities.

One of the most consistent findings in the literature has been that perceptions of confidence or comfort in specific driving situations are closely related 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; Molnar et al., 2013a, 2013b, 2013c; Rudman, Friedland, Chipman & Sciortino, 2006; Siren & Meng, 2013). This finding has persisted regardless of how confidence or comfort is measured. In a study by Baldock et al. (2006), older drivers appeared to self-regulate in a manner consistent with driving ability, measured by an on-road driving test, but only for a small number of specific situations in which they have low confidence and that they were most able to avoid (i.e., driving in the rain, driving at night, and driving at night in the rain). 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-reported self-regulation across various driving situations. Use of the DCS in a longitudinal cohort study of 928 drivers in Canada led to the finding that greater comfort with driving during the day and night was associated with less avoidance of challenging driving situations (Jouk et al., 2014). Results from other work using the DCS along with objective driving data from in-car recording devices indicated that lower comfort was significantly related to lower exposure in general and at night, average and maximum radii from home, and driving in challenging situations (Blanchard & Myers, 2010).

Siren and Meng (2013) conducted structured telephone interviews with 840 Danish drivers age 75 and older and found that feelings of discomfort (operationalized as how unpleasant driving was in a particular situation) varied across driving situations and were more likely to be reported for driving situations related to internal states or adverse conditions than complex roadway infrastructure. Significant linearity between feelings of discomfort and avoidance was found for many of the 17 driving situations presented to respondents, most notably, listening to the radio while driving, driving when it is dark, motorway/highway driving, driving when it is slippery, and having conversations while driving.

Driving-related discomfort was also found to function as an indirect self-monitoring of driving ability (Meng & Siren, 2012), providing evidence that driving discomfort may have

indirect as well as direct effects on self-regulation. Indeed, the authors make this argument, stating that "functional decline may lead to self-regulatory behaviour through a mere feeling of discomfort in challenging driving situations. In other words, the driver's self-regulation may not be a response to deliberate evaluation or monitoring of driving ability, but rather a response to a more abstract feeling such as discomfort in challenging situations" (p. 323). They go on to say that "if cognitive or other functional decline is associated with driving-related discomfort, and driving-related discomfort is associated with self-regulation of driving, the discomfort experienced might function as a type of indirect self-monitoring of driving ability and thus, be regarded as a form of awareness of changes in a person's own driving ability" (p. 323). This line of thinking is consistent with Molnar et al.'s (2013b) decision to classify individuals who reported discomfort as a motivation for driving avoidance as self-regulators.

Feelings of driving discomfort also appear to be mediated by other factors, although the research on antecedents of confidence in driving has been quite limited (Carmel, Rechavi & Ben-Moshe, 2014). Findings from a few earlier studies suggested that driving confidence was associated with cognitive performance (Anstey & Smith, 2003) and driving experience, as measured by frequency of and miles driven (Marottoli & Richardson, 1998). More recently, findings from a telephone survey of 1,053 older drivers in Michigan about driving-related concerns expressed by adult children indicated that participants whose adult children had expressed concern reported being less comfortable merging onto a busy freeway, driving 200 miles in a familiar area, and more likely to avoid driving in inclement weather (Kostyniuk, Molnar & Eby, 2009). Tuokko et al. (2013) reported that after controlling for age and sex, driving scores for driving comfort during the day and at night were significantly related to perceived health status (overall health and health symptoms such as pain, stiffness, limited strength in five body areas particularly relevant to driving) in a large cohort of 928 drivers in Canada.

Enabling factors and barriers to self-regulation

There are a host of what are often termed social and environmental factors that can potentially enable or inhibit the adoption of self-regulatory practices by older drivers. For example, it has been suggested that families can play a key role helping older drivers make decisions about appropriately self-regulating driving by talking with them about their concerns (Kostyniuk, Molnar & Eby, 2009). Families, friends, and others also play a direct role in providing transportation support, which can affect older drivers' decisions about whether to self-regulate their driving.

