Self-Regulatory Driving Behaviour, Perceived Abilities and Comfort Level of Older Drivers with Parkinson's disease compared to Age-Matched Controls

by

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Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

Introduction: Multiple studies have shown the symptoms of Parkinson's disease (PD) can impair driving performance. Studies have also found elevated crash rates in drivers with PD, however, none have controlled for exposure or amount of driving. Although a few studies have suggested that drivers with PD may self-regulate (e.g., by reducing exposure or avoiding challenging situations), findings were based on self-report data. Studies with healthy older drivers have shown that objective driving data is more accurate than self-estimates.

Purposes: The primary objectives of this study were to examine whether drivers with PD restrict their driving (exposure and patterns) relative to an age-matched control group and explore possible reasons for such restrictions: trip purposes, perceptions of driving comfort and abilities, as well as depression, disease severity and symptoms associated with PD.

Methods: A convenience sample of 27 drivers with PD (mean 71.6±6.6, range 57 to 82, 78% men) and 20 age-matched control drivers from the same region (70.6±7.9, range 57 to 84, 80% men) were assessed between October 2009 and August 2010. Driving data was collected for two weeks using two electronic devices (one with GPS) installed in each person's vehicle. Participants completed trip logs, questionnaires on background and usual driving habits, and measures of cognitive functioning, depression, quality of life, daytime sleepiness, driving comfort and abilities. Contrast sensitivity and brake response time were also assessed. Severity of PD was assessed using the Unified Parkinson's Disease Rating Scale (UPDRS) motor scores. An interview was conducted at the end of the second assessment to examine influence of the devices, driving problems and any departures from usual patterns over the monitoring period.

Results: Of the 128 PD patients screened for possible study participation, 35% had already stopped driving. Former drivers were older, more likely to be women and had poorer UPDRS motor scores. Only 48% of those who were eligible for the study agreed to participate. Compared to controls, the PD group had significantly slower brake response times, higher depression and quality of life scores, less comfort driving at night and poorer perceptions of their driving abilities. The PD group also had significantly lower cognitive functioning scores than controls, and a significantly greater proportion (74% versus 45%) were classified as having mild cognitive impairment. Compared to vehicle recordings, both groups mis-estimated the amount they drove over two weeks (measurement error was 94 km for the PD group and 210 km for the controls). The PD group drove significantly less overall (days, trips, distance and duration), at night, on week-ends and in bad weather and for different purposes. Four of the PD drivers had minor accidents over the two weeks, while one lost his license.

Conclusions: Self-estimates of exposure were inaccurate warranting the continued use of objective driving data. Overall, the findings suggest that drivers with PD appear to restrict their driving exposure and patterns relative to controls. The PD group were more likely to combine several activities into one trip, possibly due to fatigue. Moreover, they were more likely than controls to drive for medical appointments and less likely to drive for leisure activities and make out of town trips. The findings need to be replicated with larger samples and longer monitoring periods to examine changes in self-regulatory practices associated with disease progression and symptomatology. Other researchers are also likely to have similar difficulty in recruiting drivers with PD as this group may quit driving at an earlier age and those who are still driving are fearful of being reported to licensing authorities. Future studies also need to screen for cognitive impairment which often goes undetected, particularly in otherwise healthy drivers.

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University of Waterloo
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Chapter 1: Introduction

Maintaining one's driving privilege is synonymous with independence and mobility for many seniors (Dickerson, Molnar, Eby, Adler, Bedard, Berg-Weger et al., 2007). Given the lack of suitable public transportation options in many communities, driving is the preferred mode of travel in North America, especially for those living in rural and suburban areas (Benekohal, Michaels, Shim & Resende, 1994; Dickerson et al., 2007; Johnson, 2002; Rudman, Friedland, Chipman & Sciortino, 2006; Turcotte, 2006). For instance, Turcotte (2006) found that having a valid driving license and household vehicle increased the probability that older Canadians would leave their home on a given day and engage in community activities.

Conversely, driving cessation has been associated with increased depression (Fonda, Wallace & Herzog, 2001; Marotolli, Mendes de Leon, Glass, Williams, Cooney, Berkman et al., 1997), reduced out-of-home activities, social isolation, reduced quality of life (Marotolli, Mendes de Leon, Glass, Williams, Cooney & Berkman, 2000) and other negative consequences such as loss of identity, self-worth and loneliness (Eby & Molnar, 2009; Johnson, 1999). Driving cessation may also precipitate institutionalization (Freeman, George, Munoz & West, 2006) and possibly even early mortality (Edwards, Perkins, Ross & Reynolds, 2009). Understandably, seniors are reluctant to give up driving, and those that do, often regret this decision (Johnson, 1999; Rudman et al., 2006).

While it is important to help seniors drive safely for as long as possible and plan for the transition to non-driving, licensing authorities must consider public safety (Dickerson et al., 2007). As described below, seniors are disproportionately involved in fatal crashes and the number of older drivers is rapidly increasing. With an aging population also comes an increased prevalence of medical conditions that can compromise safe driving. The focus of the present study is on older drivers with Parkinson's disease (PD). To set the stage for this study, concerns about older drivers in general, and drivers with neurological conditions in particular, are outlined below. A brief description of PD and the possible effects of PD on driving is introduced in this chapter and discussed in detail in Chapter Two.

The third section of this chapter reviews policies for regulating at-risk drivers (i.e., age-based screening, physician reporting and restricted licensing). Policies of the Ministry of Transportation of Ontario (MTO) are of particular interest as only Ontario drivers were recruited for the present study. It has been argued that age-based regulation by licensing authorities is discriminatory, costly and potentially unnecessary if older drivers recognize their limitations and modify their driving accordingly (e.g., Ball, Owsley, Stalvey, Roenker, Sloane & Graves, 1998). There is a growing body of research on self-regulation, most of which has been conducted with healthy older drivers. Conceptual frameworks for understanding the behaviour of older drivers, particularly strategic decision-making, are described to lay the foundation for the current study.

1.1 Statement of the Problem

Older drivers are the fastest growing segment of the driving population in both Canada (e.g., Dobbs, 2008) and the United States (e.g., Burkhardt & McGavock, 1994; Dickerson et al., 2007), which reflects the demographic shift due to population aging. The most recent data (Transport Canada, 2007) shows that there are currently over three million licensed drivers over the age of 65, representing 13.6% of the driving population; 1.2 million in Ontario alone. This figure will double over the next decade, as there are another three million licensed drivers in the upcoming cohort (aged 55 to 64).

The number of licensed older female drivers over 65 will also grow dramatically over the next three decades, approaching parity with men (Burkhardt & McGavock, 1999; Dobbs, 2008;

Eberhard, 1996). With more active lifestyles, seniors are expected to become even more reliant on their vehicles, making more trips, driving further distances and keeping their licenses longer than prior generations (e.g., Burkhardt & McGavock, 1999; Dobbs, 2008).

These trends pose significant public health concerns as older drivers are disproportionately involved in collisions causing serious injury and death, when exposure (amount of driving) is taken into consideration (Staplin, Lococo, Gish & Decina, 2003). Increased risk of fatal collisions begins at age 70 and escalates thereafter (Bédard, Stones, Guyatt & Hirdes, 2001; Dickerson et al., 2007). In Ontario, drivers 80+ have the second highest rate of fatal collisions, after the youngest group of drivers (Casson & Racette, 2000; Higgins, 2003; Marshall, Wilson, Molnar, Man-Son-Hing, Stiell & Porter, 2007). Data compiled by the MTO (2003) shows that the number of licensed drivers over age 80 doubled between 1996 and 2001.

It has been argued that using exposure as the denominator inflates the crash risk of older drivers (e.g., Hakamies-Blomqvist, Raitanen & O'Neil, 2002; Janke, 1991; Langford, Methorst & Hakamies-Blomqvist, 2006) and that drivers with low annual mileage (< 3000 km) have more crashes regardless of age. Some have challenged these findings (e.g., Staplin, Gish and Joyce, 2008), as will be discussed further in Chapter Two. Experts in the field, however, agree that older drivers are overly involved in certain types of collisions and are more susceptible to serious injury and death as a result of collisions (e.g., Dickerson et al., 2007; Dobbs, 2008; Eby and Molnar, 2009).

There is now general consensus emerging from national forums held in recent years in both Canada and the United States and reflected in position papers (such as Dobbs, 2008 and Dickerson et al., 2007), that the focus should be on medically at-risk drivers, regardless of age. And since medical conditions affect people differently, it has been argued that fitness-to-drive should be determined through medical review as well as comprehensive (functional) assessments of individual driving capabilities.

Drivers with neurological disorders have twice the rate of at-fault crashes than controls, and those with dementia have more than a three-fold increase (Dobbs, 2008). Dementia and neurological disorders with associated cognitive impairment (such as stroke and Parkinson's disease) are of particular concern with respect to driving safety (e.g., Dobbs, 2008; Hopkins, Kilik, Day, Rows & Tseng, 2004; Klimkeit, Bradshaw, Charlton, Stolwyk & Georgiou-Karistianis, 2009; Uc & Rizzo, 2008). Individuals with PD have a six-fold risk of developing dementia compared to healthy older adults (Aarsland, Andersen, Larsen, Lolk, Nielson & Kragh-Sorensen, 2001). In fact, 20% of individuals with PD already have mild cognitive impairment at time of diagnosis (Uc, 2010).

1.2 Parkinson's disease

Parkinson's disease (PD) is a progressive, neurodegenerative disorder of the central nervous system for which there is no cure. Parkinson's disease occurs when neurons containing dopamine in the substantia nigra are destroyed. Consequently, dopamine is depleted and is not delivered to the motor cortex (responsible for controlled muscle action, movement and balance). Once 60% to 80% of the dopamine producing cells are destroyed, the symptoms of PD begin to appear (National Parkinson Foundation Inc, 2002).

Parkinson's disease is the second most common neurodegenerative disorder after Alzheimer's disease (Marshall, 2008), affecting more than 100,000 people in Canada (Parkinson Society Canada, 2010). The average age of onset is 60 years but PD may appear in a small percentage (5-10%) of individuals before the age of 40 and 20% before the age of 50 (Parkinson Society Canada, 2010). Parkinson's disease is seen across all ethnic groups, however, men are more prone to developing PD (Siederowl & Stern, 2003). Generally, men have a 1.5x greater risk of developing PD than women, likely due to increased exposure to toxins or genetic factors (Wooten, Currie, Bovbjerg, Lee & Patrie, 2004). It is expected 1% of people over the age of 60 and 2% of people over the age of 70 will be affected with PD in the near future (Parkinson Society Canada, 2010). In the oldest age group (80+), the prevalence of PD is expected to more than double in the coming years (Kontakos & Stokes, 2000).

Cardinal motor symptoms of PD are resting tremor, bradykinesia (slowness of movement), muscle rigidity and postural instability (usually in later stages). In addition to motor symptoms, secondary symptoms (such as freezing, cognitive impairment or dementia) may arise. Together with the side effects of PD medications (e.g., daytime sleepiness), these symptoms can impair driving ability and consequently lead to elevated crash risk (Uitti, 2009), even in the early stages of PD (Heikkila, Turkka, Korpelainen, Kallanranta & Summala, 1998; Klimkeit et al., 2009). Additionally, PD related dementia can lead to difficulty recalling safe driving behaviours and rules of the road (Carp, 1988).

As will be presented in Chapter Two, there is some evidence that drivers with PD have higher crash rates compared to healthy older drivers (e.g., Adler, Rottunda, Bauer & Kuskowski, 2000; Dubinsky, Gray, Husted, Busenbark, Vetere-Overfield, Wiltfong et al., 1991). Several studies have shown impairments in driving performance (e.g., Madeley, Hulley, Wildgust & Mindham, 1990; Stolwyk, Charlton, Triggs, Iansek & Bradshaw, 2006a; Wood, Worringham, Kerr, Mallon & Silburn, 2005), although some drivers with PD appear to be able to drive safety (e.g., Devos, Vandenberghe, Nieuwboer, Tant, Baten & De Weerdt, 2007; Heikkila et al., 1998; Singh, Pentland, Hunter & Provan, 2005).

1.3 Role of Licensing Authorities and Physicians

Ultimately, it is the responsibility of licensing authorities and physicians to identify and regulate at-risk drivers (MacDonald & Hebert, 2010). Currently, however, there are no universally accepted standards or policies for regulating older and/or medically-at-risk drivers, and policies vary between and within countries (Blanchard & Myers, 2010; Klimkeit et al., 2009; Langford & Koppel, 2006). Age-based requirements are controversial and costly, and with the exception of in-person renewal for drivers 85+, there is limited evidence that other policies (e.g., road and vision tests) are effective in reducing fatal crashes (Grabowski, Campbell & Morrisey, 2004; Landford & Koppel, 2006).

Recently, Adler & Rottunda (2010) recommended that all states in the US should implement in-person renewal and mandatory testing procedures for any driver with a neurodegenerative disorder. Additionally, they argued that all states should require physicians to report any driver with Alzheimer's disease or PD to licensing authorities. Marshall (2008) also identified PD as one of the medical conditions that can affect driving and should serve as a "red flag" to Canadian physicians and authorities that further evaluation may be required.

In Canada, seven provinces require medical review for private class license holders beginning at various ages (70, 75, 80), sometimes in combination with vision tests. Ontario does not have age-based medical review requirements (Myers, Blanchard, Vrkljan & Marshall, 2010). Only two provinces (Alberta and Ontario) have a different renewal period once drivers age, both beginning at age 80. Ontario is quite unique with respect to the Senior Driver Renewal Program (SDRP) which requires all drivers once they turn 80 (and every two years afterwards) to undergo vision and rules testing, driver record review and a 90 minute group education session.

In most provinces, including Ontario, physicians are required by law to report to licensing authorities all patients who, in their opinion, may be medically unfit to drive (Jang, Man-Son-Hing, Molnar, Hogan, Marshall, Auger et al., 2007). Jang et al. (2007) surveyed physicians across Canada and found that almost half do not feel confident or qualified to assess driving fitness, and nearly a quarter were not aware of the Canadian Medical Association (CMA) guide for physicians on *Determining Fitness to Drive*. Consistent with the findings of an earlier survey of Saskatchewan physicians (Marshall & Gilbert, 1999), the majority of physicians surveyed by Jang et al. (2007) acknowledged their legal responsibility for reporting, despite concerns about jeopardizing the relationship with their patients.

Comparatively, a survey of Canadian neurologists found that less than half were in favour of mandatory physician reporting (McLachlan & Jones, 1997). Jang et al. (2007) speculated that this reluctance may be due, in part, to the burden of reporting as a neurologist's patient load is largely comprised of at-risk groups (e.g., those with seizures, stroke and dementia). Although the CMA (2006) has published guidelines for determining fitness-to-drive in patients with stroke and dementia, there are no comparable guidelines for patients with PD (refer to http://www.cma.ca/index.php/ci_id/18223/la_id/1.htm). In the absence of clear guidelines, physicians and neurologists can only make subjective decisions on fitness to drive (Heikkila et al., 1998; Klimkeit et al., 2009). Physicians and neurologists often overestimate the driving ability of their PD patients (Cubo, Martin, Gonzalez, Bergarache, Campos, Fernandez et al., 2010; Heikkila et al., 1998; Klimkeit et al., 2009). The study by Cubo et al. (2010) also suggested that drivers with PD may hide medical information when renewing their licenses and that medical advice had little influence on the decision to quit driving.

Some have argued that licensing restrictions may be useful for managing at-risk, often older drivers (Langford & Koppel, 2011; MacDonald & Hebert, 2010). In addition to corrective lenses, the most common restrictions currently employed by provincial licensing authorities are: daytime driving only, limited distance/radius, vehicle equipment, speed limit/roadway and passenger requirements (Myers et al., 2010). Ontario currently offers no options (apart from equipment) for restricted licenses. Not surprisingly, surveys show that seniors would rather have restricted licenses than lose their driver's license. However, some restrictions (such as daytime driving only) were viewed as more acceptable than others (e.g., driving within 10 miles of home, having another licensed driver in the vehicle) that may limit autonomy (Marshall, Man-Son-Hing, Molnar, Wilson & Blair, 2007). In any case, evidence is lacking on the types of restrictions that are most effective (Langford & Koppel, 2011; Myers et al., 2010).

Additionally, imposing restrictions may not be necessary if older drivers already restrict their driving. There is substantial evidence (which will be presented in Chapter Two), that as a group drivers modify their driving as they age. Crash risk may be reduced if seniors adopt safer driving practices commensurate with their abilities and regulate their driving to reduce task demands (Ball et al., 1998; Eby & Molnar, 2009; Kostyniuk & Molnar, 2008).

1.4 Self-Regulation

Self-regulation has been described as a gradual process of self-imposed restrictions, which may eventually lead to driving cessation (Dellinger, Sehgal, Sleet & Barrett-Connor, 2001; Hakamies-Blomqvist & Wahlstrom, 1998). As described in Chapter Two, drivers can self-regulate by reducing driving exposure (frequency and distance), changing their driving patterns (when and where they drive) and avoiding difficult driving situations.

Several conceptual frameworks have been developed concerning the process of self-regulation and more broadly driver decision-making. According to the model developed by Rudman and colleagues (2006) based on interviews with current and former older drivers, the decision to self-regulate is influenced by a host of intrapersonal, interpersonal and environmental factors. In particular, their model underscores the importance of personal level of confidence or comfort in the process of self-regulation. However despite awareness of functional declines and/or low comfort levels, some individuals may chose not to restrict their driving in order to maintain their independence, (Baldock, Mathias, McLean & Berndt, 2006; Lindstrom-Fornieri, Tuokko, Garrett & Molnar, 2010; Myers, Paradis & Blanchard, 2008). Others may not recognize declining abilities. This is especially true for drivers with cognitive impairment (Aarsland et al., 2001; Eby & Molnar, 2009), but also for those who simply lack insight into the effects of their condition on driving (Klimkeit et al., 2009).

Michon’s hierarchial model of operational, tactical and strategic driving skills is frequently cited in the driving literature (Michon, 1985). Operational aspects of driving (e.g., steering, braking, lane positioning) are largely learned automatic responses. Drivers have more control over tactical maneuvers such as adjusting their speed and following distance based on driving conditions. At the highest level are strategic decisions such as trip and route planning. As described by Klimkeit et al. (2009), symptoms associated with PD can impair all levels of driving skills. For instance, motor symptoms such as rigidity and tremor may affect steering, braking and the ability to check blind spots. Cognitive deficits, meanwhile, can impair the ability to detect hazards and other executive functions.

Eby and Molnar (2009) extended Michon’s model to older drivers, adding a fourth level: life-goals or lifestyle (such as where to live or what type of vehicle to buy). According to Eby and Molnar, lifestyle together with strategic decisions (how much to drive and under what conditions) offer the greatest opportunity for effective self-regulation. Strategic-level decisions can be influenced by many factors (e.g., age, gender, personality), and changes in driving behaviour may occur as a result of circumstance (i.e., retirement, flexibility of schedules) and not simply recognition of declining driving abilities (Eby & Molnar, 2009).

More recently, Lindstrom-Forneri and colleagues (2010), in conjunction with Candrive (Canadian Driving Research Initiative for Vehicular Safety in the Elderly), proposed another framework for guiding research. In the *Driving as an Everyday Competence* (DEC) model (shown in **Figure 1.1**), competence refers to what the driver is capable of, while performance refers to actual behaviour. Level of competence, meanwhile, is determined by the interaction between individual (e.g., diagnosis, co-morbidities), contextual (e.g., driving experience) and environmental factors (e.g., laws). Driver competence is further moderated by beliefs, awareness and self-efficacy (confidence). Beliefs about driving capacity, together with actual capacity, determine performance or skills at all levels (Lindstrom-Forneri et al., 2010). For example, a person who is aware of functional declines may choose to drive in off peak periods (strategic decision), where traffic is lighter (tactical), possibly reducing the need for hard braking (operational maneuver) and potentially lowering crash risk. However, drivers must be aware of their capabilities to plan accordingly at the strategic level (Eby & Molnar, 2009; Lindstrom-Forneri et al., 2010).

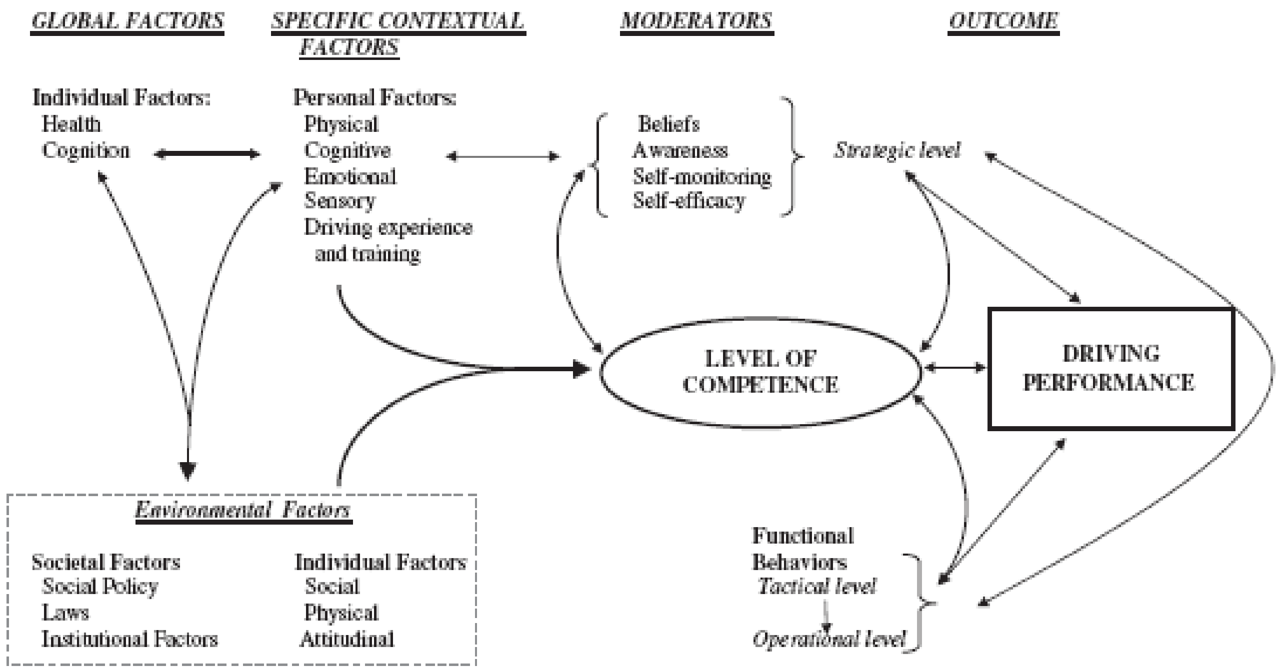

Figure 1.1. Driving as an Everyday Competence (DEC) Model. Lindstrom-Forneri et al. (2010). Reprinted with permission from Dr. Holly Tuokko.

1.5 Summary and Overview

The growing number of older drivers and their disproportionate involvement in fatal collisions is a concern. Driving is complex and requires multiple skills and abilities that can be compromised in individuals with various medical conditions. Physicians are often reluctant to report their patients to licensing authorities and lack tools and guidelines for determining fitness-to-drive. The impact of neurodegenerative disorders including PD on driving safety is receiving more attention. However, as described in Chapter Two, there has been little research on self-regulatory practices in this population. It is important to empirically examine how personal (e.g., severity and symptoms of PD), interpersonal (e.g., availability of other household drivers) and environmental factors (e.g., location of residence, weather conditions), as well as moderators (e.g., perceptions) influence driving behaviour (particularly strategic level decisions).

The aim of the present study was to gain a better understanding of self-regulatory driving practices in drivers with PD, specifically when and where they drive, as well as primary reasons for driving. As presented in Chapter Two, in-vehicle devices have been used to objectively assess driving exposure and patterns in healthy older drivers. The present study used such devices to examine the naturalistic driving of older drivers with PD compared to an age-matched control group. A review of the relevant literature on both healthy older drivers and drivers with Parkinson's disease is presented in the next chapter. Chapter Three outlines the study objectives and expectations, sample selection and recruitment, as well as data collection procedures and analyses. The findings are presented in Chapter Four and discussed in Chapter Five.

Chapter 2: Literature Review

2.1 Introduction

Safe driving is complex, requiring the ability to carry out simultaneous tasks and make quick decisions in a rapidly changing environment. Impairments in visual, spatial, cognitive and psychomotor functioning, either singly or in combination, can compromise safety putting the driver, passengers and other road users at risk. Some researchers have projected that within the next few decades there will be a dramatic increase in total driver fatalities involving older drivers (e.g., Dobbs, 2008; L'Ecuyer, Chouinard & Hurley, 2006), underscoring the need to identify those at greatest risk. Drivers with Parkinson's disease (PD) are considered a high-risk group due to progressive declines in motor, cognitive and visual processing skills (e.g., Adler & Rottunda, 2010; Devos et al., 2007; Klimkeit et al., 2009; Marshall, 2008: Stolwyk et al., 2006a).

To set the stage for the present study, this chapter begins by reviewing the literature on older drivers in general with respect to driving performance, exposure and patterns. Driving performance refers to *how* people drive and has typically been examined in terms of crashes or collision causing behaviours (errors). Exposure refers to the *amount* of driving, commonly expressed as driving frequency, distance and duration. Patterns, meanwhile, refers to *when* and *where* people drive such as time of day, roadways, as well as traffic and weather conditions. Reasons for driving (i.e., trip purposes) are also important to consider. Factors associated with self-regulation and issues in measuring self-regulation in older drivers in general are reviewed.

The next section reviews the literature on drivers with PD. The section begins with studies on driving performance (crash rates and errors) and factors associated with poor performance. Compared to driving performance, relatively little research has been conducted on self-regulatory practices and factors related to driving restrictions and cessation in the PD population. Following a review of the available literature in this area, the final section provides a brief summary, including implications for the present study.

2.2 Studies on Older Drivers in General

2.2.1 Performance

Advanced age and gender (male) are major risk factors for fatal collisions (Ryan, Legge & Rosman, 1998; Zhang, Lindsay, Clarke, Robbins & Mao, 2000). As noted in Chapter One, the rise in fatal collisions begins at age 70 and escalates thereafter. Men are 1.4 times more likely to be involved in collisions and fatally injured compared to older women drivers (Zhang et al., 2000), possibly because men may be less healthy than women of the same age (Bayam, Liebowitz & Agresti, 2005). Compared to younger drivers, older drivers are more susceptible to serious injury and death when involved in crashes of equal severity (e.g., Li, Braver & Chen, 2003). In fact, forty percent of all fatal crashes may be associated with age-related frailty (Staplin et al., 2003).

Compared to younger drivers, older drivers are more likely to be at-fault and are involved in different types of collisions, namely multiple (versus single vehicle) crashes, those occurring in the daytime, at lower speeds and at intersections (Cooper, 1990; Preusser, Williams, Ferguson, Ulmer & Weinstein, 1998; Ryan et al., 1998; Zhang et al., 2000). According to McGwin and Brown (1999), the majority of crashes (80%) in older drivers occur within a 25 mile radius from home. Collisions caused by older drivers often involve errors of omission and inattention such as failure to heed stop signs, traffic signals, yield right of way and check when changing lanes (Bayam et al., 2005; McGwin & Brown, 1999).

Weather conditions also influence collisions rates. For example, Zhang et al. (2000) found the rate of fatal collisions increased by 60% for older drivers in Ontario when it was snowing. Even in healthy older drivers, reduced visibility and glare are problematic, particularly when driving at night, in heavy precipitation, or both (Ball et al., 1998; Owens, Wood & Owens, 2007). Not surprisingly, difficulty seeing is the most frequently reported reason by older drivers for driving restriction (Satariano MacLeod, Cohn & Ragland, 2004).

2.2.2 Exposure

Compared to younger drivers, older adults drive less often, shorter distances and closer to home (Collia, Sharp & Giesbrecht, 2003; Davey & Nimmo, 2003; Keall & Frith, 2006; Rosenbloom, 1999). The tendency of older adults to drive fewer km has been associated with lower rates of full-time employment and being female (Bauer, Adler, Kuskowski & Rottunda, 2003; Keall & Firth, 2006; Rosenbloom, 1988).

As mentioned in Chapter One, studies have shown that drivers with low annual mileage have higher crash rates, regardless of age (Alvarez & Fierro, 2008; Hakamies-Blomqvist et al., 2002; Janke, 1991; Keall & Frith, 2004; Langford et al., 2006). This "low mileage" group may be predominately drivers with impairments who are already self-restricting (Langford et al., 2006). Driving context is equally important as exposure. For instance, low mileage drivers tend to drive more in congested urban areas which pose a higher risk of collisions whereas high mileage drivers are more likely to use freeways and multi-lane roads with limited access points (Keall & Frith, 2004; Langford, Methorst & Hakimies-Blomqvist, 2006). Reduced exposure can also lead to declines in driving skills in older drivers (Chipman, 1982).

However, the above studies should be interpreted with caution as both crashes and mileage were self-reported. Staplin and colleagues (2008) found that annual distance was underestimated by low mileage drivers and overestimated by high mileage drivers when compared to odometer readings. More recently, two studies have shown that older drivers misestimated weekly distance (in both directions), compared to objective data from in-vehicle devices (Blanchard, Myers & Porter, 2010; Huebner, Porter & Marshall, 2006).

2.2.3 Patterns

Older adults generally prefer to drive during the day (Burns, 1999; Hakamies-Blomqvist & Wahlstrom, 1998) and on weekdays versus weekends (Keall & Frith, 2004). Moreover, older drivers are more likely to break down long trips into several shorter trips (e.g., Lerner-Frankiel, Vargas, Brown, Krusell & Schoneberger, 1990). They may also combine several activities into a single trip known as "trip chaining" (Blanchard, 2008; Burkhardt, 1999; Rosenbloom, 1999). Using 1986, 1992 and 1998 data from Canada's General Social Survey, Newbold, Scott, Spinney, Kanaroglou & Paez (2005), found that older Canadians undertake fewer trips than those in the labor force and travel by car for different reasons, for example entertainment, purchasing goods and services, religious activities and entertainment.

The most common form of self-regulation reported by older drivers is reduced night driving (e.g., Charlton, Oxley, Fildes, Oxley, Newstead, Koppel et al., 2006; Kostyniuk & Molnar, 2008; MacDonald, Myers & Blanchard, 2008; Myers et al., 2008; Sabback & Mann, 2005). Other situations that older drivers (women in particular) reportedly avoid are unfamiliar areas, highways, poor weather, and heavy traffic or rush hour (e.g., Baldock et al., 2006; Benekohal et al., 1994; Burns, 1999). Recently, Scott and colleagues (2009) report that Canadian seniors are driving more during morning and evening peak periods based on comparisons of 24-hour surveys conducted by phone interviews in the 2005 versus the 1992 General Social Survey. In any case, estimates of the proportion of seniors who adopt self-regulatory practices vary widely from study to study (Charlton et al., 2006; Kostyniuk & Molnar, 2008) and until recently have been based on self-report data.

Only two studies to date, both conducted at the University of Waterloo, have objectively measured driving patterns in older adults using electronic recording devices (one with GPS capabilities) installed in participant vehicles for one (Blanchard, 2008) and two weeks (Trang, 2010), respectively. While self-reports of usual patterns were consistent with objective driving data with respect to when they drove (day versus night) and driving in residential, city and rural areas, older drivers did not self-regulate as much as they reported with respect to driving on freeways/highways, in rush hour, in bad weather and overall frequency of driving in challenging situations. The study by Blanchard is reported in her dissertation (2008), as well as two publications (Blanchard, Myers & Porter, 2010 and Blanchard & Myers, 2010). The study by Trang is reported in her thesis (2010) and has been recently accepted for publication.

2.2.4 Factors Associated with Self-Regulation

As noted in Chapter One, personal level of discomfort emerged as a key determinant of self-regulation in Rudman et al.'s qualitative study with current and former drivers (2006). While many researchers have discussed the potential importance of driver perceptions (e.g., Ball et al., 1998; Charlton et al, 2006; Kostyniuk & Molnar, 2008; Satariano et al., 2004) in self-regulation, until recently these constructs have not been well-defined or consistently measured. The Driving Comfort and Perceived Abilities Scales, developed inductively with older drivers provide conceptually grounded and psychometrically supported tools for examining these constructs (MacDonald et al., 2008; Myers et al., 2008).

While these earlier studies showed that perceived comfort and driving abilities were related to self-reported restrictions and avoidance, subsequently Blanchard & Myers (2010) and Trang (2010) demonstrated associations with objectively measured driving exposure and patterns. Both studies found that driving comfort (particularly at night) and perceived driving abilities were associated with multiple indicators of actual driving (such as driving distance and duration). Both studies also found that men had significantly higher day and night driving comfort scores and drove significantly more km at night than women. Trang (2010) found that men drove substantially more overall (trips, km and duration). Her study also demonstrated that seasonal variation in daylight is important to consider when examining night driving.

Only a few studies have empirically examined driving radius (distance from home). Keall and Firth (2006) used two-day travel diaries in conjunction with digitized maps to calculate the distance between a person's residence and reported destinations. Low mileage drivers (< 3000km/year), who tended to be older, were found to drive nearer the vicinity of their homes. The two Waterloo studies, meanwhile, assessed radius from home in older drivers using an in-vehicle GPS data logger, together with digitized maps (Google Earth). Both studies found that driver perceptions (particularly night comfort) and perceived driving abilities were associated with maximum radius from home (Blanchard & Myers, 2010; Trang, 2010). Additionally, Trang found that men made significantly more trips further from home (average and maximum radius).

To better understand driving patterns, both studies examined trip purposes using diaries or logs. The greatest number of trips was for shopping and errands, followed by social and entertainment purposes. Discretionary trips (e.g., social activities, shopping) were positively associated with exposure (km driven) and the number of trips (day and night). Moreover, older drivers with an average radius of less than 5 kilometers made significantly more trips for medical reasons and significantly fewer trips for social, entertainment and leisure, compared to those whose average radius was greater than 5 kilometers (Blanchard, 2008).

While both samples cited bad weather as the primary reason for postponing or cancelling trips, in Blanchard's study only 23% of her monitoring period (June to October) had bad weather. In contrast, over half the monitoring period in Trang's study (November to March), had inclement weather. Trang found that trips for social/entertainment purposes were more likely to occur on days with good versus inclement weather. Additionally, out-of-town trips were more likely to occur on days with clear versus poor road conditions. Compared to women, men drove significantly more often on days with bad weather and poor road conditions (Trang, 2010).

As shown above, there has been considerable research regarding self-regulatory practices on older drivers in general. Comparatively, only a few studies have been conducted on self-regulatory practices and perceptions in drivers with PD. The vast majority of studies have focused on driving performance and factors affecting performance. As this is not the focus of the present study, this body of research is reviewed as succinctly as possible below.

2.3 Studies on Drivers with PD

As mentioned previously, symptoms of PD can impair the ability to drive safely. For example, motor symptoms (e.g., bradykinesia, rigidity, tremor and freezing) can lead to impaired vehicle control due to slower reaction time, problems turning to view blind spots and reversing (Cordell, Lee, Granger, Vieira & Lee, 2008). Cognitive deficits (e.g., reduced information processing speed, memory, depth perception, concentration, attention and spatial awareness) can impair decision-making, including navigation and hazard avoidance (Stolwyk et al., 2006a). Not surprisingly, studies have focused on examining driving performance (crashes and errors) and factors related to performance in drivers with PD. Although not all studies have employed a control group, those that have are summarized in Appendix A.

2.3.1 Crash Rates

Both simulator (e.g., Devos et al., 2007; Uc, Rizzo, Anderson, Dastrup, Sparks & Dawson, 2009a; Zesiewicz, Cimino, Malek, Gardner, Leaverton, Dunne et al., 2002) and survey studies (Adler et al., 2000; Dubinsky et al., 1991), have found that drivers with PD have more collisions than controls, as shown in **Appendix A**. In the study by Zesiewicz and colleagues (2002), older age, cognitive scores and greater disease severity predicted simulator crashes. Uc et al. (2009a), meanwhile, found that motor dysfunction, visual perception and cognitive scores predicted crashes in drivers with PD under low-contrast conditions.

Survey studies have also found that drivers with PD are at an increased risk of collisions compared to controls, when adjusted for self-estimated mileage (Adler et al., 2000; Dubinsky et al., 1991). Cognitive impairment (MMSE scores ≤ 26) was associated with crashes in Dubinsky et al.'s study, while movement restriction was associated in Adler et al.'s study. Those with movement restrictions had a 3.2x increased risk of being involved in a crash compared to those without movement restrictions. Additionally, a large German survey reported 15% of 5210 drivers with PD were involved in an accident, with 11% being at-fault (Meindorfner, Korner, Moller, Stiasny-Kolster, Oertel & Kruger, 2005), however, no controls were included.

2.3.2 Driving Errors

Fourteen studies were found that examined errors in drivers with PD compared to controls: seven used simulators, six examined on-road performance and one did both. These studies have typically included drivers with mild to moderate disease severity, tested during the "on" state of medication (Klimkeit et al., 2009).

Compared to controls, most studies have found that drivers with PD make more errors (details are in **Appendix A**). Simulator studies have shown that drivers with PD have slower reaction time, including late deceleration at traffic signals (Madeley et al., 1990; Stolwyk et al., 2006a,b), worse steering control (Madeley et al., 1990) and difficulty maintaining lane positioning (Stolwyk et al., 2005; 2006a,b). Additionally, drivers with PD have more problems adjusting their speed and navigating curves (Stolwyk et al., 2005; 2006a, 6). They are also more likely to drive through red lights (Madeley et al., 1990).

On-road studies have yielded similar findings. Compared to controls, drivers with PD had more difficulty reading road signs (in daylight), changing lanes, maintaining lane position, monitoring their blind spot, negotiating intersections, moving their foot from one pedal to another and steering (e.g., Wood et al., 2005). Drivers with PD have also been shown to have more difficulty navigating through traffic, making left hand turns (Heikkila et al., 1998), controlling their vehicles and decision-making in general (Cordell et al., 2008). In a study using instrumented vehicles, as well as in-car observers (Uc, Rizzo, Johnson, Dastrup, Anderson & Dawson, 2009b), drivers with PD drove more poorly overall and made more operational (e.g., incorrect turns, missed stop signs) and tactical errors (e.g., lane violations, speed control).

2.3.3 Factors Associated with Driving Performance

As shown in **Appendix A**, multiple factors have been associated with poor performance in PD drivers, including: disease severity (e.g., Grace et al., 2005; Uc et al., 2007; Zesiewicz et al., 2002), impaired reaction time (Heikkila et al., 1998); visual perception and information processing speed (Stolwyk et al., 2006a; Uc et al., 2009a,b), cognitive ability (Dubinsky et al., 1991; Grace et al., 2005; Stolwyk et al., 2006a; Uc et al., 2009b; Zesiewicz et al., 2002) and poorer contrast sensitivity (e.g., Devos et al., 2007; Uc et al., 2009a,b; Vaux et al., 2010).

However, developing a clinical battery that predicts who is safe versus unsafe has been more challenging (Klimkeit et al., 2009). Only a few studies have attempted to distinguish between drivers with PD who passed versus failed a road test. Devos and colleagues (2007) found that drivers with PD had more collisions and traffic related offenses than controls on a simulator, although 72.5% were considered safe on a road test. Those who failed the road test had significantly longer disease duration (years), greater disease severity (UPDRS motor scores), worse contrast sensitivity and higher clinical ratings of dementia. Together, these four measures were sensitive and specific (over 90%) predictors of passing/failing the road test. Recently, Classen, Witter, Lanford, Okun, Rodriguez, Romrell and colleagues (in press) found that 56% of drivers with PD failed a road test, compared to only 12% of control drivers. The UFOV (subtest 2) and the Rapid Paced Walk test correctly classified 81% of pass/fail outcomes.

The effect of medication use on driving has also garnered attention, particularly the use of dopamine agonists (Comella, 2003; De Bie, Miyasaki & Lang & Fox, 2007; Martin, 2007). A survey of 638 PD patients by the Canadian Movement Disorder Group found that 51% had excessive daytime sleepiness (EDS) based on Epworth Sleepiness Scale (ESS) scores > 7, while 3.8% reported sudden onset of sleep (SOS) while driving (Hobson, Lang, Martin, Razmy, Rivest & Fleming, 2002). Meindorfner and colleagues (2005), meanwhile, found that 8% of 5210 drivers reported SOS while driving and 2.2% of these reportedly had a collision. The authors found a cut-off score of ≥ 7 on the ESS predicted 75% of SOS episodes. In 50% of the SOS cases, participants were taking dopamine agonists.

Amick, D'Abreu, Moro-de-Casillas, Chou and Ott (2007a) examined EDS in relation to on-road performance. Of the 21 drivers with PD, five (23.8%) reportedly suffered from EDS. However, there were no associations between EDS and medications with on-road performance, consistent with prior studies (Hobson et al., 2002; Meindorfner et al., 2005). The review by Klimkeit et al. (2009) concluded that there is currently little evidence that SOS and EDS are contributing factors to crashes in PD drivers (Klimkeit et al., 2009).

Madeley and colleagues (1990) reported that drivers in their study were quite confident, despite impaired performance on a driving simulator. Other studies have found that drivers with

PD tend to overestimate their driving abilities compared to actual performance (Wood et al., 2005) and ratings by a driving instructor and a psychologist (Heikkila et al., 1998). For example, six drivers with PD considered themselves fit to drive even though they failed a road test (Heikkila et al., 1998). However, Wood et al. (2005) said there were no differences in confidence between drivers with PD and controls. Unfortunately, none of the above studies describe how confidence or perceived abilities were actually measured.

2.3.4 Driving Restrictions and Cessation

Only two studies have examined self-regulatory practices in drivers with PD. Both Adler et al., (2000) and Wood et al., (2005) found that, compared to controls, drivers with PD drive less (fewer km). Both studies found that drivers with PD are less likely to drive alone, while Alder et al. found that PD drivers also drive less at night, in peak traffic and long distance.