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. More recently, in focus groups of older adults, Hassan, King and Watt (2015) found that having a spouse or other family member to rely on for transportation facilitated the transition to non-driving, while having family members who relied on the older driver or living alone appeared to lead to extended driving. A related factor – feeling pressure from others to continue driving – was also found to be associated with engaging in more challenging driving situations in a longitudinal cohort study of 928 older drivers in Canada (Jouk et al., 2014).

Choi, Adams, and Kahana (2013) examined the impact of transportation support on self-regulatory behaviors (avoiding driving at night or on the highway) among 566 community dwelling older drivers living in retirement communities. They found that those participants reporting at least some transportation support from peers (e.g., peer friends or neighbors) were more likely to report avoiding driving at night or on the highway, after controlling for health status and other sociodemographic characteristics including sex. However, reported transportation support from a spouse or from family had no effect on self-regulation controlling for health status and other sociodemographic characteristics.

Molnar et al. (2014) also found an association between having transportation support and self-regulation but the direction of the association was reversed; however, their measure of such support included both family and friends. Analysis of findings from a series of multivariable models indicated that study participants who did not have friends or family to drive them were considerably more likely to restrict their driving across various strategic driving situations than those who had someone to drive them. One possible explanation for this finding was that participants without family or friends available to drive them had given more active consideration to self-regulation expressly because they were aware of their limited transportation options. Further research in this area is warranted.

Baldock et al. (2006) examined what he termed "regulatory self-efficacy" or the ease of avoiding difficult driving situations among a sample of Australian 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.

Carmel, Rechavi, and Ben-Moshe (2014) examined the effects of what appeared to be, at first glance, a similar variable termed driving-related self-efficacy (people's confidence in their abilities to confront various problems) on self-regulation among 860 Israeli drivers age 70 and older. Self-regulation was measured by both avoidance of difficult driving situations and voluntary cessation of driving. Results from structural equation modelling indicated that the self-efficacy variable had the strongest effect on self-regulation, accounting for 47 percent of variability. They also found that driving-related self-efficacy was predicted by age of driving onset, followed by self-assessed vision, and frequency of daily driving. However, it could be argued that their conceptualization of driving-related self-efficacy relates more closely to the concepts of driving confidence or comfort than to the concept of regulatory self-efficacy of Baldock et al. (2006).

There has also been interest in perceived barriers to self-regulation. Baldock et al. (2006) examined six such barriers (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). The most frequently reported barriers were lifestyle (i.e., a style of or preference for 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). Perceived barriers reported by older drivers in a US study (Stalvey & Owsley, 2000) were not too dissimilar with one notable exception. Lack of transportation was the most frequently mentioned barrier (70 percent), followed by unavailability of friends/family (57 percent) and lifestyle (54 percent). By contrast, only a quarter of the Australian drivers mentioned lack of transportation 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. In a Canadian study, the most frequently reported barriers 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; Blanchard & Myers, 2010). Perceived barriers were significantly associated with all objective measures of driving examined (e.g., distance, duration, number of trips, stops, days, driving at night) except radius from home.

Limitations of the Self-Regulation Literature

The ability to interpret findings and draw conclusions from the current literature on self-regulation by older drivers is often a challenge because of limitations in individual studies or the collective literature itself. First, self-regulation of driving is frequently operationalized as simply avoiding various driving situations without taking into account why individuals are avoiding those situations. However, as identified in this review, there are reasons for avoiding driving situations that have little or nothing to do with self-regulation. Without taking these reasons into account, it is likely that many older drivers are misclassified as "self-regulators" when in fact they are not.