Although estimates of the proportion of drivers with PD who stop driving post-diagnosis vary considerably (Klimkeit et al., 2009), a few studies have examined differences between current and former drivers. In a large survey study of 5520 drivers with PD, Meindorfner and colleagues (2005) reported 23% were current drivers, 37% were self-regulating and 40% had quit driving. Compared to current drivers, former drivers were older (70+), more likely to be female, have longer disease duration (> 8 years) and greater severity (not defined). Reported reasons for cessation included disease progression, as well as finding driving too difficult and dangerous. Self-regulating drivers reported motor impairment as the number one reason for restricting, followed by driving difficult, sleepiness at the wheel and being involved in an accident. Unfortunately, self-regulation was not defined nor was this group of drivers described.

More recently, Cubo and colleagues (2010) found that former drivers with PD stopped driving on average of 2.5±4.5 years after diagnosis. Compared to current drivers, former drivers were significantly older, had longer disease duration, greater cognitive dysfunction (memory, attention and executive function), greater disease severity (measured by Hoehn & Yahr and the SCOPA-motor scale) and more difficulty with activities of daily living (ADL). Drivers stopped driving primarily for personal reasons (64%), followed by family advice (12%), accident involvement (8%), advice from neurologist (3%) and unfit medical certificates (3%). Other studies have cited anxiety on the road (McLay, 1989), concentration difficulties (Zesiewicz et al., 2002) and pressure from family/friends/doctors (Borromei et al., 1999) as reasons for driving cessation.

2.4 Summary and Implications

The majority of studies to date on drivers with PD have focused on performance using simulators, on-road assessment or surveys, consistent with the work in this area on healthy older drivers. Participants may have difficulty adapting to simulator technology and experience simulator sickness, particularly older drivers (Klimkeit et al., 2009; Rizzo, Uc, Dawson, Anderson, & Rodnitzky, 2010). Road assessment, meanwhile, is conducted during the day and in good weather and in-car observers may influence driving behaviour (Baldock et al., 2006; Eby & Molnar, 2008; Myers et al., 2008). Both types of assessment constitute artificial conditions. Another criticism of this area is that few studies on PD drivers have assessed distance travelled (Klimkeit et al., 2009) and those that have have relied on driver self-estimates (e.g., Alder et al., 2000; Wood et al., 2005). As shown in **Appendix A**, some studies had no inclusion/exclusion criteria (e.g., Adler et al., 2000), while others had minimal criteria (e.g., valid licensing and currently driving).

Only a few studies have examined self-reported restrictions in PD drivers. Self-report measures of driving exposure and patterns are subject to recall and social desirability bias

(Lajunen & Summula, 2003). Unreliable memory is a particular concern in persons with PD (Rizzo et al., 2010). Self-estimates of distance driven (exposure) have been shown to be inaccurate in healthy older drivers (Blanchard et al., 2010; Huebner et al., 2006) and older drivers may not regulate as much as they report on questionnaires (Blanchard et al., 2010).

Additionally, the influence of driver perceptions in PD drivers has not been reliably measured. The extent to which drivers with PD reduce or stop driving, and whether this is primarily due to insight into their condition versus other factors is presently unknown. While studies have shown that drivers with PD tend to overestimate their driving abilities (Heikkila et al., 1998), this is also true of healthy older drivers (Kleimkeit et al., 2009).

As presented earlier in this chapter, two studies have examined self-regulatory practices in healthy older drivers using objective measures. Blanchard (2008) and Trang (2010) used simple electronic devices to assess driving exposure and patterns, as well as other sources of data to determine reasons for driving (trip logs) and driving conditions (weather reports). The present study builds on their work to develop a better understanding concerning self-regulatory practices, as well as the role of perceived driving comfort and abilities in drivers with PD.

Chapter 3: Methods

This chapter begins with the study rationale, objectives and a priori expectations. Ethics approval and consent are presented next, followed by sample recruitment and selection criteria. Step-by-step study procedures are outlined, and instruments and materials described. The final section describes data handling procedures and analyses.

3.1 Study Rationale, Objectives and Expectations

As described in Chapter Two, only two studies to date have examined self-regulatory practices in drivers with PD. Compared to healthy older drivers, those with PD drove fewer kilometers and avoided more challenging driving situations (at night, in peak traffic and long distance trips). However, self-estimates of exposure (km driven) have been shown to be inaccurate (Blanchard et al., 2010; Huebner et al., 2006), raising questions about the reliability and validity of other self-reported driving practices (such as avoidance ratings). As noted, unreliable memory is a concern with PD populations (Rizzo et al., 2010) and cognitive declines associated with Parkinson's, even in the early stages of the disease, can further impair recall.

As noted in the review article by Klimkeit et al. (2009), there is a need for further research on the amount of driving by individuals with PD, the context of driving (e.g., roadways, variable weather conditions, familiar/unfamiliar routes), as well as the capacity of drivers with PD to self-regulate and/or compensate for their functional declines. Instrumented vehicles provide the opportunity to examine naturalistic driving and have been used by Uc, Rizzo and colleagues (e.g., Uc et al., 2009b; Rizzo et al., 2010) to study drivers with PD. However, their research has focused on performance (errors) and not general driving practices (i.e., exposure and patterns). Moreover, the use of in-vehicle cameras and observers may influence a person's normal driving behaviour (Lajunen & Summula, 2003).

As noted at the outset (Chapter One), the primary aim of the present study was to develop a better understanding of self-regulatory practices in drivers with PD by examining when and where they drive, as well as the primary reasons for driving (i.e., trip purposes). The study builds on and extends the work by researchers at the University of Waterloo who used simple electronic devices to objectively assess driving exposure and patterns in healthy older drivers, together with supplemental data (trip logs, Google maps, archives), to examine driving context.

As noted by Klimkeit et al. (2009), it is essential that studies on drivers with PD employ age-matched controls as individuals who volunteer for research studies may be more confident. In a naturalistic driving study, a matched control group is also required to account for the influence of local and seasonal weather and road conditions. The specific objectives of this study were as follows:

1) To examine the extent to which drivers with PD restrict their driving (exposure and patterns) compared to an age-matched control group;
2) To examine perceived comfort level and driving abilities in drivers with PD compared to an age-matched control group;
3) To examine the correspondence between self-report and actual driving restrictions; and
4) For drivers with PD, to examine associations between driving (exposure and patterns), indicators of disease severity (motor scores) and symptoms (depression, sleepiness).

As this was the first study to examine naturalistic driving exposure and patterns in a PD population, it was difficult to formulate a priori expectations. As described previously, individuals with PD can be impacted by a wide range of symptoms (physical, visual and cognitive), as well as negative effects of medications, all of which can impair driving performance (Uc & Rizzo, 2008; Devos et al., 2007; Stolwyk et al., 2006a; Cordell et al., 2008;

Zesiewicz et al., 2002; Wood et al., 2005). However, the extent to which various symptoms associated with PD, either singly or in combination, affect driving exposure and patterns is presently unknown. One might speculate that drivers who experience more sleepiness, depression and other symptoms may restrict their driving (e.g., by driving less overall or only in good conditions, reserving car trips for more essential purposes or relying more on others to drive). However, as noted in Chapter Two, drivers who lack insight into their condition may overestimate their driving abilities and consequently not self-regulate or restrict their driving. One's ability to make strategic driving decisions depends on higher-order executive functions. Thus, it was expected that individuals showing signs of cognitive impairment may not restrict their driving to the same extent as those showing no such indications.

3.2 Ethics Approval and Consent

Prior to recruitment or any contact with potential participants, ethics approval was obtained from both the Office of Research Ethics at the University of Waterloo and the Research Ethics Board at Wilfred Laurier University (WLU). Letters of information were distributed and informed consent obtained from all participants prior to data collection. As drivers with PD were recruited from the WLU's Movement Disorder Research and Rehabilitation Center (MDRC), recruitment protocols were different for the PD and control groups, as described below. Confidentiality was protected by using unique identification codes on all data sources, assigned in order of study entry. None of the questionnaires or scales requested the respondent's name or other personal information and signed consent forms were kept separately and secure (in a locked file cabinet). The master list of participant names and IDs was kept in a password protected file. All participants were assured that no personal information or results (e.g., speeding violations, reported crashes) would be reported to licensing authorities.

3.3 Sample Recruitment

The study consisted of two groups: a sample of drivers with PD and an age-matched control group of older drivers with no neurological disorders, recruited during the same timeframe and from the same region of Kitchener-Waterloo (K-W) to control for seasonal factors and driving conditions respectively. For instance, Trang (2010) found that time of year (hours of daylight) influenced the amount of night driving, while weather and road conditions influenced postponement of discretionary trips.

As described in the proposal, the goal was to recruit 40 PD and 20 control participants. Study entry was staggered due to availability of equipment (15 sets of in-vehicle devices; two Pelli-Robson charts; one brake test), as well as the time required for participant recruitment, assessments and monitoring of naturalistic driving. The intent was to recruit four consecutive waves of participants, each consisting of 10 PD and five control drivers.

The original study inclusion and exclusion criteria, which comprised both individual and vehicle characteristics are outlined in **Table 3.1.** To be eligible for the study, all participants needed to have a valid driver's license and be currently driving at least 3x per week. They also had to live in the K-W region and be available for at least two weeks during the study period. To be compatible with the CarChip, their car had to be 1996 or newer and a non-hybrid model. They also had to be the primary driver of this vehicle (defined as driving 70% of the time or more). Those in the PD group had to have a confirmed diagnosis of PD and at least two cardinal symptoms (i.e., bradykinesia, resting tremor, muscle rigidity and/or postural instability). Except for the PD distinction, the same exclusion criteria (other neurological disorders, schizophrenia, eye disorders, untreated sleep apnea and use of anti-anxiety medications) applied to both groups.

Table 3.1 Study Inclusion/Exclusion Criteria

PD Group		Control Group	
Inclusion	**Exclusion**	**Inclusion**	**Exclusion**
Current driver, valid license, drive 3x/week	Other neurological conditions (Stroke, Dementia)	Current driver, valid license, drive 3x/week	Neurological conditions (PD, Stroke, Dementia)
Aged 65+; male	Schizophrenia	Aged 65+; male	Schizophrenia
Live in K-W region	Glaucoma, Macular Degeneration	Live in K-W region	Glaucoma, Macular Degeneration
Primary Driver (70%)	Untreated Sleep Apnea	Primary Driver (70%)	Untreated Sleep Apnea
Car: 1996 or newer and non-hybrid	Anti-anxiety medications	Car: 1996 or newer and non-hybrid	Anti-anxiety medications

Initially we planned to include only men, aged 65 and older, in the study. As will be detailed in Chapter Four, challenges in recruiting drivers with PD which became evident half way through the study led to a relaxation of both the age and gender criteria. Additionally, drivers who lived outside K-W, but in nearby areas (such as Guelph), were accepted into the study. Recruitment strategies for the PD and control groups are described below.

3.3.1 Drivers with Parkinson's disease

The PD group was recruited from the MDRC by the director (Dr. Almeida) and his staff. The MDRC is a specialized research center located in a redesigned building (previously an elementary school) in a quiet residential neighborhood close to the universities. Individuals with PD are often referred to the MDRC by neurologists to receive more frequent assessments, alternative therapies (e.g., physio-acoustic chair) and rehabilitative exercise programs. The exercise program is offered quarterly in three months intervals with classes 3x/week. In return for these services, MDRC participants agree to be called upon for research studies as needed.

Baseline data for each person is routinely entered into the MDRC database and charts are updated at time of re-assessment, usually every three to six months. In addition to patient contact information, age and gender, the database contains time of diagnosis, onset of symptoms, predominant symptoms, medications, UPDRS scores, and other medical problems (i.e., vision disorders). Additional information such as MMSE scores, scores on various tests (e.g., Timed Up and Go, Sit to Stand, gait analysis, pegboard), as well as heart rate and blood pressure may be included, depending on the type of study the person is in.

As the MDRC database did not include any information on driving status, a screening form was developed for this purpose (shown in **Appendix B**) and subsequently given to all new and returning patients at the time of initial or re-assessment. Patients who were eligible for our study (as determined by Dr. Almeida) were contacted by MDRC staff who then reviewed the study information (also in **Appendix B**), determined interest and booked appointments.

3.3.2 Control Group

Volunteers were primarily recruited via presentations to groups at local rotary clubs and senior centres. Those who expressed interest were then interviewed in person or by phone. The study researcher explained the study, answered questions, determined eligibility and scheduled appointments at the MDRC. During the screening process, potential subjects were asked about their vehicles and the number of drivers in their household. Recruitment materials for the control group are shown in **Appendix C**.

3.4 Study Protocol

All participants were assessed in a designated space at the MDRC and all equipment and materials were securely stored in the researcher's office. The study protocol is shown in **Figure 3.1**. To ensure consistency of the process, the researcher used a check list for each assessment (shown in **Appendices D and E**, respectively). Details for the first (baseline) and second (follow-up) assessments are provided below.

3.4.1 Baseline Assessment

The first visit, beginning with further explanation of the study and written consent, took about an hour, on average. Participants were asked to complete a background questionnaire, followed by the Epworth Sleepiness Scale, the Geriatric Depression Scale, the Parkinson's disease Questionnaire-8 and the Montreal Cognitive Assessment. Contrast sensitivity was then measured using a Pelli-Robson Chart. All materials are shown in **Appendix D**.

The researcher then explained the trip logs using the instructions and example shown in **Appendix D** and discussed potential problems with the electronic devices that could occur over the monitoring period. Each person was given a set of 42 trip logs, the instructions and example sheets, as well as a troubleshooting list (Frequently Asked Questions) for problems with the devices. Following the explanations, the researcher accompanied the person to their vehicle in the parking lot, inserted and tested the two electronic devices and left the set of trip logs (secured to a clip board) on the passenger seat. The researcher also recorded the odometer reading.

Participants were instructed to drive as they normally would for the next two weeks. They were also asked, if possible, not to service their vehicle over this period (a precautionary measure to avoid improper re-installation of the CarChip). Should any concerns or problems arise, control participants were instructed to contact the study researcher directly, while the PD group was instructed to contact the MDRC staff.

3.4.2 Second Assessment

At the end of the two week monitoring period, the study researcher met again with each participant as soon as possible at the MDRC. The second assessment took about an hour and 15 minutes on average, and began with removing the electronic devices, recording the odometer reading and collecting the trip logs. The researcher reviewed the trip logs while participants completed a driving habits questionnaire, the Driving Comfort Scales (DCSs) and the Perceived Driving Abilities (PDA) Scales. The brake test (BRT) test was administered next to give participants a break from writing.

After the BRT test, participants completed the Situational Driving Frequency and Avoidance (SDF, SDA) and the Activities-Specific Balance Confidence (ABC) Scales. A brief interview was then conducted concerning the person's experiences over the monitoring period. Control participants were asked for permission for future contact. Finally, all participants were given a pamphlet on winter driving tips from the Transportation Health and Safety Association of Ontario as a token of appreciation. The checklist for the second assessment and the full set of materials, including the interview script, are in **Appendix E**.

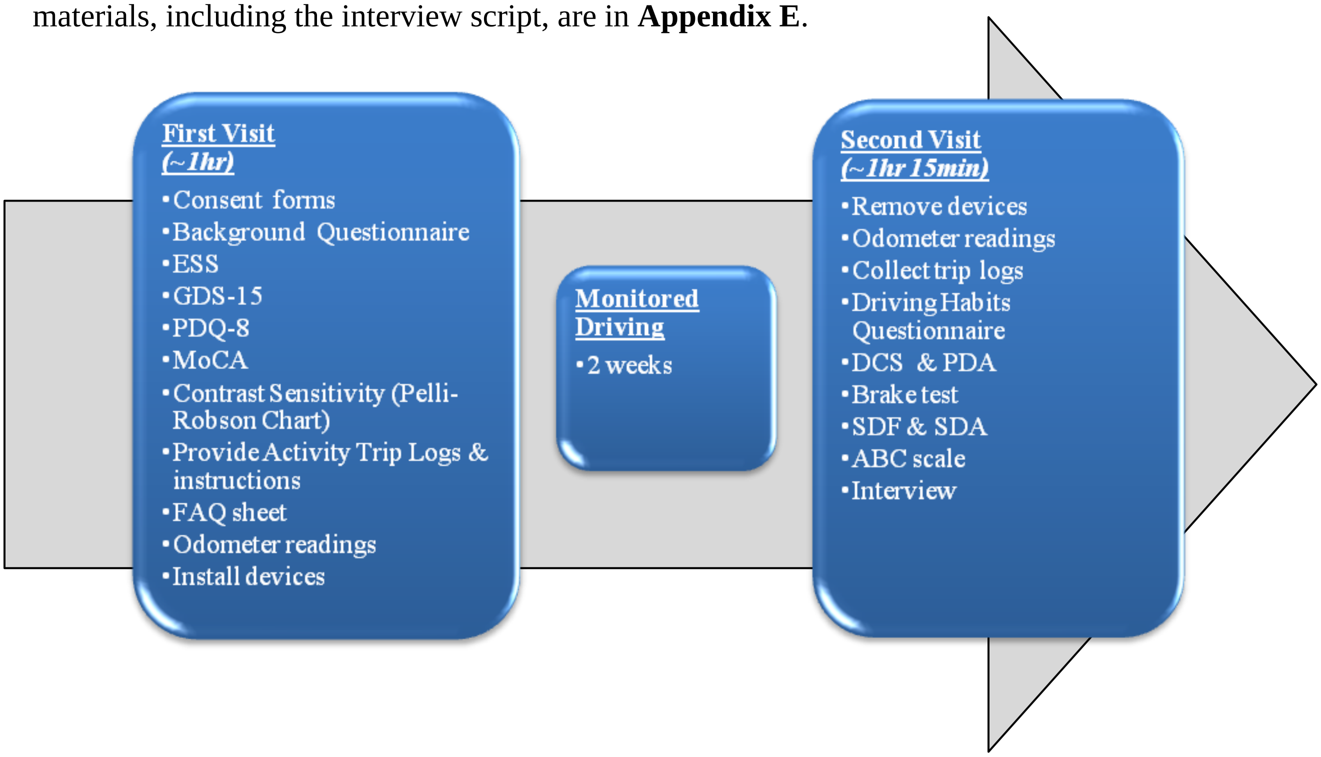

Figure 3.1 Study Protocol
Note: **ESS** = Epworth Sleepiness Scale, **GDS-15** = Geriatric Depression Scale, **PDQ-8** = Parkinson's disease Questionnaire, **MoCA** = Montreal Cognitive Assessment, **DCS** = Driving Comfort Scales, **PDA** = Perceived Driving Abilities Scales, **SDF/SDA** = Situational Driving Frequency/Avoidance Scales, **ABC** = Activities-specific Balance Confidence Scale

3.5 Instruments

This section describes the assessment tools in detail. The order of administration was described above and is shown in **Figure 3.1**. For brevity, some of the materials (e.g., background and driving habits questionnaires) are described in the same section. All tools were self-administered unless otherwise indicated.

3.5.1 Background and Driving Habits Questionnaires

The background and driving habits questionnaires were both modified from previous studies (Blanchard, 2008; Trang, 2010). Shown in **Appendix D**, the background questionnaire consisted of two parts: general information (e.g., age, gender, education) and information on health and mobility. The control group was asked an additional question related to medications.

Two versions of the driving habits questionnaire or DHQ (shown in **Appendix E**) were used: a 27-item version for controls and a 33-item version for PD participants. The DHQ was used to solicit information on driving history, perceived importance of and primary reasons for driving, general driving habits and preferences, thoughts about driving reduction and cessation, and driving problems in the past year. The PD group was asked additional questions about various symptoms and medication use that could affect their driving.

3.5.2 Epworth Sleepiness Scale

The Epworth Sleepiness Scale (ESS), shown in **Appendix D**, is a short, self-administered tool measuring a person's usual level of daytime sleepiness or average sleep propensity (ASP) in daily life (Johns, 1991). The ESS has shown good test-retest reliability, internal consistency and person and item reliability in PD populations (Hagell & Broman, 2007).

The ESS asks the person to rate the likelihood of dozing off or falling asleep in each of eight situations from 0 (would never doze off) to 3 (high chance of dozing). The last item is specifically on dozing while "in a car, while stopped for a few minutes in traffic". Total scores can range from 0 to 24. Scores < 10 are considered normal, 10 to 12 borderline, and > 12 abnormal. ESS scores ≥ 10 have shown 75% sensitivity and 82.5% specificity rate in identifying excessive daytime sleepiness (EDS) in persons with PD (Suzuki, Miyamoto, Miyamoto, Okuma, Hattori, Kamei et al., 2008). The ESS has also shown adequate sensitivity in predicting prior episodes of falling asleep while driving in individuals with PD (Hobson et al., 2002). Higher ESS scores have also been associated with worse UPDRS and Hoehn & Yahr scores (Kumar, Bhatia & Behari, 2003; Suzuki et al., 2008; Hobson et al., 2002; Amick et al., 2007), depressive symptoms and taking higher dosages of dopaminergic drugs (Suzuki et al., 2008; Valko, Waldvogel, Weller, Bassetti, Held & Baumann, 2010).

The ESS was chosen over other scales (e.g., the SCOPA-SLEEP, PD Sleep Scale or the Pittsburg Sleep Questionnaire) as this is the only tool that includes at least one item on driving. However, it is important to note that the ESS measures excessive daytime sleepiness (EDS) and not fatigue. A recent study showed fatigue was associated with depression, disease severity and duration whereas ESS was related to medication use (Valvo et al., 2010). To assess fatigue, two questions in the Driving Habits Questionnaire asked participants if they ever feel tired when driving (#20) and if they have difficulties remaining alert when driving (#21).

3.5.3 Geriatric Depression Scale-15

Although frequently unrecognized and untreated, depression is thought to occur in about 40% of individuals with PD (Snyder & Adler, 2007). To examine the relationship between depression and driving behaviour, the 15-item Geriatric Depression Scale (GDS) was used. The GDS is easy to complete (yes/no format) and has been widely used with seniors in general and

PD populations (e.g., Weintraub, Oehlberg, Katz & Stern, 2006; Weintraub, Saboe & Stern, 2007). Scores can range from 0 to 15, with higher scores indicating more severe depression.

The GDS-15 has demonstrated good sensitivity (88%) and specificity (85%) in distinguishing between depressed and non-depressed individuals with PD using scores ≥ 5 as the cut point (Weintraub et al., 2006; 2007). Depression in older adults with PD has been correlated with disease severity (measured by Webster's rating scale), duration and cognitive impairment (Meara, Michelmore & Hobson, 1999).

3.5.4 Parkinson's disease Questionnaire

The Parkinson's disease Questionnaire (PDQ-8) was used to assess perceived health related quality of life (HRQoL). Adapted from the longer PDQ-39, the PDQ-8 includes one item from each of the eight domains (i.e., mobility, ADL, emotional well-being, stigma, social support, cognitive impairment, communication and bodily discomfort). Each item is rated from never (0) to always (4). Scores are summed and divided by the total possible score (32) to produce a value from 0 (good QofL) to 100 (poor QofL) (Jenkinson, Fitzpatrick, Peto, Greenhall & Hyman, 1997).

The PDQ-8 has shown good internal consistency, test-retest reliability and construct validity (Tan, Luo, Nazri, Li & Thumboo, 2004; Tan, Lau, Au & Luo, 2007). Evidence for construct validity includes significant correlations with UPDRS motor scores and Hoehn & Yahr ratings (Tan et al., 2004; 2007). The PDQ-8 was modified for completion by the control group by removing the term Parkinson's disease from the header and the last item.

3.5.5 Montreal Cognitive Assessment

The Montreal Cognitive Assessment (MoCA) is a relatively new screening measure for mild cognitive impairment (Gill, Freshman, Blender & Ravina, 2008). Compared to the Mini-

Mental State Exam (MMSE), the MoCA addresses a broader range of cognitive domains and is more challenging (Nazem, Siderowf, Duda, Have, Colcher, Horn et al., 2009). The MoCA is comprised of multiple tests (12 in total) of executive/visuospatial functions (3 tests), naming (1 test), memory (1 test), language (2 tests), attention (3 tests), abstraction (1 test) and orientation (1 test) (Gill et al., 2008; Nazem et al., 2009). The MoCA is scored from 0 to 30. Persons scoring < 26 on the MoCA are considered to have mild cognitive impairment (Nasreddine, Phillips, Bédirian, Charbonneau, Whitehead, Collin et al., 2005).

Three studies have found that the MoCA was more sensitive than the MMSE in detecting cognitive impairment in older adults with PD (Zadikoff, Fox, Tang-Wai, Thomsen, de Bie, Wadia et al., 2008; Nazem et al., 2009; Dalrymple-Alford, MacAskill, Nakas, Livingston, Graham, Crucian et al., 2010). Using scores of < 26 on both measures, 50% of 131 patients with PD considered not impaired on the MMSE, were classified as having mild cognitive impairment (MCI) on the MoCA (Nazem et al., 2009). The MoCA is also less prone to ceiling effects than the MMSE (Zadikoff et al., 2008; Gill et al., 2008). Lower MoCA scores (< 26) have also been associated with older age, male gender, less formal education and greater disease severity (UPDRS and Hoehn & Yahr scores), all factors associated with development of dementia in later PD (Nazem et al., 2009). Recently, Dalrymple-Alford et al. (2010) reported that MoCA scores <26/30 had a sensitivity of 90% and a specificity of 75% in detecting mild cognitive impairment in PD patients, while the sensitivity and specificity of scores <21/30 for identifying those with dementia were 81% and 95%, respectively. The MoCA has shown good test-retest and inter-rater reliability and convergent validity in a sample of PD patients (Gill et al., 2008). Prior to data collection, the researcher was trained by Dr. Roy in administering and scoring the MoCA.

3.5.6 Contrast Sensitivity

Contrast Sensitivity (CS) is essential for driving (particularly at night), seeing objects on the road (e.g., pavement markings) and signs at a distance (Owsley, Stalvey, Wells, Sloane & McGwin, 2001). CS deficits in PD populations are due to the neuropathology and do not reflect a normal aging process (Amick, Grace & Ott, 2007b). Devos and colleagues (2007) found significantly poorer CS scores in drivers with PD who failed (versus passed) a road test.

In healthy older drivers, CS has been related to crash risk (e.g., Owsley et al., 2001; Owsley, 1994; Wood, Dique & Troutbeck, 1993) and self-reported driving restrictions (Ball et al., 1998; West, Gildengorin, Haegerstrom-Portnoy, Lott, Schneck & Brabyn, 2003). MacDonald and colleagues (2008) found that drivers with poorer CS scores were significantly more likely to rate their abilities to see road signs, pavement lines, objects at night, curbs and medians as poorer. As CS deficits worse than 1.25 on the Pelli-Robson chart have been related to crash involvement in prior studies (Owsley et al., 2001), this cut-off was used in the current study to indicate impairment.

Shown in **Figure 3.2**, the Pelli-Robson chart is the gold standard for measuring CS by determining an individual's ability to discern objects from the background (Long & Zavod, 2002). CS decreases by 0.15 logMAR units for every successive triplet, from the top left to bottom right, with the letter size remaining constant. Lowest CS occurs when two of the three letters in a triplet cannot be correctly distinguished. The Pelli-Robson chart is relatively easy and quick to administer (Wood & Troutbeck, 1995).

A distance of one meter was marked with tape to standardize the viewing distance. The chart was placed on an easel and moved up or down as needed depending on the person's height. The two versions of the charts were alternated (for left eye, right eye and binocular assessments) to prevent memorization. Participants were instructed to wear their glasses/contacts as usual. Light level or luminance (LUX) was measured by a luminance meter and controlled to 200 LUX as close as possible. Maintaining this level was sometimes difficult in the researcher's office and required closing the drapes (on bright days) or turning on the lights (on cloudy days).

Figure 3.2 Pelli-Robson Chart.

3.5.7 Driving Comfort Scales

The Driving Comfort Scales (DCSs) were developed inductively with older drivers using a sequential and rigorous process (Myers et al., 2008). As participants were adamant that most driving situations were more challenging at night, two separate DCS-D (daytime) and DCS-N (nighttime) scales were created. The 13-item DCS-Day (DCS-D) and the 16-item DCS-Night (DCS-N) scales are shown in **Appendix E.** Both scales are unidimensional and hierarchal, with good person (DCS-D, .89; DCS-N, .96) and item reliabilities (DCS-D, .98; DCS-N, .97). The DCS-D and DCS-N scales have high internal consistency (.92 and .97) and good test-retest reliability over 7-16 days ($ICC_{2,1}$ = .91 and .86) respectively (Myers et al., 2008). Blanchard and

Myers (2010) reported further support for the test-retest reliability of the DCS-D and DCS-N scales ($ICC_{2,1}$ = .89, .92, respectively) with a new sample of older drivers over one week.

When completing the DCS scales, respondents are instructed to consider confidence in their own abilities and driving skills, as well as the situation itself (including other drivers). Scores can range from 0% to 100% where higher scores reflect higher comfort (Myers et al., 2008). To make this scale (as well as the perceived abilities scales, described below) easier for PD participants, checkboxes (as opposed to writing their rating) were used.

3.5.8 Perceived Driving Abilities Scales

The 15-item Perceived Driving Abilities (PDA) Scales (**Appendix E**) were developed to assess perceptions of current driving abilities (PDA) and perceived changes in driving abilities compared to 10 years ago (PDA change), respectively (MacDonald et al., 2008). These tools, also developed with older drivers, are unidimensional and hierarchal, with good internal consistency (α=.94, .87, respectively), person (.92, .82, respectively) and item reliability (.96, .90) respectively (MacDonald et al., 2008). Replication with a new sample of older drivers showed moderate test-retest reliability ($ICC_{2,1}$ = .65, .66, respectively) and better internal consistency for the current than the change scale (α=.92; α=.77) (Blanchard & Myers, 2010).

Respondents rate their current driving abilities on a four-point scale (ranging from "poor" to "very good"), and on the PDA Change Scale from "a lot worse" to "better", compared to 10 years ago. Higher scores (range 0 to 45) indicate more positive perceptions and fewer declines, respectively (MacDonald et al., 2008).

3.5.9 Brake Test

Reaction time (BRT) is slower in drivers with PD compared to controls (Madeley et al., 1991; Singh et al., 2007; Zesiewicz et al., 2002) and has been associated with the ability to drive safely (Singh et al., 2007). Reaction time is considered the time interval between stimulus onset and initiation of movement (i.e., see a stop sign and lifts foot off the accelerator). Movement time is the time between initiation and completion (i.e. lifting foot and depressing brake pedal) (Magill, 2001). Response time is calculated by summing reaction and movement times.

Developed at the University of Waterloo for Lisa MacDonald's study (2007), the brake test (shown in **Figure 3.3**) consisted of two foot switches mounted on a board in the position of accelerator and brake pedal, a timing device and a stimulus of red and green lights (positioned 3 meters from the board and controlled by the researcher). To assess discrimination reaction time, participants were instructed to move their foot from the accelerator to the brake when the red light (versus the green light) was shown. There were five practice trials followed by a standardized sequence of 15 light stimuli.

As PD is known to affect the ability to inhibit the response in a choice or discriminatory brake tests (Gauggel, Rieger & Feghoff, 2004), a simple brake test (response + movement time) was chosen for the current study. Only one stimulus (the red light) was employed. Participants were instructed to move their foot from the gas to the brake pedal after seeing the red light. A total of 30 trials were conducted with 10 trials at intervals of two, five and 10 seconds, respectively. The fore-period (time before red light was shown to participants) was varied across the trials to reduce anticipation by participants. A countdown timer was used (downloaded from the internet - http://www.online-stopwatch.com/full-screen-online-countdown/) to signal the researcher to press the red light button (via a beep transmitted through researcher's earphones connected to the laptop). This protocol was standardized so that all participants had three practice trials, in advance of the 30 scored trials. The distance between the light stimulus and pedals was also standardized at three meters, although participants could adjust the distance between the chair and pedals as needed. The brake test protocol is shown in **Appendix J.**

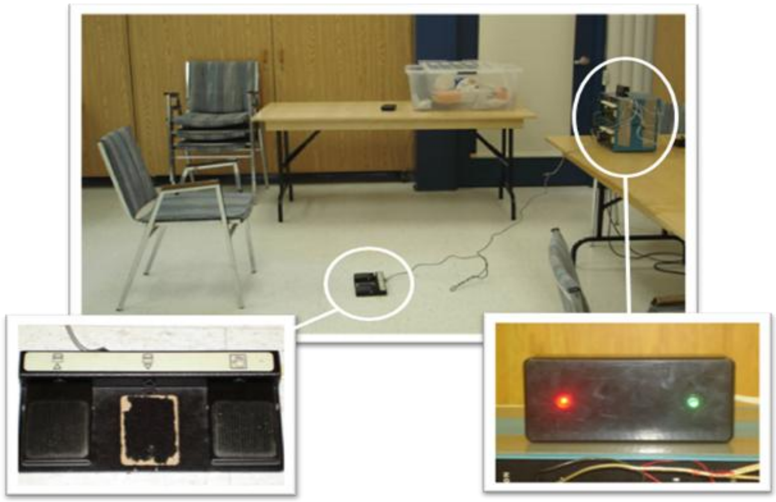

Figure 3.3 Brake Test Apparatus (MacDonald et al., 2008)

3.5.10 Situational Driving Frequency and Avoidance Scales

Self-reported regulatory driving practices were assessed with the Situational Driving Frequency (SDF) and Avoidance (SDA) Scales (**Appendix E**). As explained in MacDonald et al. (2008), the 14-item SDF asks people how often they drive in various challenging situations using a five-point scale (from "never" to "very often: 4-7 days/week"). On the SDA, participants are asked to check (from a 20 item list) the driving situations they try to avoid when possible. Scores can range from 0 to 56 on the SDF and from 0 to 20 on the SDA. Higher scores indicate greater frequency or avoidance of challenging driving situations. Scores on the SDF and SDA scales have demonstrated high internal consistency (α = .92, .87) and 7-14 day test-retest reliability (ICC= .89, .86) respectively (MacDonald et al., 2008). Additional psychometric evidence collected by Blanchard and Myers (2010) showed high internal consistency (α=.92, .87) and good test-retest reliability (ICC=.89, .86).

3.5.11 Activities-specific Balance Confidence Scale

Falls occur in 50% of individuals with PD due to compromised motor function (Ashburn, Stack, Pickering & Ward, 2001). It is possible that individuals with PD who have difficulty walking and using public transportation may be more reliant on driving, especially if they are afraid of falling. Thus, participants were asked about falls on the background questionnaire. To assess balance confidence, the Activities-specific Balance Confidence (ABC) Scale was used. As with the DCS and PDA Scales, checkboxes were used for easier completion.

The 16-item ABC scale is a widely used measure of balance confidence (Jorstad, Hauer, Becker & Lamb, 2005) with good test-retest reliability and evidence of construct validity (Myers, Fletcher, Myers & Sherk, 1998; Myers, Powell, Maki, Holliday, Brawley & Sherk, 1996; Powell & Myers, 1995). As shown in **Appendix E**, each item is rated from 0% (no confidence) to 100% (complete confidence). For the present study, five items (# 17-21) were added to explore balance confidence when using public transport and pedestrian crosswalks.

Falls, fear of falling and reduced balance confidence (assessed by the ABC scale) are more prevalent in adults with PD, and ABC scores have been related to decreased mobility (Adkin, Frank & Jog, 2003; Franchignoni, Martignono, Ferriero & Pasetti, 2005). Adkin and colleagues (2003) found that subjects with PD had lower ABC scores than controls, and in the PD group, ABC scores were negatively correlated with disease severity (UPDRS motor scores), postural instability and gait impairment. Mak & Pang (2009) found that fall history, UPDRS motor and ABC scores were the most significant predictors of recurrent falls in persons with PD. Scores of < 69 on the ABC were the most sensitive (93%) in predicting falls.

3.6 Measures of Driving Exposure and Patterns

To objectively measure driving, two electronic data loggers, the CarChip Pro and the Otto Driving Companion were temporarily installed into each participating vehicle. Trip logs were used to identify the driver and obtain supplementary information, described below.

3.6.1 CarChip Pro

The CarChip Pro (Model 8226; Davis Instruments, Hayward, CA) is a portable electronic data-logging device that is installed in the vehicle's on-board diagnostic (OBDII) system port as shown in **Figure 3.4**. Similar to previous studies (Blanchard, 2008; Huebner et al., 2006; Trang, 2010), the CarChip was used to record date and time stamped driving data. Huebner et al. (2006) showed that CarChips provided more accurate data on distance (km), compared to GPS devices. Measurement error of CarChip recordings was only 0.1 km on a short course (1.8 km) and 0.3 on a longer course (26 km) in a sample of older drivers.

Data logging begins automatically when the engine is turned on, and stops when the engine is turned off (Huebner et al., 2006). The devices were set to record information at one-second intervals. Default settings of .35 and .50g force were used to assess hard and extreme accelerations and decelerations, respectively. The capacity of this model is 300 hours of data, before overwriting begins (Davis Instruments, 2008). Data was uploaded directly to a computer using the CarChip software, Version 2.3.

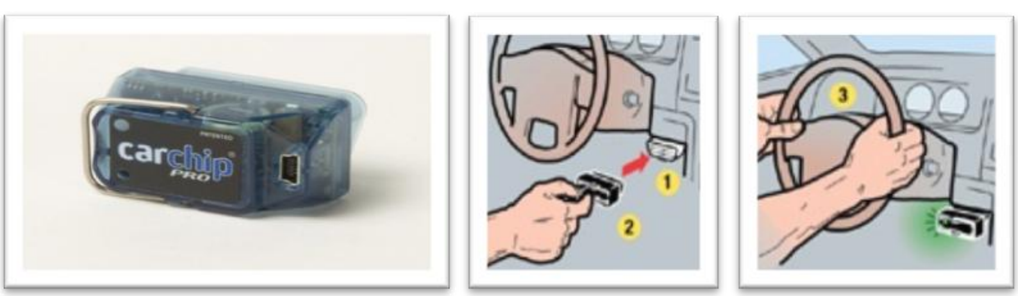

Figure 3.4 CarChip Pro (from Davis Instruments)

3.6.2 Otto Driving Companion

Powered by the AC adapter, the Otto Driving Companion® (Model PM2626; Persen Technologies, Winnipeg, MB) is a small, lightweight device (see **Figure 3.5**) which is mounted on the dashboard to pick up satellite signals. The GPS capabilities are necessary to determine vehicle position (e.g., roadways and left-hand turns) when paired with digital maps. The Otto was set to record date and time-stamped information at one-second intervals (for up to 320 hours without overwriting). Data was uploaded directly to the computer through the Otto website (www.myottomate.com), or when an internet connection was not available, through the Otto Configuration Software, Version 1.03.

Figure 3.5 Otto Driving Companion (From Persen Technologies Inc.)

3.6.3 Trip Logs

The trip logs (shown in **Appendix D**) were adapted from prior studies (Blanchard, 2008; Trang, 2010). Checkboxes were inserted where possible to make completion easier for PD participants. As noted in the protocol section above, trip logs were secured on a clipboard and left in the person's vehicle. For each trip, the driver was asked to indicate the date and time, who was driving (each way), if there were passengers, if they listened to the radio and general weather conditions. At the bottom, they were asked to check the number of stops, time of medication (PD only), arrival time, trip purpose and location.

3.7 Unified Parkinson's disease Rating Scale (UPDRS)

Although the UPDRS is considered the gold standard for assessing PD progression (e.g., Scanlon, Katzen, Levin, Singer & Papapetropoulos, 2008) and captures a broader spectrum of PD symptoms, many studies still use the Hoehn & Yahr Scale. For the present study, the UPDRS motor score was the primary measure of disease severity.

The UPDRS has four sections (Mentation, Mood and Behaviour; ADLs; Motor Exam; and Complications of Drug Therapy). Participant UPDRS motor scores were provided by Dr. Almeida who assesses (clinical exam and interview) all patients at the MDRC. As shown in **Appendix F**, motor scores on the UPDRS can range from 0 to 108 (higher scores indicate greater disease severity) and are calculated using the subscale scores for bradykinesia (0 to 36), tremor (0 to 32), rigidity (0 to 20) and postural instability (0 to 20). Overall UPDRS motor scores (and not the scores for each subscale or cardinal symptom) were provided to the researcher.

As the Hoehn & Yahr Scale provides a general determination of PD severity (Scanlon et al., 2008) and has been used in numerous studies, Dr. Almeida provided instructions on converting UPDRS motor scores to Hoehn & Yahr stages, as shown in **Appendix F**. Compared with the original 5-point scale, the modified Hoehn & Yahr includes two incremental stages (0.5) (Goetz, Poewe, Rascol, Sampaio, Stebbins, Counsell et al., 2004). Ease of administration likely accounts for the popularity of the Hoehn & Yahr Scale (Goetz et al., 2004), however the tool does not have a standardized scoring protocol (Scanlon et al., 2008) nor does it capture non-motor impairments or progressive disability (Goetz et al., 2004).

3.8 Data Handling and Analysis

All scales were scored according to the developers' instructions. For instance, the developers of the DCSs stipulate that 75% of items on the DCS-D (10/13) and DCS-N (12/16), respectively, must be completed for a total score to be calculated (Myers et al., 2008). Other scales (ESS, GDS-15, PDQ-8) require that all items be completed.

To determine the use of parametric (versus non-parametric) analyses, continuous scores and variables (e.g., driving indicators) were assessed for normality using both visual examination (normal probability plots, histograms, stem and leaf plots) and statistical tests (Fisher skewness and kurtosis, Kolmogrov-Smirnov and Shapiro-Wilks tests). Acceptable values for normality were $\pm$1.96 for Fisher skewness and kurtosis, and $\pm$0.50 for Pearson skewness (Pett, 1997).