Further underscoring this point are findings from two related papers on the psychometric properties of a particular instrument used to measure driving avoidance (the Driving and Avoidance Scale, DRAS). Sullman and Taylor (2010) and Taylor and Sullman (2009) found that the failure of the DRAS to assess reasons for driving avoidance was a significant limitation. Similar to findings presented earlier in this review, they noted that avoidance can be due to practical issues such as the price of gas or concern for the environment (the latter having been found to be associated with social desirability responding). Beyond the specific implications for this particular instrument, it seems that one way to address the concerns more generally would be to ask people about their specific motivations for driving avoidance as part of any instrument used for collecting these data before reaching conclusions about what constitutes self-regulation. As noted earlier, motivations related to awareness of specific functional impairments, as well as motivations related to more general feelings of driving discomfort should be considered as relevant to self-regulation.

Second, most studies examine a relatively narrow set of driving situations as a proxy for self-regulation. In addition, the situations investigated generally only relate to the strategic level of driver performance and decision-making. Further, even at this level, many important self-regulatory practices are ignored or understudied (e.g., combining trips to reduce driving demand, taking a practice run to familiarize oneself with the route). This would be less problematic if there was consistency in rates and the same factors came into play across specific driving situations. However, as indicated in this review, this is not the case. Findings highlighted in this review suggest considerable variation across not only strategic self-regulatory behaviors but also levels of self-regulation, with regard to both the rates of these self-regulatory behaviors and as importantly, the factors that influence them. Caution should be exercised in extending findings from one or a few driving situations too broadly.

Third, many of the studies identified in the review rely on a cross-sectional study design involving comparisons of participant characteristics and behaviors across different groups rather than following the same individuals over time to assess changes they may be undergoing, as is the case in a longitudinal design. When coupled with the reliance on convenience samples, as is the case in most studies of older drivers, generalizing study findings to the larger population of older drivers is often difficult. There is a need for future research on older driver self-regulation that endeavors to obtain greater randomness when selecting participants for research projects. One way to obtain this randomness is to start with a list of all older drivers in a population, such as can be obtained from licensing agency records and randomly selecting older adults to contact for participation.

Fourth, most studies of self-regulation rely on self-report by drivers. However, concerns have been raised by a number of researchers 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), and other measures related to self-regulatory driving practices. It is now 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, time, and other information (e.g., Grengs, Wang & Kostyniuk, 2008; LeBlanc et al., 2006; LeBlanc, Sayer, Winkler & Bogard, 2007, Porter & Whitton, 2002).

To date, only a small number of studies have 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; Molnar et al., 2013c; Myers, Trang & Crizzle,, 2011; Porter et al., 2015), with mixed results (see Molnar, 2013 for a review). Despite the promise of data collected through in-vehicle instrumentation, there are still challenges in interpretation, particularly when information about the context of the driving situation is unknown. For straightforward driving behaviors such as driving exposure, objective data may be superior to self-reports, although further empirical testing is needed. However, for better understanding the context of driving and broader concepts of decision making, there is an important role for self-report, particularly when used in conjunction with objectively-derived data. As suggested by Molnar et al. (2013c), self-reported data, when used in combination with objectively derived data, help to uncover motivations for objectively identified driving avoidance, as well as examine the extent to which drivers' behavior is in line with their intentions and the factors that might undermine translating intention into actual behavior.

Fifth, the increased research attention on self-regulation has come largely as a result of the promise such behavior seems to hold for extending the safe driving of older adults. Yet there is a paucity of research on the effects of self-regulation on actual crash risk and results among the few studies to date have been mixed (e.g., Ball et al., 1998; Ball et al., 2006; Charlton et al., 2006; De Raedt & Kristofferson, 2000; Owsley et al., 2004; Raitanen et al., 2003; Ross et al., 2009). 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, thus reinforcing the need for longitudinal cohort studies of older drivers.

Framework for Future Research

To help overcome the limitations outlined in the above section, a framework for future research is needed that represents a more comprehensive, theoretically-informed, and uniform approach to understanding how older drivers self-regulate their driving at multiple levels of driver performance and decision making. A set of recommendations for such a framework is proposed here.

1. **Multiple levels of driver performance and decision-making should be used as a framework for thinking about the decisions that older adults make with regard to self-regulation.** It is useful to conceptualize self-regulation in future research using the three levels of self-regulation identified in this review -- tactical, strategic, and life-goal -- because each level has implications for understanding self-regulatory behaviors and for countermeasures. It is important to distinguish between types and levels of self-regulation in interpreting results and making conclusions about self-regulatory behavior. In addition, the life-goal level of self-regulation warrants future attention in particular for two reasons. First, this level has been researched in few studies in the past. Second, self-regulation at the life-goal level can possibly have the greatest long-term impact on a person's lifelong mobility (e.g., moving to a home where there are many non-driving community mobility options) and extending the time over which a person can safely drive (e.g., purchasing a vehicle that has advanced technology that can help overcome deficits in driving abilities; Eby et al., 2015).

Within each level, there is a range of self-regulatory behaviors that can be explored. This is especially important as the research to date points to the complex nature of self-regulation and variability across driving situation in terms of both the prevalence of the behaviors and the factors that affect them. In addition, given the advances in technology that have occurred over the past several years, there are increasing opportunities to collect objective data on tactical self-regulatory behaviors such as gap acceptance, speed choice, lane changing behavior, and engagement in secondary activities within the vehicle, thus extending the kinds of self-regulatory behaviors that researchers have tended to focus on.

2. **Research on self-regulation needs to move beyond simply asking older drivers about avoidance behaviors.** It is important to understand the motivations for avoiding various driving situations and only consider those individuals who are avoiding driving situations for reasons related to declining driving abilities or feelings of discomfort to be "self-regulators." It is also useful to compare individuals who report driving avoidance for reasons other than self-regulation to not only self-regulators, but also those older drivers who do not modify their driving, to better understand how these groups differ from one another in terms of other health and driving measures.

3. **Researchers need to continue to obtain self-reported data about self-regulation, even as we move toward increasing opportunities for collecting objective driving data through relatively simple in-vehicle recording devices and more sophisticated vehicle instrumentation.** The research to date points to the important role that self-perceptions about health and functioning, confidence and comfort, and so forth play in decisions to self-regulate driving. Much of this important information cannot be derived from objective data collected within a vehicle. These kinds of data

require that we engage with older drivers and explore their thoughts and perceptions. Self-reported data on self-regulation, in conjunction with objective driving data can help us better understand the context for self-regulatory behavior. This is especially important when "baseline" data are not available for comparison. In these cases, the most appropriate use of objective driving exposure data may be to help verify and quantify self-reported changes in driving.

4. **One way to address many of the limitations of current studies is to improve the study designs employed in self-regulation research.** First, there is a need to work toward conducting more prospective, longitudinal studies and move away from the reliance on cross-sectional analyses, although we recognize that this is not always feasible. However, by following the same individuals over time, we will be able to collect "baseline" data and document individual and group changes in health and functioning over time, and their impacts on self-regulatory behaviors. This will help overcome a major limitation in cross-sectional studies having to do with unidentified differences between groups that are not taken into account and may be confounding study results. In addition, for studies that involve some type of intervention to facilitate self-regulation or some intermediate behavior associated with self-regulation such as improved insight, it is important to include a control or comparison group, matched by sex and age at the very least, as we know that these characteristics tend to affect self-regulation. There is also a need to move away from convenience samples in the study of self-regulation so that we are better able to make inferences to the larger population, and more generally, to ensure that study data are interpreted appropriately for whatever study design is being used.

5. **It is important to extend the current research by trying to tease out the relationships between self-regulation and other factors for which there is already considerable evidence, rather than continuing to simply replicate such relationships.** That is, there is a need to better understand the specific mechanisms that underlie these relationships. This is especially important for sex effects – we already know that sex exerts a strong influence on self-regulation, with women being more likely than men to self-regulate their driving. It is important that future research empirically examine rather than simply speculate about what is driving this relationship.

6. **Finally, further research is needed that focuses on how self-regulation actually affects safety and crash risk.** If we are going to continue to promote self-regulation as a way to extend the time period over which older drivers can safely drive, we need better evidence that this is the case.

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