The Statistical Package for the Social Sciences (SPSS) software, Version 18.0, was used for all quantitative analyses. Qualitative data (i.e., open-ended responses on the BQ, DHQ and trip logs, as well as the interview) were subjected to content analysis, categorized and entered into SPSS for further analysis.

3.8.1 Driving Data

Driving data from the CarChip and Otto were downloaded and entered into Microsoft Excel for cleaning (e.g., removal of trips with 0.0 km and by non-participants) prior to entry into the SPSS database. While all sources of driving data were triangulated for verification, similar to Blanchard (2008) and Trang (2010), the Otto GPS data was used primarily to examine roadways, turns and radius (or distance) from home, while CarChip data was used for all the other driving indicators.

Similar to Blanchard (2008) and Trang (2010), a trip was defined as leaving and returning to one's home. Each trip could be comprised of several segments, defined as stops and starts. Trip segments from the CarChip data were cross-referenced with the trip logs and Otto data to derive complete trips. Stops made while the engine was running were counted in the total number of stops, but not the final stop (at home). Night driving was determined by comparing the time-stamped CarChip data to daily archives of local sunrise and sunset times (http://www.sunsetsunrise.com). Night driving was defined as the period of darkness from sunset to sunrise. Partial night trips were considered trips that began in daylight and were completed in darkness (or vice versa). Amount of daylight (hours:minutes) in which at least one person drove was calculated for the K-W region using the sunrise/sunset website.

To examine radius, GPS data from the Otto was uploaded to Google Earth to calculate maximum and minimum radius from home. Radius was measured by drawing a direct line from the location of the person's home to the furthest point of his/her trip. When only a few segments were missing for a given trip, attempts were made to reconstruct routes by examining other, similar trips by the same individual. Driving patterns, or the types of roads driven (residential, city, rural, highway, freeway) were also examined using Google Earth which contains maps of the K-W region. To determine reasons for driving, trip purposes (as described in the trip logs) were matched with individual CarChip segments, which were then categorized and grouped. Further details are presented in Chapter 4.

3.8.2 Weather Data

Hourly temperatures and weather descriptors (i.e., rain, snow) for the K-W region were retrieved from Environment Canada (http://www.weatheroffice.gc.ca/canada_e.html) for each day of the study period. Severe weather advisories and alerts (e.g., snowstorm, thunderstorm), meanwhile, were retrieved from the local K-W newspaper "The Record". All weather data was entered into Microsoft Excel for organization by days and months. Descriptions for each wave of the study included: hours of daylight, maximum and minimum temperature, cold days (temperature < -15ºC) and hot days (> 32 ºC), weather advisories (e.g., severe storm), type and time of precipitation. Days with no precipitation were considered favourable or "clear".

Weather conditions were examined for all days of the study period in which subjects drove, as well as the days they did not drive. As reported by Blanchard (2008) and Trang (2010), regional forecasts did not always correspond to the conditions participants described in their trip logs (due to localized conditions and changes throughout the day). Furthermore, perceptions of observable weather conditions have been found to have a greater influence of driving behaviour than weather forecasts (Kilpelainen & Summala, 2007). For this reason, weather descriptions from the trip logs were used if there were discrepancies. Trip logs from other participants (driving on the same day) were cross-referenced when possible. In addition to examining the number of days with inclement weather over the study period, the number of opportunities (days) for driving across all participants were examined, similar to Blanchard (2008) and Trang (2010).

3.8.3 Descriptive and Comparative Analysis

Descriptive analysis for continuous variables consisted of measures of central tendency (i.e. mean, standard deviations, range), while categorical variables were expressed as frequencies and percentages. Comparative analysis was used to examine group (PD and control) differences, as well as associations between scores on various measures. Depending on whether variables were normally distributed, either parametric (e.g., Pearson *r*, independent or paired *t*-tests, ANOVAs) or non-parametric equivalents (e.g., Spearman *rho*, Mann-Whitney U, Wilcoxin, Kruskal-Wallis) were used. Binary or categorical variables (e.g., PD versus control, men versus women) were compared using Chi-square (χ^2).

Similar to Blanchard and colleagues (2010), paired *t*-tests and Bland-Altman plots were used to compare self-estimates to actual driving over the two weeks. Measurement error (ME) and coefficient of variance (CV; expressed as a percentage) were calculated to examine agreement between participants' own estimates of weekly distances and actual exposure. Measurement error denotes the discrepancy between measures (Bland and Altman, 1986), while the CV looks at variability in relation to the mean (relative dispersion). A CV of ≤ 10% is considered an acceptable level of agreement (Atkinson & Nevill, 1998). Bland-Altman plots with 95% confidence intervals were also constructed to show a graphical representation of self-estimated versus actual kilometers driven over the two weeks. Self-reported practices (e.g., times of day, roadways) were also compared with indicators of actual driving in the same situation over the monitoring period using both paired *t*-tests and kappa statistics.

Similar to Blanchard et al. (2010), using both the CarChip and GPS data, a Frequency Index (FI) of actual driving in 10 of the 14 challenging situations depicted on the SDF Scale was created. The four situations that could not be examined were: # 1 (driving in the winter), # 6 (over the posted speed limit), # 12 (in new or unfamiliar areas) and # 14 (in parking lots with tight spaces). To examine the correspondence between actual and reported driving patterns, the FI was compared to SDF ratings on the same 10 items. As the study had a two-week monitoring period, the first three response options on the SDF Scale (never, less than once a month but not weekly, more than once a month but not weekly) were collapsed. Independent (PD) and paired *t*-tests were used to compare self-reported (SDF-10) versus actual frequency of driving in challenging situations between and within groups, respectively. Measurement error (ME) and coefficient of variance (CV) were also examined.

Chapter 4: Results

As described in Chapter Three, new and returning PD patients at the MDRC were screened for driving status and study eligibility. This chapter begins by presenting the results of this process, changes to eligibility criteria to increase the sample size, reasons for non-participation and comparisons of current and former drivers. The next section describes recruitment of the final sample (both the PD and control groups) over consecutive waves of data collection followed by a description of data completeness.

The PD and control groups are first compared with respect to general and health characteristics, driving experiences and preferences, functional and performance scores, as well as perceptions of driving comfort and abilities. Self-reported (usual or typical) driving habits are presented next, followed by results on actual driving (exposure and patterns) and trip purposes. Findings from the interview on experiences over the monitoring period (e.g., influence of the devices, car or driving problems) follow. The next section compares self-reported and actual driving exposure and patterns. The chapter concludes with additional findings concerning the associations between self-reported symptoms, functional and performance scores, perceptions and actual driving behaviour in the PD group.

4.1 Screening Results

Between July, 2009 (when screening began) and February 22, 2010 (end of wave 2), 98 PD patients (62 men and 36 women) were screened at the MDRC. However, only 10 men with PD met the study criteria and were willing to participate. Following consultation with the committee, several strategies were implemented to increase study enrolment, namely: reducing the age from 65+ to 55+, including women in the study and accepting participants living outside

K-W, but nearby (e.g., Cambridge, Guelph and Hamilton). Using the broader criteria, screening forms for women with PD, as well as the men who did not meet the original criteria were reconsidered. Between February 24 and June 30, 2010, 30 further patients (22 men and 8 women) were screened by Dr. Almeida. Additionally, a reporter wrote an article on the study which appeared in both the K-W Record and Guelph Mercury on March 6, 2010. As a result of this article, two PD (2 men) and two controls (1 man and 1 woman) were recruited for the study.

The total sampling pool of 128 patients screened at the MDRC over the 12-month period (June, 2009 to June, 2010) ranged in age from 39 to 90 (mean 69.2 ± 10.1); 62% were men. Motor scores on the UPDRS ranged from 8.5 to 68 (mean 30.7 ± 11.0). As shown in **Figure 4.1**, 61% (78/128) were current drivers. Less than half (48%) of those who were eligible (27/56) agreed to participate.

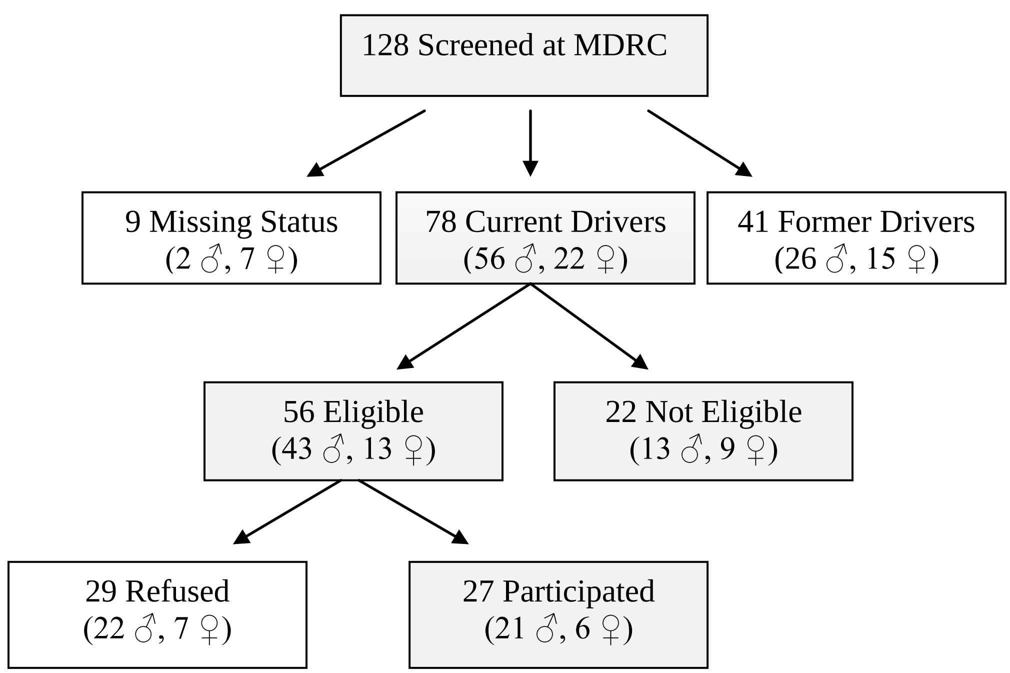

Figure 4.1 Screening Results

Twenty-two of the current drivers (28%) were not eligible due to living outside the region (50%), being under age 55 (22.7%), driving less than 3x/week (9.1%), having a hybrid vehicle (4.5%), having had a stroke (4.5%), glaucoma or AMD (4.5%), or not being diagnosed with PD (4.5%). The two individuals in question were diagnosed with Progressive Supernuclear Palsy. Half of those eligible for the study (29/56) did not wish to participate. Reasons given were fear of being reported to licensing authorities (37.9%), surgery or illness (20.7%), not wanting to be tracked by the GPS (17.2%), being away on vacation (13.8%) or family members not supporting the study (6.9%). A few simply said that they did not drive much anymore (3.4%).

4.1.1 Current versus Former Drivers

On the screening form, those who used to drive but were no longer driving were asked how long ago they had stopped driving and the main reasons for stopping. On average, people had stopped driving 4.27±3.95 years ago (range .8 to 15 years). The most common reason for driving cessation was difficulty moving (43.9%), followed by lack of confidence or nervousness (22.0%), neurologist's suggestion (12.2%), difficulty concentrating (9.8%), sleepiness due to medications (7.3%), family's suggestion (2.4%) and no need to drive anymore (2.4%).

Information from the MDRC database was used to compare the characteristics of the 78 current and 41 former drivers with PD. Current drivers were significantly younger (mean 67.7±10.2 versus 72.5±9.8, p <.02) and more likely to be men (χ^2 = 8.92, p < .05). Former drivers had significantly worse UPDRS motor scores (26.9±8.4 versus 36.4±12.1, p <.001) and were more likely to have freezing symptoms (χ^2 = 4.25, p < .05) than current drivers. There were no differences in the type or number of medications taken.

4.2 Recruitment Waves

Data collection began October 19, 2009 and ended August 24, 2010. The final sample (N=47) comprised 27 drivers with PD and 20 drivers without PD (controls). There were four consecutive waves of data collection, each containing at least five PD and five control drivers as shown in **Table 4.1**. There were no significant age differences between waves for either group. The PD sample was monitored for 182 days in total, compared to 105 days for the smaller sample of controls.

Table 4.1 Participant Breakdown by Wave, Group and Gender

Wave (Monitoring Period)	PD Group	Control Group
1. Oct 19 to Dec 18, 2009	5 (all men)	5 (all men)
2. Jan 13 to Feb 22, 2010	5 (all men)	5 (all men)
3. Mar 1 to Apr 22, 2010	9 (5 men, 4 women)	5 (2 men, 3 women)
4. May 4 to Aug 24, 2010	8 (6 men, 2 women)	5 (4 men, 1 woman)
Totals	**27 (21 men, 6 women)**	**20 (16 men, 4 women)**

Note: Dates shown pertain to first and last appointment for each wave.

Three-quarters of the PD group (20/27 or 74%) lived in the cities of Kitchener and Waterloo (n=15, 55.6%), Cambridge (n=2, 7.4%), Guelph (n=2, 7.4%) and Hamilton (n=1, 3.7%). Seven participants (5 men, 2 women) lived in rural areas of the K-W region, in the towns of Baden (n=3, 11.1%), St. Agatha (n=1, 4.8%), New Dundee (n=1, 4.8%), Belwood (n=1, 4.8%) and Mount Forest (n=1, 4.8%), respectively. Rural was defined as living in places with < 1000 residents and/or where access to key amenities was > 5 km (Statistics Canada, 2008).

Four of the control subjects (all men) had previously participated in Trang's (2009-2010) driving study. The remaining 16 participants (12 men, 4 women) were recruited from rotary clubs (6 men, 1 woman), the Breithaupt Senior's Center (3 men, 2 women), the Waterloo Adult Recreation Center (1 man), the MDRC (1 man) and via the K-W Record article (1 man, 1 woman). All control participants lived in Kitchener or Waterloo (n=19, 95%), except for one woman who lived in the rural town of Wellesley.

4.3 Data Completeness

As might be expected, the PD group took significantly longer than controls to complete the assessment battery at both the first (54.3±11.7, range 25 to 80 minutes versus 45.3±7.2, range 35 to 65 minutes; $t_{45} = 3.27$, $p < .01$) and the second visit (69.6±15.4, range 50 to 120 versus 58.8±11.2, range 45 to 80 minutes; $t_{45} = 2.68$, $p < .01$). All 47 participants completed the questionnaires, scales, both performance tasks and the interview. If the researcher noted missing responses on the self-administered tools, the person was asked whether s/he simply missed the question/item or preferred not to answer. Unfortunately, seven PD participants forgot to bring their medications to the first assessment (as requested in the study letter), precluding detailed examination of the effects of PD medications (and dosage) singly and in combination.

As expected from prior studies, some of the driving data was missing. As shown in **Table 4.2**, one man with PD in wave 3 had no driving data (CarChip, Otto or trip logs). As will be explained in section 4.9, this person had lost his driving license over the study period. While this subject was removed from all analyses involving actual driving data, his other data was included.

Table 4.2 Usable CarChip and Otto Data by Group and Wave

Monitoring Period	PD Group N=27		Control Group N=20	
	CarChip	**Otto**	**CarChip**	**Otto**
1. Oct to Dec, 2009	5	5	5	5
2. Jan to Feb, 2010	4[a]	5	5	5
3. March to April, 2010	8[b]	8[b]	5	3[c]
4. May to August, 2010	7[a]	8	5	4[d]
Totals	**24**	**26**	**20**	**17**

[a] Two men with PD missing CarChip data; both had complete Otto data.
[b] One PD (man) had no driving data (CarChip, Otto or trip logs).
[c] Two controls (1 man and 1 woman) missing Otto data (two weeks and 3 days respectively).
[d] One control (man) missing one week of Otto data.

The remaining 46 participants all had at least one source of driving data (CarChip or Otto), although sometimes incomplete (as detailed in **Table 4.2**). CarChip data was not recorded for two PD subjects as the device was not compatible with their vehicles (a 2010 Mercedes GLK-350 and a 2006 Dodge Caravan). For these two cases, Otto data was used for number of days and nights driven, distance, duration, trips and stops. However, as the Otto does not record force of braking or acceleration, this examination was limited to 24 PD participants.

All 20 controls had complete CarChip data. One person in wave 3 (who disconnected the GPS from the power source) had no Otto data. Two others were missing one week (wave 4) and three days (wave 3), respectively, due to the cable coming loose. In the latter case, routes for the three days were re-constructed using segment data from the CarChip and logs. As described in Chapter Three, segments are recorded each time the vehicle is turned on and off (i.e., the period between starts and stops). Segments are combined to form complete trips (i.e., from the time a person left their home until they returned).

The CarChips recorded a total of 740 trips (341.5 for PD and 398.5 for control drivers), while the Otto recorded 620 trips (342.5 for PD and 337.5 for control drivers). There were a total of 1748 segments recorded by the CarChips. Trip purposes were missing from participant logs for only 2.3% of the segments (40 of 1748). In a few cases there were actually more trip log entries than CarChip segments. For example, some drivers recorded picking up or dropping off passengers as stops in their trip logs. However, if the car was not turned off, the CarChip would not distinguish these as separate segments.

4.4 Sample Characteristics

4.4.1 General and Health Characteristics

Selected characteristics are shown in **Tables 4.3** and **4.4**, while additional results from the Background Questionnaire (BQ) and the Driving Habits Questionnaire (DHQ) can be found in **Appendix H.** Age (both range and means) was similar for the PD and control groups. Only three participants in each group were 80 or older. Although women in the control group were younger, there were no significant differences between or within groups. Both groups were predominately male and three-quarters were well-educated (college or university) and living with a spouse. Only 21% of the sample was currently employed. Thirty-two percent of participants were the only (sole) driver in their household and 58% had only one vehicle. No significant group differences emerged for any of these variables.

Table 4.3 Sample Characteristics by Group

	Total Sample N=47	PD Men n=21	PD Women n=6	Control Men n=16	Control Women n=4
Men **Women**		71.8±6.7 57-82	70.8±7.0 63-82	71.5±8.3 57-84	66.8±5.3 59-71
Age by group	71.1±7.1 57-84	71.6±6.6 57-82		70.6±7.9 57-84	
Education					
Less than High School	3 (6.4)	2 (7.4)		1 (5)	
High School	10 (21.3)	6 (22.2)		4 (20)	
College/University	34 (72.3)	19 (70.4)		15 (75)	
Employed					
No	37 (78.7)	22 (81.5)		15 (75)	
Yes	10 (21.3)	5 (18.5)		5 (25)	
Part Time	5	3		2	
Full Time	5	2		3	
Living Arrangements					
With spouse/partner	36 (76.7)	20 (74.1)		16 (80)	
Alone	9 (19.1)	5 (18.5)		4 (20)	
With family members	2 (4.2)	2 (7.4)		0 (0)	

Table 4.3 Continued….

	Total Sample N=47	PD Men n=21	PD Women n=6	Control Men n=16	Control Women n=4
Sole Driver					
No	31 (66.0)	19 (70.4)		12 (60)	
Yes	15 (31.9)	8 (29.6)		7 (35)	
Missing	1 (2.1)	0 (0)		1 (5)	
# Vehicles					
1 vehicle	27 (57.5)	15 (55.6)		12 (60)	
2 vehicles	19 (40.4)	11 (40.7)		8 (40)	
Missing	1 (2.1)	1 (3.7)		0 (0)	

Note: values are Mean±SD and range or frequencies (%)

As shown in **Table 4.4,** most participants rated their health as good or excellent. Only five people (all PD) rated their health as fair. Apart from PD, the number of reported medical conditions by both groups was similar. The most common problems reported by PD and control participants, respectively, were high blood pressure, cholesterol or heart related (56% versus 50%), followed by arthritis, rheumatism and/or osteoporosis (44% versus 35%), back problems (26% versus 10%), hearing problems (19% versus 35%), sleep disorders (11% versus 15%); and cataracts (7% versus 20%). Ninety-five percent of the sample rated their eyesight as the same or better than most their age. Only two PD participants rated their eyesight as worse. The PD group reportedly took more medications than controls (t = 2.11, p < .05). Based on information from the background questionnaire and the MDRC database, it appears that 23 of the 27 PD subjects were using Levodopa, two were using Azilect, one Requip and another was using both Azilect and Requip.

Sixteen PD (59%) and nine controls (45%) reportedly were enrolled in regular exercise classes or activities. Twelve of the PD participants were in the MDRC exercise program: nine concurrently with the driving study and three who had recently completed this program. Only seven people said they used a cane (six of whom were in the PD group) and one used a walker (one woman in PD group). A significantly greater proportion of control participants felt that they could walk a quarter of a mile ($\chi^2 = 4.15$, $p < .05$) and fewer had reportedly fallen over the past year ($\chi^2 = 7.72$, $p < .01$).

A physical difficulty index consisting of both upper and lower body problems was created. The PD group reported more difficulties overall ($t = -3.84$, $p < .01$), both upper ($t = -3.28$, $p < .01$) and lower body related ($t = -3.14$, $p < .01$) than controls. Specifically, the PD group reported more difficulty initiating movement ($\chi^2 = 5.51$, $p < .02$), more involuntary movements such as shaking and twitching ($\chi^2 = 14.77$, $p < .01$), limited strength or movement ($\chi^2 = 11.88$, $p < .01$), maintaining balance ($\chi^2 = 4.42$, $p < .05$), as well as difficulty staying awake or remaining alert ($\chi^2 = 5.10$, $p < .05$). However, when asked on the DHQ, a greater proportion of the control group (8 or 40%) than the PD group (7 or 26%) reported feeling tired when driving. More detailed results are shown in **Appendix H.**

Table 4.4 Selected Health Characteristics

	Total Sample N=47	**PD Group n=27**	**Control Group n=20**
Health			
Excellent	16 (34.0)	4 (14.8)	12 (60)
Good	26 (55.4)	18 (66.7)	8 (40)
Fair	5 (10.6)	5 (18.5)	0
Poor	0	0	0
Diagnosed conditions			
Mean±S.D.	1.81±1.30	1.89±1.12	1.7±1.53
Range	0 to 5	0 to 4	0 to 5
Perceived eyesight			
Better than most	18 (38.3)	9 (33.3)	9 (45)
About the same	27 (57.4)	16 (59.3)	11 (55)
Worse than most	2 (4.3)	2 (7.4)	0
Taking medications *	2.48±2.00	3.00±1.94	1.80±1.91
	0 to 8	1 to 8	0 to 7
No	6 (12.8)	0	6 (30)
Yes	41 (87.2)	27 (100)	14 (70)

Table 4.4 Continued….

	Total Sample N=47	PD Group n=27	Control Group n=20
Days/week of moderate activity	3.55±1.93 0-7	3.15±1.90 0-7	4.1±1.89 0-7
Exercise classes or activities			
No	22 (46.8)	11 (40.7)	11 (55)
Yes	25 (53.2)	16 (59.3)	9 (45)
Physical Difficulty Index *	1.98±2.25 0 to 7	3.0±2.34 0 to7	.6±1.14 0 to 4
Lower Body Index *	1.19±1.48 0 to 5	1.81±1.59 0 to 5	.35±.75 0 to 3
Upper Body Index *	.87±1.15 0 to 4	1.33±1.27 0 to 4	.25±.55 0 to 2
Use Cane/Walker			
No	39 (83.0)	20 (74.1)	19 (95)
Yes	8 (17.0)	7 (25.9)	1 (5)
Walk ¼ mile *			
No	5 (10.6)	5 (18.5)	0
Yes	42 (89.4)	22 (81.5)	20 (100)
Fallen past year *			
No	35 (74.5)	16 (59.3)	19 (95)
Yes	12 (25.5)	11 (40.7)	1 (5)

Note: values are frequencies and percentages or Mean±SD and range
*****significant group differences

4.4.2 Driving Experience and Preferences

All participants had at least 37 years of driving experience. Three control participants (two men, one woman) currently held another class of license (bus for two, motorcycle for one). As shown in **Appendix H**, forty percent of the sample had discussed their driving with a family member (48% of PD versus 30% of controls), 21% with friends (30% of PD versus 10% of controls) and 28% with an eye care professional (33% of PD versus 20% of controls).

Only 6% of the sample (two in the PD and one in the control group) said their physician had asked about their driving. One of these individuals was told by his neurologist to stop driving during the study and is profiled in section 4.9. While none of the controls had seriously thought about driving reduction or cessation, seven in the PD group said they had thought about reducing their driving, four of whom had thought about quitting in the next few years.

As shown in **Appendix H,** overall the sample reported few driving problems over the past year. Only three reportedly were involved in accidents, one got a traffic violation, and one got lost (all PD subjects). A similar number in both groups had near misses or backed into things. The control group rated continuing to drive as significantly more important than the PD group ($t = -2.06$, $p < .05$), however reasons for continuing to drive were similar in both groups. Maintaining their present lifestyle was seen as most important, followed by getting to shops and services and being able to meet commitments such as volunteer work or helping others.

4.5 Disease Severity and Functional Scores

Table 4.5 presents the results on disease severity (UPDRS motor scores and Hoehn & Yahr) for the PD group, followed by the Epworth Sleepiness Scale (ESS), depression (GDS-15), quality of life (PDQ-8) cognition (MoCA) and balance confidence (ABC) scores for both groups. More detailed results for each of these measures are in **Appendix I**. Comparisons between the 12 individuals with PD who were or had recently been in the MDRC exercise program (exercisers) and 15 who had not (non-exercisers) are also shown below.

Table 4.5 Functional Scores by Group and PD Exercisers versus Non-Exercisers

Scores	**Total Sample N=47**		**PD Group n=27**	
	Controls n=20	**PD n=27**	**MDRC Exercisers n=12**	**Non Exercisers n=15**
UPDRS motor**	-	30.13±8.56	26.58±5.10	32.97±9.80
Hoehn & Yahr	-	2.57±.51	2.46±.54	2.67±.49
ESS Total	5.15±2.96 0 to 12	6.85±3.62 1 to 15	7.0±3.74 2 to 15	6.73±3.65 1 to 14
Normal (< 10)	19 (95)	22 (81.5)	10 (83.3)	12 (80)
Borderline(10-12)	1 (5)	3 (11.1)	1 (8.3)	2 (13.3)
Abnormal (>12)	0 (0)	2 (3.7)	1 (8.3)	1 (6.7)

Table 4.5 Continued….

Scores	Total Sample N=47		PD Group n=27	
	Controls n=20	**PD n=27**	**MDRC Exercisers n=12**	**Non Exercisers n=15**
GDS-15 Total*	1.05±1.50 0 to 6	2.00±1.84 0 to 7	2.0±2.13 0 to 1	2.0±1.64 0 to 6
Normal (0-5)	19 (95)	25 (92.6)	11	14
Suspected (6-10)	1 (5)	2 (7.4)	1	1
Depressed (11-15)	0	0	0	0
PDQ-8 Total*	6.09±8.51 0 to 28.13	16.20±15.60 0 to 62.50	12.76±11.80 0 to 31.25	18.96±18.0 0 to 62.5
MoCA Total*	25.25±2.61 18 to 29	22.78±3.12 16 to 28	23.25±2.96 19 to 27	22.4±3.29 16 to 28
MCI				
Normal (≥26)	11 (55)	7 (25.9)	4	3
MCI Yes (<26)	9 (45)	20 (74.1)	8	12
Dementia (<21)	1 (5)	7 (25.9)	3	4
ABC*	91.9±12.0 51.6 to 100	85.6±11.6 62.5 to 100	86.98±10.16 65.6 to 100	84.58±12.90 62.5 to 98.44

Note: Values are Mean±SD and range or Frequencies (%)
Comparison are chi-square $\chi^2(p)$, independent t-test $t(p)$ or Mann Whitney U $z(p)$
MCI = Mild cognitive impairment.
* significant difference between PD and control groups
**significant difference between PD exercisers versus non-exercisers

4.5.1 Disease Severity

Higher UPDRS motor scores (which can range from 0 to 108) indicate greater disease severity (motor impairment). In the current PD sample, scores ranged from 18 to 50 (mean 30.13±8.56). As shown in the table above, individuals involved in the MDRC exercise program had significantly lower scores than non-exercisers ($t = 2.18$, $p < .05$). No significant difference emerged for the scores of fallers (29.1±5.9) versus non-fallers (30.8±10.1).

The UPDRS motor scores were converted to Hoehn & Yahr stages as described in **Appendix F**. With respect to Hoehn & Yahr staging, 6 of the 27 were classified at stage 2 (22%), fifteen at stage 2.5 (56%), four at stage 3 (15%) and two at stage 4 (7%).

4.5.2 Sleepiness

Scores on the Epworth Sleepiness Scale (ESS) can range from 0 to 24, with scores > 12 indicating a high probability of falling asleep suddenly during the day. Although not significant, the PD group had worse ESS scores than controls (t = 1.72, p = .09). Most PD participants fell into the normal range < 10 (81%), three (11%) were borderline (scores of 10-12) and two (7%) had scores in the high risk range. Comparatively, 95% of controls were considered normal, the remaining 5% borderline. Complete ESS results are in **Appendix I**.

4.5.3 Depression

Scores on the Geriatric Depression Scale-15 (GDS) can range from 0-15, with scores of 11 or higher indicative of depression. Although the scores for the majority of both groups fell into the normal range, as shown in **Table 4.5**, the PD group had significantly higher scores than controls (z = -2.14, p < .05). Only three participants (two of whom had PD) had suspected depression. Of note, the one control participant with suspected depression had just lost his job. With respect to scores on individual items (shown in **Appendix I**), the PD group reported more problems with memory than controls (χ^2 = 7.72, p < .01).

4.5.4 Perceived Quality of Life

As explained in Chapter Three, the Parkinson's disease Questionnaire (PDQ-8) was adapted for the control participants. Scores on the PDQ-8 can range from 0 (good quality of life) to 100 (poor quality of life) percent. The PD group had significantly worse PDQ-8 scores than controls (z = 2.70, p < .01), indicating worse perceived quality of life. Responses on individual PDQ-8 items were also examined, as shown in **Appendix I.** Comparatively, the PD group reported more problems in five of the eight areas: getting around in public (t = 2.80, p < .01);

dressing ($t = 3.76$, $p < .01$); concentration ($t = 3.25$, $p < .01$), communication ($t = 2.63$, $p < .01$) and painful muscle cramps/spasms ($t = 2.80$, $p < .01$).

4.5.5 Cognitive Ability

Scores on the Montreal Cognitive Assessment (MoCA) can range from 0 to 30, with scores < 26 indicative of mild cognitive impairment (MCI). The PD group had significantly lower MoCA scores than controls ($t = 1.88$, $p < .01$), and a greater proportion of PD drivers (n=20, 74%) compared to controls (n=9, 45%) scored below 26 ($\chi^2 = 4.11$, $p < .05$), indicative of MCI. Seven of the PD group and one of the controls had scores below 21, indicating possible dementia. The groups were also compared on each of the 12 subtests (see **Appendix I**). The PD group performed significantly worse on one subtest: the memory component ($t = -2.14$, $p < .05$).

4.5.6 Balance Confidence

Scores on the Activities-specific Balance Confidence (ABC) Scale can range from 0 to 100 percent, with higher scores indicating greater balance confidence. The PD group had significantly lower balance confidence than controls ($z = -2.37$, $p < .02$). As previously noted, 11 of the PD participants, but only one of the controls, reported falling in the past year. Fallers in the PD group had significantly lower ABC scores compared to non-fallers (78.8±11.6 versus 90.3±9.3, $t = 2.86$, $p < .01$).

Scores on the five items added to the ABC for this study were also examined. The PD group scored significantly worse than controls on three of these items: using a pedestrian crosswalk to walk across a busy street ($z = -2.44$, $p < .05$), crossing a busy street at a timed intersection ($z = -2.45$, $p < .05$) and crossing a busy street with no timed intersection ($z = -2.02$, $p < .05$). Complete ABC results are shown in **Appendix I**.

4.6 Performance Scores

As described in Chapter Three, contrast sensitivity was assessed at the first visit, while the brake test was administered during the second visit. The number of hard and extreme accelerations and decelerations (braking) during the monitoring period were examined using the CarChip data. Performance results are presented below.

4.6.1 Contrast Sensitivity

As described in Chapter Three, luminance (LUX) or light level in the room was measured prior to administering the Pelli-Robson charts to each person and adjusted as close as possible to 200 LUX. There was no significant difference in average luminance for the PD and control groups (222.41±45.66 versus 212.65±33.13). The right eye was assessed first, followed by the left eye and binocular vision. Charts were switched each time.

Contrast sensitivity (CS) scores can range from 0 to 2.25 with scores below 1.25 indicating impairment. As shown in **Table 4.6**, the PD group had significantly worse CS in the right eye. Binocular scores were also lower for the PD group (approached significance). Two PD subjects scored in the impaired range for their right eye, while one control did so for the left eye. Both the PD and control groups had significantly better binocular scores versus left ($z = -3.45$, $p < .01$; $z = -3.06$, $p < .01$) and right eye ($z = -3.86$, $p < .01$; $z = -2.56$, $p < .01$) scores, respectively.

Table 4.6 Contrast Sensitivity Scores

	PD Group n=27	Control Group n=20	Significance
Left Eye	1.67±.25	1.68±.40	$z = -.94$, $p = .35$
Right Eye	1.54±.40	1.76±.21	**$z = -2.26$, $p = .029$**
Binocular	1.85±.15	1.92±.09	$z = -1.84$, $p = .07$

Note: values are Mean±SD. Comparisons are Mann-Whitney U test, *z*(*p*)

4.6.2 Brake Reaction, Movement and Response Times

As described in Chapter Three and **Appendix J**, following practice, each person had 10 trials at intervals of 2, 5 and 10 seconds, respectively. Scores were averaged across the 30 trials. Response time was calculated by adding reaction and movement time. The PD group had significantly slower response times for the 5 and 10 second intervals, and across all trials, as shown in **Table 4.7.** Reaction time at the 5 and 10 second intervals approached significance.

Table 4.7 Reaction, Movement and Response Times

Brake Test	PD Group n=27	Control Group n=20	Significance
2 second interval			
Reaction Time	.397±.078	.359±.072	t = 1.73, p =.09
Movement Time	.232±.076	.211±.082	z = -1.36, p = .18
Response Time	.629±.120	.570±.134	t = 1.61, p = .12
5 second interval			
Reaction Time	.341±.046	.313±.054	t = 1.91, p =.06
Movement Time	.254±.090	.214±.083	z = -1.88, p = .06
Response Time	.596±.111	.527±.125	**z = -2.35, $p < .05$**
10 second interval			
Reaction Time	.341±.051	.319±.050	t = 1.46, p =.15
Movement Time	.240±.081	.212±.088	z = -1.85, p = .06
Response Time	.581±.108	.531±.124	**z = -1.96, $p < .05$**
Total Scores			
Reaction Time	.360±.052	.330±.057	t = 1.79, p =.08
Movement Time	.242±.080	.212±.083	z = -1.51, p = .13
Response Time	.605±.106	.543±.126	**z = -2.15, $p < .05$**

Note: values are Mean±SD (seconds). Comparisons are independent t-test $t(p)$ or Mann-Whitney U test, $z(p)$

4.6.3 Braking and Acceleration Patterns

The CarChip measures the force exerted on the brake and accelerator pedals. The default settings classify "hard" as any force > .35g and < .5 g units, while forces of .5 and above are considered "extreme". To control for the amount of driving, number of instances of braking and accelerations recorded by the CarChip were divided by the number of trips made by each person. As shown by the ranges in **Table 4.8**, there were relatively few instances of hard or extreme episodes of either braking or accelerations over the two weeks when controlling for number of trips. For example, the greatest number of hard braking instances by anyone in the PD group was 30 over 10 trips. In the control group, one person had 110 instances of hard braking over 20 trips. The only significant group difference was that the controls had significantly more instances of extreme accelerations.

Table 4.8 Instances of Hard and Extreme Braking and Acceleration

	PD Group n=24	Control Group n=20	Significance
Hard			
Braking	.55±.72 0 to 3	.98±1.44 0 to 5.5	*z* = -1.34, *p* =.18
Acceleration	.37±.40 0 to .22	.70±.87 0 to .71	*z* = -1.18, *p* = .24
Extreme			
Braking	.03±.06 0 to 1.7	.08±.15 0 to 3.7	*z* = -1.45, *p* =.15
Acceleration	.01±.03 0 to .14	.04±.08 0 to .30	***z* = -2.22, *p* = .03**

Note: values are Mean±SD and range. Comparisons are Mann-Whitney test, *z*(*p*)

4.7 Driver Perceptions

Scores on the Day and Night Driving Comfort Scales (DCS-D and DCS-N) can range from 0 to 100 with higher scores indicating greater comfort in driving. Scores on the Perceived Driving Abilities (PDA) Scales, current and change (compared to 10 years ago), can range from 0 to 45 with higher scores indicating more positive perceptions of current abilities and less decline (change) in abilities, respectively. In both the PD and control groups, DCS-D and DCS-N scores were strongly correlated ($r = .91$, $p < .001$ and $r = .85$, $p < .001$, respectively). Daytime driving comfort scores were associated with PDA scores in both the PD ($r = .71$, $p < .001$) and control groups ($r = .65$, $p < .01$). Similarly, night comfort and PDA scores were related ($r = .82$, $p < .001$ and $r = .52$, $p < .05$) for the PD and control groups, respectively.

As shown in **Table 4.9**, Daytime (DCS-D) comfort scores were significantly higher than night time (DCS-N) scores for both the PD (paired t = 5.49, $p < .01$) and control groups (paired t = 3.25, $p < .01$). The PD group scored significantly lower on the DCS-N scale overall (t = -2.5, $p < .05$) and were significantly less comfortable driving at night even in good weather and traffic conditions (DCS-N item #1) than controls (z = -2.11, $p < .05$). The controls also had better PDA scores than the PD group (t = -2.06, p =.05) and women scored higher than the men in the control group (t = -2.27, $p < .05$). Neither group perceived much change in their driving abilities relative to 10 years ago (PDA Change score).

Table 4.9 Perception Scores by Group and Gender

	Group N=47		**PD by Gender n=27**		**Control by Gender n=20**	
	PD n=27	**Control n=20**	**Men n=21**	**Women n=6**	**Men n=16**	**Women n=4**
DCS-D	71.1±19.2 28.9-100	79.8±13.3 50-100	73.1±19.2 28.9 to 100	64.1±19.1 42.3 to 92.3	79.9±14.1 50 to100	79.3±10.7 67.3 to 92.3
DCS-N[a]	58.6±26.1 1.6-100	73.8±15.5 40.6-100	60.3±27.3 1.6 to 100	52.6±22.5 32.8 to 87.5	76.1±15.9 40.6 to 100	64.8±11.4 53.1 to 78.1
DCS-N item #1[a]	83.3±23.0 25-100	95.0±13.1 50-100	82.1±25.2 25 to 100	87.5±13.7 75 to 100	93.8±14.4 50 to 100	100±0 100 to 100
PDA[a, b]	33.4±8.7 13-44	37.7±5.4 27-44	32.7±9.4 13 to 44	36.0±5.4 27 to 41	36.9±5.8 27 to 44	40.8±1.7 39 to 43
PDA Change	25.3±5.7 10-34	26.9±3.3 19-30	25.4±5.7 10 to 34	25.2±5.9 18 to 33	27.1±3.5 19 to 30	25.8±1.7 24 to 28

Note: Mean±SD and range; between and within group comparisons are independent t-tests $t(p)$ or Mann-Whitney U test $z(p)$ (DCS-N item #1);
a = significant group difference; b = significant control gender difference

Rural PD drivers had significantly higher PDA scores than urban drivers, as shown in **Table 4.10**. Although comfort scores were also higher, differences were not significant.

Table 4.10 Perceptions of Rural versus Urban PD drivers

	Rural n=7	**Urban n=20**	***t* or *z* (*p*)**
DCS-D	75.3±20.9 42.3 to 100	69.6±18.9 28.9 to 96.2	-.66 (.51)
DCS-N	69.4±23.9 40.6 to 100	54.8±26.4 1.6 to 95.3	.62 (.21)
DCS-N item #1	92.9±18.9 50 to 100	80.0±23.8 25 to 100	-1.58 (.16)
PDA	38.9±5.2 28 to 43	31.6±9.0 13 to 44	**-2.00 (.05)**

Note: Mean±SD and range; All independent t-test except DCS-N item#1 (Mann-Whitney U)

Those with and without MCI (according to MoCA scores above or below 26) were also compared in both groups, as shown in **Table 4.11**. Drivers with PD considered to have MCI had significantly lower DCS-D scores ($t = 2.13$, $p < .05$) and generally lower DCS-N and PDA scores than those not impaired. Conversely, those considered impaired in the control group had higher DCS-D and PDA scores than their non-impaired counterparts (although not significant).

Table 4.11 Perception Scores by Group and Cognitive Status

	PD Group n=27			**Control Group n=20**	
	No-MCI n=7	**MCI n=20**	**MCI* n=15**	**No-MCI n=11**	**MCI n=9**
DCS-D[a]	80.8±10.9 65.4 to 94.2	67.7±20.5 28.9 to 100	72.3±20.0 42.3 to 100	77.4±14.5 50 to 100	82.7±11.8 57.7 to 100
DCS-N	67.9±20.1 42.2 to 95.3	55.3±27.6 1.6 to 100	64.8±24.0 34.4 to 100	74.3±15.0 50 to 100	73.3±17.1 40.6 to 89.1
DCS-N item #1	92.9±12.2 75 to 100	80.0±25.1 25 to 100	90.0±15.8 50 to 100	95.5±10.1 75 to 100	94.4±16.7 50 to 100
PDA	36.4±4.5 28 to 42	32.4±9.6 13 to 44	36.3±7.0 20 to 44	35.9±6.2 27 to 44	39.9±3.5 31 to 43

Note: Mean±SD and range; Impaired = MoCA scores <26. [a] = significant difference PD group;
*Results when the 5 individuals who rated their health as fair were removed.

Although only five PD participants rated their health as fair (compared to good or excellent), they had substantially lower scores on the DCS-D (53.8±16.5 versus 75.0±17.8, *t* =

-2.42, $p < .05$), DCS-N (26.9±16.3 versus 65.8±22.4, $t = -3.65$, $p < .01$), DCS-N item#1 (50.0±25.0 versus 90.9±14.5, $z = -3.24$, $p < .01$), PDA (20.8±6.8 versus 36.3±6.2, $t = -4.98$, $p < .01$) and PDA Change scores (16.4±4.2 versus 27.4±3.6, $t = -5.98$, $p < .01$), the latter indicating more perceived decline in their driving abilities. All had MCI (MoCA scores ranged from 21 to 25). As shown in **Table 4.11**, when these five individuals were removed, differences in perception scores for those with and without MCI in the PD group were less pronounced and DCS-D scores were no longer significant. In the control group, those rating their health as excellent (n=12) compared to good (n=8) had significantly higher DCS-D (84.8±9.5 versus 72.4±15.2, $t = 2.26$, $p <.05$), PDA (39.7±4.2 versus 34.8±5.9, $t = 2.17$, $p <.05$) and PDA Change scores (28.1±2.1 versus 25.0±4.0, $t = 2.29$, $p <.05$).

Two of the PDA items (# 14 ability to make quick driving decisions and # 15 ability to drive safely, avoid accidents) were examined further for those with and without MCI in each group. As shown in **Table 4.12**, controls with MCI rated their abilities to make quick driving decisions significantly better ($t = 2.25$, $p < .05$) than those without MCI. The same was true for the PD group (but not significant). When the five individuals who rated their health as fair were removed, the remaining 15 people with MCI had even higher ratings of their perceived abilities to make quick driving decisions and driving safety.

Table 4.12 Perceived Abilities to Make Decisions and Drive Safely

	PD Group N=27		**Controls Group N=20**	
PDA items	**No MCI n=7**	**MCI n=20**	**No MCI n=11**	**MCI n=9**
#14 – Make quick decisions*	2.29±.49	2.35±.67	2.45±.52	2.89±.33
#15 – Drive safely	2.71±.49	2.45±.60	2.72±.47	2.89±.33

Note: Mean±SD and range, Comparisons were independent *t*-tests *t*(*p*);
* *p < .05 for controls.* MCI = MoCA scores < 26

Additionally, PD participants who viewed themselves as having better eyesight (n=9) than others their age had significantly higher PDA scores (t = -3.94, p < .01) than those who considered their eyesight to be the same (n=16) or worse (n=2). There were no differences in driving comfort scores. In the control group, there were no differences between the 9 who rated their eyesight at better than most and the 11 who rated their eyesight about the same.

The four PD drivers who had thought about quitting driving had substantially lower DCS-N scores (37.5±11.8 versus 62.2±26.3, t = 1.82, p < .02) compared to those who had not (n =23). Similarly, PD drivers who had thought about reducing their driving (n=7) had significantly lower DCS-N scores (38.4±9.1versus 65.6±26.6, t = 3.96, p < .01) than those who had not (n = 20). While not significant, those who had thought about reducing the amount they drove had somewhat higher MoCA scores (mean 23.7, range 19 to 27 versus 22.5, range 15 to 28) than those who had not. The same was found for those who had thought about quitting (mean 24.8, range 22 to 27 versus 22.4, range 16 to 28). Recall that none of the controls had thought about reducing or quitting driving.

In the PD group, the number of reported driving problems over the past year was inversely related to DCS-D (r = -.49, p < .01) and DCS-N scores (r = -.39, p <.05). In the control group, the number of problems was also related to DCS-D (r = -.59, p = <.01), DCS-N #1 (ρ = -.62, p < .01) and PDA scores (r = -.71, p < .001).

4.8 Self-Reported Driving Behaviour

Usual driving patterns and preferences, as assessed via the DHQ, are shown in **Table 4.13**. The sample drove on average 5.6 days per week with trips lasting 15 to 30 minutes being the most common. Compared to 10 years ago, 33% of the PD group said they drive much less now, as did 15% of the controls (shown in **Appendix H**). Overall, the sample reported driving at all times of the day and on all roadways. A larger proportion of the control group reportedly drove in the afternoon (χ^2 = 4.15, p < .05), at night (χ^2 = 11.80, p < .01) and on freeways (χ^2 = 18.12, p < .01). The sample generally preferred to drive than to use other modes of transport (e.g., bus, taxi). As shown in **Appendix H,** only 7.4% of the PD group said they were close enough to walk for shopping and errands (compared to 40% of the controls). A substantially higher proportion of the PD group preferred to have a passenger as opposed to driving alone (χ^2 = 7.85, p < .05). Forty-three percent of the sample (equal proportions of both groups) said that others relied on them to drive.

Table 4.13 Self-Reported Driving Patterns and Preferences

	Total Sample N=47	**PD Group n=27**	**Control Group n=20**
Days usually driven	5.61±1.41 3 to 7	5.22±1.48 3 to 7	6.15±1.14 4 to 7
Length of trips			
Less than 15 min	4 (8.5)	2 (7.4)	2 (10)
15-30 min	30 (63.8)	19 (70.4)	11 (55)
30-60min	11 (23.4)	5 (18.5)	6 (30)
1 hour+	2 (4.3)	1 (3.7)	1 (50)
Type of Roads			
Residential	41 (87.2)	22 (81.5)	19 (95)
Main city streets	44 (93.6)	24 (88.9)	20 (100)
Rural	27 (57.4)	14 (51.9)	13 (65)
Freeway *****	28 (59.6)	9 (33.3)	19 (95)
Highway	38 (80.9)	20 (74.1)	18 (90)
Time of Day			
Morning	46 (97.9)	26 (96.3)	20 (100)
Afternoon *****	42 (89.4)	22 (81.5)	20 (100)
Early evening	36 (76.6)	19 (70.4)	17 (85)
At night *****	29 (61.7)	11 (40.7)	18 (90)
Transport Preference			
Drive self	46 (97.9)	27 (100)	19 (95)
Someone else drive	0	0	0
Special transit, Taxi, Bus	0	0	0
Walk	1 (2.1)	0	1 (5)
Others rely on you to drive			
No	27 (57.4)	16 (59.3)	11 (55)
Yes	20 (42.6)	11 (40.7)	9 (45)

Table 4.13 Continued....

	Total Sample N=47	PD Group n=27	Control Group n=20
Driving Preference *			
Alone	11 (23.4)	3 (11.1)	8 (40)
Passenger	16 (34.0)	13 (48.1)	3 (15)
No Preference	20 (42.6)	11 (40.7)	9 (45)

Note: values are frequencies (%), Comparisons are Chi-Square;
* significant group difference

Situational Driving Frequency (SDF) and Avoidance (SDA) scores by group and gender are shown in **Table 4.14** below. Scores on the SDF can range from 0 to 56, with higher scores indicating driving more often in challenging situations. Scores on the SDA, meanwhile, can range from 0 to 20 with higher scores indicating greater avoidance of challenging situations. Compared to controls, the PD group had significantly lower SDF scores and higher SDA scores. Rural PD drivers had higher SDF scores (36.3±5.6 versus 32.7±8.9) and lower SDA scores (6.6±4.1 versus 9.6±4.8) than urban drivers, although not significant. Those with and without MCI were also compared in both groups. Average scores on the SDA were quite similar. Scores on the SDF were lower for individuals with MCI in the PD group (32.3±7.8 versus 38.6±7.9) and higher for those with MCI in the control group (40.6±5.6 versus 37.4±7.5), but not significantly.

Table 4.14 SDF and SDA Scores by Group and Gender

	Group N=47		**PD by Gender n=27**		**Control by Gender n=20**	
	PD n=27	**Control n=20**	**Men n=21**	**Women n=6**	**Men n=16**	**Women n=4**
SDF M±SD Range	33.9±8.15 16 to 48	38.8±6.74 23 to 53	34.7±8.7 16 to 48	31.2±5.3 23 to 38	39.3±7.2 23 to 53	37.0±5.1 32 to 44
t(p)	**-2.18 (*p* < .05)**		.94 (*p* = .36)		.59 (*p* = .57)	
SDA M±SD Range	8.52±4.86 0 to 20	4.20±3.33 0 to 9	8.2±5.0 0 to 20	9.7±4.5 5 to 17	4.0±3.2 0 to 9	5.0±4.2 0 to 9
t(p)	**3.42 (*p* < .01)**		-.65 (*p* = .52)		-.37 (*p* = .61)	

Note: Mean±SD and range; Comparisons are independent t-tests, *t*(*p*).

As shown in **Table 4.15,** SDF scores in the PD group were significantly and positively related to driving comfort and perceived ability scores, and inversely related to SDA scores. Scores on the SDA were also related to DCS and PDA scores in the expected direction. Similar associations emerged between the SDA and perception scores in the control group as shown in **Table 4.16**. However, the correlation between SDF and SDA scores did not reach significance, nor did associations between SDF and perception scores.

Table 4.15 Associations SDF, SDA and Perceptions (PD group, n=27)

	DCD-D	DCS-N	PDA	SDF	SDA
SDF	.51**	.57**	.42*	-	-.54**
SDA	-.52**	-.65**	-.53*	-.54**	-

Note: Correlations are Pearson *r*(*p*) or Spearman Rank *ρ*(*p*) for DCS-N#1.
* *p* < .05, ** *p* < .01

Table 4.16 Associations SDF, SDA and Perceptions (Controls, n=20)

	DCD-D	DCS_N	PDA	SDF	SDA
SDF	.22	.32	.38	-	-.38
SDA	-.66**	-.75**	-.46*	-.38	-

Note: Correlations are Pearson *r*(*p*) or Spearman Rank *ρ*(*p*) for DCS-N#1.
* *p* < .05, ** *p* < .01

4.9 Profile of Participant #32

As mentioned earlier, one study participant who was driving at the first assessment (devices were installed in his vehicle) was no longer driving at the second assessment. This man (subject ID # 32), aged 72, from Hamilton, Ontario presents an interesting case. He lives alone in an apartment/condo and was diagnosed in 2004 with PD. His UPDRS motor score (19) was at the low end of the sample range (18 to 50). He reported being in good health and exercised at a moderate intensity 7 days/week, although not in the MDRC exercise program. On the BQ, he reported experiencing problems staying awake (and his ESS score of 10 was borderline), initiating movement, maintaining his balance, as well as persistent pain and limited strength and movement. Despite these problems, his balance confidence (ABC) score was high (85.9%).

He was not depressed according to the GDS-15 (score = 2) nor did he rate his quality of life as poor (score on the PDQ-8 = 12.5%). However, he scored 22 on the MoCA, indicating mild cognitive impairment. In the memory test, he was only able to remember one of the five words he was asked to recall.

His binocular vision on the Pelli-Robson was normal (1.95). His right eye CS was slightly worse (1.65) and his left eye CS was near the impairment cut off (1.35). On the brake test, his overall reaction time (.429 seconds) was one of the slowest (range of .259 to .460 seconds for the PD sample as a whole), however, his movement (.207) and response times (.633) were moderate (sample range of .161 to .454, and .432 to .865 seconds, respectively).

He did not report being involved in an accident over the past year but did mention he had a near miss. He was not very comfortable driving during the day (DCS-D = 55.8%) and even less so at night (DCS-N = 40.6%). He rated his perceived driving abilities quite low (PDA = 20/45), but did not perceive much change in his abilities, compared to 10 years ago. His SDF score was moderate (32/56). However, he reportedly avoided 50% of the challenging driving situations on the SDA Scale (10/20).

He reported that he had seriously thought about reducing the amount he drove as well as giving up driving in the next few years. He had discussed his driving with family, friends and his eye care professional. And his neurologist had told him to stop driving sometime between the first and second study visits. At the second assessment he said that his neurologist had referred him for a comprehensive driving evaluation but he refused to go. He expected to lose his license and had returned his leased vehicle to the dealership. A relative drove him to the second visit in her personal vehicle. Unfortunately, no driving data was retrieved for this individual.

4.10 Actual Driving Behaviour

As described earlier, the Otto (GPS) data was primarily used for examining where people drove (roadways) and calculating radius (distance driven from home). The CarChip data was the primary source of information for the exposure variables. However, as two participants had missing CarChip data, the exposure data from the Otto was used in these cases

4.10.1 Exposure

The PD group drove on average five days per week, making one trip and two stops per day. The longest trip by a PD participant was 325.5 kilometres (km) to the cottage, lasting 4 hours. Comparatively, the control group drove an average of six days per week, making one trip and three stops per day. The longest trip by a control driver was 494.4 km, lasting over 8 hours from Waterloo to New York State (and back) for a motorbike show. Four controls drove over 1,000 km over the two weeks. Comparatively, the highest mileage by a PD driver was 816 km over the two weeks.

The majority of both groups drove with a passenger at least once over the two weeks (88% of PD and 90% of controls). When the number of trips with a passenger was adjusted for the total number of trips, the PD group drove proportionately more with a passenger than the controls (54% versus 41%), although the differences were not significant.

Results for the primary indicators of driving exposure are shown in **Table 4.17** by group and gender. Cumulative scores were calculated for each indicator (e.g., total distance over the full two weeks), then averaged to one week to enable comparisons with prior studies (i.e., Blanchard et al., 2010). In absolute terms, the PD group drove significantly less than controls:

fewer days ($z = -3.22$, $p < .01$), trips ($z = -3.93$, $p < .01$), kilometres ($t = -2.21$, $p < .05$) and for a shorter duration ($t = -2.08$, $p < .05$).

When adjusted for number of days driven, the PD group still made significantly fewer trips ($t = -2.59$, $p = .01$) than controls. However, distance (km) and duration were no longer significantly different between groups when adjusted by either number of days or trips driven. When adjusted for number of trips, the average number of stops was actually slightly higher in the PD group than the controls (2.6±.70 versus 2.4±.73).

Compared to urban drivers with PD (n=19), rural drivers (n=7) generally drove fewer days and made fewer trips, although they drove significantly more km ($t = -2.08$, $p < .05$). There were no differences between exercisers (n=12) and non-exercisers (n=14) in the PD group. Sole drivers in the PD group (n=8, 30%) drove more days, trips, km and for a longer duration than couple drivers. Couple drivers (n=19, 70%), meanwhile, drove more at night and further from home (radius), however, differences were not significant. Similarly, there were no significant differences between sole (n=7, 35%) versus couple drivers (n=13, 65%) in the control group, although sole drivers drove more km at night than couples (neared significance).

Previously, self-reported, annual mileage was used to categorize low (<3000), middle (3000-14000) and high (>14000) exposure drivers (e.g., Langford et al., 2006). Blanchard (2008) used weekly equivalents and categorized subjects based on CarChip data as low (<57.7 km), middle (57.7 to 269.2 km) or high (>269.2 km). Using the same approach, none of our subjects fell into the low category. Twenty-one of the PD drivers (81%) were in the middle category, while five (all rural drivers) were in the high category. Twelve of controls (60%) were in the middle, while five were in the high mileage category.

Table 4.17 Driving Exposure by Group and Gender

	Group N=46		PD by Gender n=26		Control by Gender n=20	
	PD n=26	Control n=20	Men n=20	Women n=6	Men n=16	Women n=4
#Days [a]	4.84±1.35 2 to 7	6.10±.79 4.5 to 7	4.63±1.38 2 to 7	5.58±.97 4.5 to 7	6.16±.77 5 to 7	5.88±.95 4.5 to 6.5
# Trips [a]	6.63±2.90 2 to 14	9.89±3.27 5.5 to 20.5	6.48±3.18 2 to 14	7.17±1.74 5 to 9.75	10.09±3.34 5.5 to 20.5	9.06±3.29 5.5 to 13.25
#Stops [a,b]	16.25±7.61 6.5 to 33	23.88±8.22 14 to 39.5	14.71±6.95 6.5 to 33	22.10±7.81 11 to 32.5	23.53±8.53 14 to 39.5	25.25±7.80 14.5 to 31.5
Distance [a] **(km)**	188.78±102.25 60.95 to 407.9	285.66±174.34 96.05 to 686.9	183.80±113.18 60.95 to 407.9	205.39±56.35 109.3 to 251.52	301.93±184.99 96.05 to 686.9	220.58±119.71 98.75 to 335.05
Duration (hr:min) [a]	4:59±(2:04) 1:59 to 9:14	6:32±(2:59) 3:06 to 14:03	4:38±2:06 1:59 to 9:14	6:10±1:31 4:25 to 8:08	6:51±3:11 3:27 to 14:03	5:17±1:40 3:06 to 6:58
Radius (avg)	6.02±4.65 1.99 to 21.22	6.67±5.40 1.49 to 23.09	6.38±5.08 1.99 to 21.22	4.80±2.78 2.06 to 9.11	6.86±5.79 1.49 to 23.09	6.00±4.17 1.89 to 11.33
Radius (max)	18.63±24.16 3.3 to 112.4	37.85±39.88 2.69 to 121.93	20.80±27.14 3.86 to 112.4	11.38±6.11 3.3 to 18.8	38.40±36.49 3.49 to 111.96	35.80±57.62 2.69 to 121.93
Frequency Index	7.67±2.76 4 to 16	8.94±3.61 3 to 16	7.94±2.95 4 to 16	6.60±1.67 4 to 8	9.46±3.40 5 to 16	7.00±4.24 3 to 12

Note: driving data was averaged to one week;
Group comparisons; independent t-tests $t(p)$ or Mann-Whitney U test $z(p)$ (days, stops, trips, radius (max and avg))
Within PD Group comparisons; independent t-tests $t(p)$ or Mann-Whitney U test $z(p)$ (stops, radius (max and avg))
Within Control Group comparisons; independent t-tests $t(p)$ or Mann-Whitney U test $z(p)$ (days, trips, radius (max and avg))
a = significant group difference,
b = significant PD gender difference

4.10.2 Patterns

This section presents the results on when people drove (weekdays versus weekend, day versus night), under what conditions (good versus bad weather) and where people drove (types of roadways) over the monitoring period. Trip purposes are also examined in detail using information from participant trip logs as well as corresponding CarChip data.

4.10.2.1 When People Drove

When adjusted for the number of days of driving, the PD group made significantly fewer trips on weekdays ($t = -2.92$, $p < .01$) than controls and drove fewer km on the week-end ($t = -1.98$, $p < .05$), as shown in **Table 4.18**. Number of trips and distance/day were lower for the PD group than the controls on both weekdays and weekends, however, only these two comparisons were significant. The PD group drove the most on Tuesdays and Thursdays and the least on Saturdays and Sundays. In contrast, the control group drove the most on Fridays and Saturdays and the least on Wednesdays and Sundays (detailed patterns are shown in **Appendix K).**

Table 4.18 Weekday and Weekend Driving by Group

	PD Group (n=26)	**Control Group (n=20)**
Weekday		
Trips/day [a]	1.30±.39	1.68±.47
	.9 to 2.75	1.14 to 3.1
Distance (km)/day	38.88±23.75	45.43±33.77
	10.64 to 100.0	12.98 to 145.9
Duration	1:01±0:22	1:04±0:31
	0:27 to 1:57	0:32 to 2:14
Weekend		
Trips/day	1.29±.32	1.39±.41
	1 to 2	.75 to 2.5
Distance (km)/day [b]	31.37±35.46	55.68±45.93
	0 to 176.05	6.33 to 168.85
Duration	0:55±0:28	1:05±0:36
	0:17 to 2:25	0:17 to 2:45

Note: values are Mean±SD and range, [a] $p < .01$; [b] $p < .05$

Night driving was defined as the period from sunset to sunrise. Complete trips were those that started and ended in darkness, while partial trips either began or ended in darkness. The sample made at total of 165 night trips over the two weeks (49 complete and 116 partial). The proportion of complete trips was similar for the PD and control drivers (28.4% versus 30.4%). Thirty-four participants (18 PD and 16 controls) drove at night in the first week, while 41 participants (23 PD and 18 controls) drove at night in the second week. Only three PD (11.5%) and two control participants (10%) did not drive at night at all over the monitoring period.

As shown in **Table 4.19**, the PD group drove significantly less often at night (t = -3.27, p < .01), made fewer trips (t = -3.27, p < .01), drove fewer km (t = -2.62, p < .05) and for a shorter duration (z = -2.35, p < .05) than controls. Men in both groups drove more at night (trips, distance and duration), however, gender comparisons were not statistically significant. When adjusted for number of nights driven, group differences in average km and duration were not significant. Controlling for number of opportunities to drive at night (based on 14 days), the PD group drove proportionately less at night than controls ($\chi 2$ = 17.7, p = .001).

Table 4.19 Night Driving by Group and Gender

	Group N=46		**PD by Gender n=26**		**Controls by Gender n=20**	
	PD n=26	**Control n=20**	**Men n=20**	**Women n=6**	**Men n=16**	**Women n=4**
Nights Driven[a]	1.16±.80 0 to 3	2.40±1.54 0 to 5.5	1.18±.80 0 to 3	1.08±.86 0 to2.5	2.66±1.39 .5 to 5.5	1.38±1.89 0 to 4
Night Trips[a]	1.22±.91 0 to 4	2.68±1.93 0 to 7	1.26±.95 0 to 4	1.08±.86 0 to 2.5	3.0±1.85 .5 to 7	1.38±1.89 0 to 4
Night Km[a]	16.22±16.70 0 to 73.45	40.42±38.47 0 to 142.7	18.68±17.78 0 to 73.45	8.42±10.26 0 to 25.65	47.15±39.29 1.5 to 142.7	13.5±21.26 0 to 44.7
Night Duration[a] (min:sec)	25:33±23:30 0 to 1:41:17	55:20±47:54 0 to 3:22:01	28:32±24:54 0 to 101:17	16:04±16:31 0 to 40:06	63:24±47:41 3:24 to 202:01	23:05±37:46 0 to 78:57

Note: Values are Mean± and range, Comparisons are independent t-tests $t(p)$ or Mann-Whitney U test $z(p)$ (night trips, distance and duration)
a = significant group differences

4.10.2.2 Driving Conditions by Wave and Group

As the study took place over a 10-month period, it was important to compare the average amount of daylight across waves. As shown in **Table 4.20**, the average amount of daylight was similar in waves one and two, and progressively increased for waves three and four. Although the sample drove more at night in the first two waves, there were no significant differences within or between the PD and control groups by wave.

The Fall change in Daylight Savings Time (DST) occurred on November 1, 2009. Four of the five control drivers were near the end of their monitoring period at this point; one was at day 3. All the PD drivers started their monitoring period after DST. The Spring change in DST (March 14, 2010) occurred in the midst of wave 3. Except for three drivers in wave three (one control and two PD), all remaining participants completed the study after March 14, 2010.

Table 4.20 Average Daylight and Kilometres by Wave

Wave	Monitoring Period	Number of Participants	Average Daylight	Total Km	Night Km
1	Nov 11 - Dec 18	5 PD	9:18:00	135.7±109.88	17.74±15.33
	Oct 19 - Nov 12	5 Controls	10:20:07	232.41±65.83	47.86±37.18
2	Jan 13 – Jan 29	5 PD	9:29:35	194.62±102.40	22.66±3.47
	Feb 3 - Feb 22	5 Controls	10:23:33	426.85±265.51	68.81±52.32
3	Mar 1 – Apr 22	**8 PD**	**12:27:29**	**196.8±104.98**	**14.55±12.55**
	Feb 3 – 17;	1 Control	10:16:40	310.9±0	44.7±0
	Mar 22 - Apr 19	4 Controls	12:27:19	210.2±103.2	27.0±26.6
		Total 5 Controls	**11:52:37**	**230.35±100.07**	**30.53±24.39**
4	May 25 – Jun 8;	1 PD	15:10:16	99.80	17.30±0
	June 15 – Aug 3;	5 PD	14:31:00	205.3±114.6	18.3±31.3
	Aug 10 – 24	2 PD	13:55:48	278.2±37.7	.58±.81
		Total 8 PD	**14:55:18**	**210.3±103.88**	**13.71±24.98**
	May 4 – 25	**5 Controls**	**14:38:22**	**253.02±160.99**	**14.49±16.72**

Note: Average daylight calculated only for days participants drove
Daylight saving time changed on November 1, 2009 and March 14, 2010

Weather conditions were also examined for all those with driving data (26 PD and 20 controls). As each participant (n=46) drove for two weeks (14 days), there was a total of 644 possible opportunities (days) to either drive or not drive (46x14). Over the study, there were 512 days (79.5%) of clear weather and 132 days (20.5%) with inclement weather, primarily rainfall (104/644 days or 16% of total opportunities). Only four weather advisories were issued in the region over the study period: two extreme cold (< -15ºC) and two heat alerts (> 32ºC). Rain, snow and fog were classified as inclement conditions. As shown in **Table 4.21,** both groups were more likely to drive than not drive on days with poor weather. However, a significantly greater proportion of the PD group (32% versus 12%) did not drive on such days ($\chi^2 = 7.04$, $p < .01$).

Table 4.21 Days Driven and Not Driven by Weather Conditions and Group

Weather	**Total Opportunities (644 total)**	**PD Group (364 total)**	**Control Group (280 total)**
Inclement	132/644 (20.5)	81/364 (22.2)	51/280 (18.2)
Drove	**100/132 (75.8)**	**55/81 (67.9)**	**45/51 (88.2)**
Rain	72/104 (69.2)	39/72 (54.2)	33/72 (45.8)
Snow	20/22 (90.1)	8/20 (40.0)	12/20 (60.0)
Fog	8/8 (100)	8/8 (100)	0/8 (0)
Did not drive*	**32/132 (24.2)**	**26/81 (32.1)**	**6/51 (11.8)**
Rain	30/104 (28.8)	24/30 (80.0)	6/30 (20.0)
Snow	2/22 (9.1)	2/2 (100)	0/2 (0)
Fog	0/8 (0)	0 (0)	0 (0)
Favourable	512/644 (79.5)	283/364 (77.8)	229/280 (81.8)
Drove	398/512 (77.7)	199/283 (70.3)	199/229 (86.9)
Did not drive	114/512 (22.3)	84/283 (29.7)	30/229 (13.1)

Note: Values are frequencies (%); *significant group difference

4.10.2.3 Roadways

For those with usable GPS data (26 PD and 19 controls), roadways were examined by comparing trip segments to routes, as shown in Google Earth. All participants drove on city roads and a substantial proportion of both the PD and control groups drove on residential streets (95%; 100%) and highways (77%; 95%). Fewer in both groups drove on rural roads (69%; 68%) and freeways (46%; 63%), respectively. There were no significant group differences.

4.10.2.4 Radius and Trip Purposes

As noted earlier (refer to **Table 4.16**), there were no significant differences in radius (average or maximum) between groups. About half the trips by both PD and control drivers were within five km of their home (48% versus 57%), compared to between 5 and 10 km (22% versus 26%) and greater than 10 km (30% versus 17%). Rural PD drivers had a significantly larger average radius (z = -2.40, p < .02) than urban drivers. Rural PD drivers made significantly more trips with a radius greater than 10 km, compared to those between 5 and 10 km (z = -2.88, p < .01) and less than 5 km (z = -2.79, p < .01).

Similar to Blanchard (2008) and Trang (2010), trip purposes were identified by matching log entries with CarChip segments, which were then grouped into categories. The date and time for each log entry was matched with the date and time on the CarChip record for the corresponding segment to examine the amount of driving for various purposes. As shown in **Table 4.22**, the highest proportion of trips by both groups was for shopping and errands, followed by social and entertainment.

Table 4.22 Number of Trip Segments for Various Purposes

Categories	**Inclusions**	**# of trip segments by PD (n=829)**	**# of trip segments by Controls (n=924)**
Shopping and errands	Grocery or other type of shopping, banking, pharmacy, gas, haircut, etc.	367 (44.3)	394 (42.6)
Social and entertainment	Movies, visiting others, coffee, eating alone or with others, cards, galleries, shopping as a social event (with others), club meetings, video store, library, events (i.e., showers, weddings).	208 (25.1)	179 (19.4)
Helping others	Driving others (e.g., to mall, shops, appointments, hospital), shopping for others, picked up/dropped off someone, house-sitting or maintenance.	71 (8.6)	57 (6.2)

Table 4.22 Continued....

Categories	Inclusions	# of trip segments by PD (n=829)	# of trip segments by Controls (n=924)
Active leisure	Gym/fitness, hockey, hiking, golf, bowling.	74 (8.9)	64 (6.9)
Religious	Going to church, bible studies, choir.	23 (2.8)	29 (3.1)
Paid work or classes	Full- or part-time paid work, school or lecture series (term registration).	9 (1.1)	59 (6.4)
Medical	For self or spouse: doctor, optometrist, physiotherapist, chiropractor, dentist, massage	41 (4.9)	30 (3.2)
Volunteer work	Organized work done for others that was unpaid, including meetings.	7 (0.8)	63 (6.8)
Other	Funerals, cemetery visits, nursing home visits, car emergency (i.e., flat tire), visiting an ill relative/friend (in hospital, nursing home)	5 (0.6)	7 (0.8)
Out-of-town trips	Trips outside town of residence.	7 (0.8)	16 (1.7)
Missing	CarChip data with no corresponding log entry for trip purpose. Round trips with no stops (i.e., forgot item at home).	17 (2.1)	23 (2.5)

Note: Values are frequencies (%) over the full two week period.
PD group (n=26); controls (n=20).

During the interview, participants were asked about trips they would postpone if the weather was bad or if they did not feel like driving. Both PD and control drivers said that they would most likely postpone trips for shopping/errands (81% versus 60%) and recreational (74% versus 65%), respectively. Nearly half the sample (40% of PD and 50% of controls), however, said they would postpone or cancel all trips (including medical appointments). One PD subject said that "any activity is not vital enough to risk safety during bad weather", while two others said "my wife will drive if the weather is bad". Alternatively, a quarter of both groups said they would not cancel or postpone any trips. One PD subject noted that he lived close enough to stores/shops and could drive without any difficulty regardless of weather conditions.

Participants were further asked if there were any trips they felt compelled to do, even if they did not want to drive that day. The PD group mentioned seeing family (n=3), attending exercise classes at the MDRC (n=2) and shopping (n=1). Comparatively, some control drivers felt compelled to see family in hospitals or long term care (n=3), to keep medical appointments (n=2) and to meet work or volunteer commitments (n=2). The remainder of the PD (n=21) and control group (n=13) said they did not feel compelled to do anything.

Associations between the number of trip segments for specific purposes (e.g., social) and general driving (e.g., number of days driven) are shown in **Tables 4.23 and 4.24** for the PD and control groups, respectively**.** In the PD group, medical appointments, shopping and social activities were significantly associated with total number of days driven, trips and stops. Total km and stops for social trips were significant in the control group, but only night duration was associated with shopping. Active leisure was significantly associated with multiple indicators for the controls, but only with trips for the PD group. Similarly paid work and school were associated with multiple indicators for the controls: trips (day and night), stops, km and nights driven, but only with days driven for the PD group. Volunteer activities were also significantly associated with multiple indicators (stops, night duration and radius) in the controls, as were out of town trips (stops, km and radius).

Trips segments were further categorized as “obligatory” versus “discretionary”. Obligatory trips were considered those requiring a commitment such as paid or volunteer work, school, medical appointments, helping others and those in the “other” category (e.g., funerals, weddings). Discretionary trips were more optional or flexible (e.g., shopping or errands, religious services, and social and leisure activities). Out of town trips were categorized as either obligatory or discretionary based on trip log descriptions.

Discretionary trips significantly correlated with total number of trips for the PD (r = .75, p < .001) and control group (ρ = .56, p < .05. However, obligatory trips in the control group were more strongly related to total km (r = .48, p < .05 versus r = .39, p = .09), maximum (ρ = .47, p < .05 versus ρ = .01, p = .96) and average radius (ρ = .57, p < .01 versus ρ = -.04, p =.87), than in the PD group. As shown, these associations were not significant for the PD group.

Table 4.23 Associations between Driving Indicators and Trip Purposes (PD group, n=26)

	Shopping	Social	Volunteer	Helping Others	Active	Religious	Medical	Paid work/school	Out of Town trips	Other
Days Driven	.51**	.63***	.33	.23	.31	.32	.39*	-.43*	-.16	.46*
Total Trips	.49*	.56**	.24	.55**	.39*	.25	.46*	-.33	-.08	.29
Total Km	.35	.22	-.07	.33	.14	-.24	.12	-.18	.33	-.13
Total Stops	.76***	.74***	.56**	.38	.32	.17	.49*	-.32	.07	.48*
Nights Driven	-.17	.36	-.04	.38	.22	.09	.28	.09	-.33	.15
Night Trips	-.14	.30	.05	.31	.28	.09	.28	.12	-.35	.14
Night Km	-.23	.15	-.09	.14	.37	-.17	.03	.06	-.24	-.18
Night Duration	-.16	.28	-.03	.16	.35	-.10	.12	-.06	-.22	-.01
Max Radius	.04	.02	-.26	-.09	-.14	-.54**	-.22	.07	.13	-.32
Avg Radius	-.01	-.17	-.34	-.08	-.17	-.48*	-.35	.09	.32	-.41*

Note: All values Pearson *r* except for stops, night trips, distance and duration, max and avg radius (Spearman rho)
* $p < .05$; ** $p < .01$; *** $p < .001$

Table 4.24 Associations between Driving Indicators and Trip Purposes (Controls, n=20)

	Shopping	Social	Volunteer	Helping Others	Active	Religious	Medical	Paid work/school	Out of Town trips	Other
Days Driven	.31	-.01	.12	-.16	.48*	.12	-.11	.35	-.07	.49*
Total Trips	.37	.05	-.11	.14	.63**	.03	-.25	.49*	.25	.17
Total Km	.20	.59**	.02	.34	-.09	-.03	.06	.52*	.70***	.14
Total Stops	.40	.46*	.46*	.21	.28	.12	-.30	.45*	.46*	.28
Nights Driven	-.33	.05	.04	.24	.70***	-.04	-.24	.61**	.09	-.19
Night Trips	-.30	.07	.17	.22	.69***	.03	-.26	.64**	.08	-.15
Night Km	-.34	-.01	.40	.22	.32	.22	.11	.21	.16	-.14
Night Duration	-.46*	-.01	.47*	.44*	.49*	.17	-.05	.21	.22	-.11
Max Radius	.01	.14	.45*	.44	-.07	-.07	.12	-.01	.73***	-.14
Avg Radius	-.05	.38	.59**	.28	-.34	-.12	.21	.09	.73***	-.21

Note: All values Pearson *r* except for total trips, night distance and duration, max and avg radius (Spearman rho)
* $p < .05$; ** $p < .01$; *** $p < .001$

4.11 Participant Experiences

When asked if participants experienced any driving problems over the monitoring period, only four PD drivers responded “yes”, as shown in **Table 4.25.** Two PD drivers reported hitting a tree when reversing from their driveway, one hit a pole in a parking lot and another went over the curb in a construction zone. No controls reported any driving problems.

Only four (one PD and three controls) reported being affected by the electronic devices. One PD driver (woman) said she deliberately drove slower as she thought the Otto was tracking her speeding. Two control drivers (both men) reported being distracted by the blinking green light on the Otto. Another control driver (man) complained about the voice prompts “outside the coverage area” and consequently, disconnected the Otto after one week. The vast majority (94%), however, reported no problems with the devices or effects on their driving behaviour.

Three quarters of the sample said their driving was fairly typical over the two weeks. Four PD participants said they drove more, while one said he drove less than usual to work. Reasons for driving more included: scheduled appointments (dentist and doctor), birth of a grand-daughter (three trips to London, Ontario) and driving a visitor (daughter-in-law from South Korea) to tourist attractions (Buffalo, Niagara Falls and Grand Bend). One person specifically said he drove more because he was in our study (usually splits driving with wife). Five controls reported driving more than usual due to appointments (n=2), going to cottage (n=2), and attending lectures (n=1). Two controls reported they drove less due to reduced work and volunteer commitments. As mentioned previously, one control driver made a trip to New York for a motorbike show which he considered fairly typical, as he attends the show annually.

Five participants cancelled trips over the study period. One PD driver cancelled regular activities to lend her car to a friend for a day, while the other did not give a reason. Two controls cancelled trips due to their wives being ill, while one man lost his job and could not afford gas.

Table 4.25 Driver Experiences over the Monitoring Period

Interview Questions	**PD Group n=27**	**Control Group n=20**
A1. Devices Affect Driving?		
No	26 (96.3)	17 (85)
Yes	1 (3.7)	3 (15)
A3. Car/Driving Problems		
No	23 (85.2)	20 (100)
Yes	4 (14.8)	0
A4. Last 2 weeks typical?		
No	5 (18.5)	7 (35)
Yes	21 (77.8)	13 (65)
Missing	1 (3.7)	0
A5. Special Circumstances?		
No	19 (70.4)	11 (55)
Yes	7 (25.9)	9 (45)
Missing	1 (3.7)	0
A6. Regular Activities		
No	4 (14.8)	6 (30)
Yes	23 (96.3)	14 (70)
A7. Any trips not taken?		
No	24 (88.9)	17 (85)
Yes	2 (7.4)	3 (15)
Missing	1 (3.7)	0

Note: Values are frequencies (%). Missing responses from subject #32.

4.12 Self-Reported versus Actual Driving Behaviour

4.12.1 Exposure

When asked if they could estimate the number of kilometres they drove over the two weeks, 87% of the sample (22 of the 26 PD and 18 of the 20 controls) did so. Carchip data was available for all these individuals. As shown in **Table 4.26,** mean self-estimates in the PD group were significantly lower than actual distance driven over the two weeks. While self-estimates were also lower in the control group, the means were not significantly different.

Table 4.26 Estimated and Actual km Driven by Group

	Estimated km	Actual km (CarChip)	*t*(*p*)
PD (n = 22)	282.91±154.03 40 to 600	387.68±216.10 121.9 to 815.8	-3.687 **(.001)**
Control (n = 18)	493.89±284.96 100 to 1000	584.96±361.08 192.1 to 1373.8	-1.365 (.19)

Note: Mean±SD, range; comparisons are paired t-tests *t*(p)

As shown in **Figure 4.2** below, 20 of the 22 PD drivers (91%) mis-estimated by 50 km and 14 (64%) were off by at least 100 km. Two people under-estimated by more than 250 km. Agreement with the CarChip data was poor (CV was 89.9%, ME = 94.2 km). PD drivers with MCI (n=16) did not significantly mis-estimate to a greater extent than those without MCI (n=6).

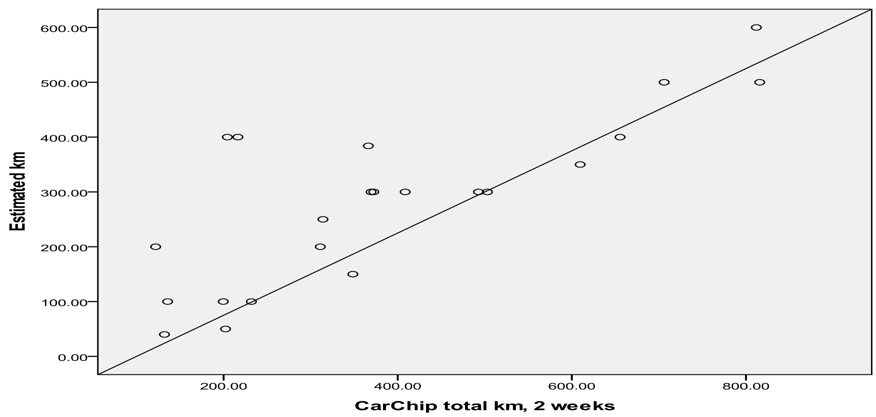

Figure 4.2 PD Group - Scatter plot of Estimated versus Actual kilometres with line of equality (slope)

Bland-Altman plots with 95% confidence intervals were constructed to show the extent of agreement between self-estimated and actual km driven (means of both on the x-axis and the difference between the two on the y-axis). As shown in **Figure 4.3**, only a couple of points (subjects) fall outside the limits of agreement. Eighteen of the PD drivers under-estimated (82%), while four over-estimated distance driven.

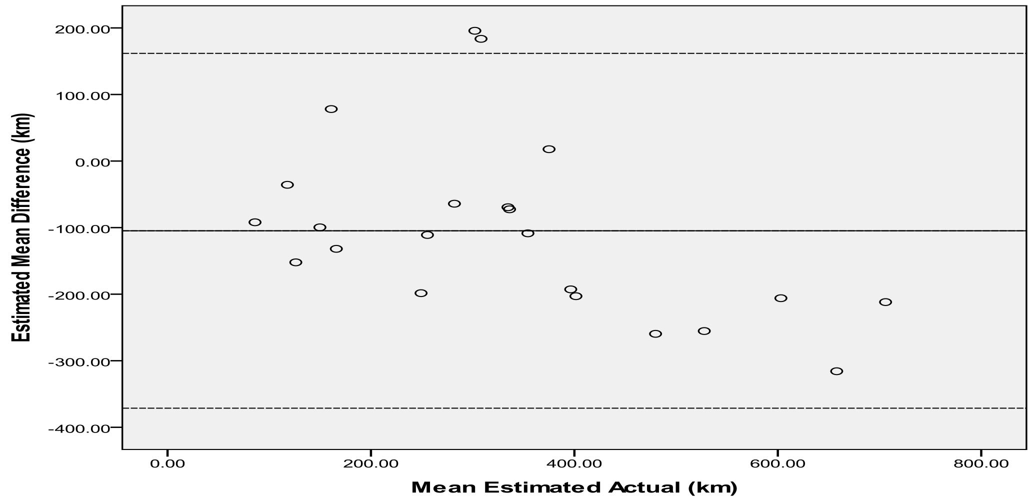

Figure 4.3 PD Group - Bland-Altman Plot with 95% limits of agreement of difference in distance (Estimated – Actual) versus average values of both measures
Note: the mean difference and line of equality are far apart (-104.77 versus 0)

Although mean differences were not significant, the controls also mis-estimated the number of km they actually drove, as shown in **Figure 4.4**. The estimates of 12 drivers (67%) were off by at least 100 km, while six were off by more than 250 km (four over and two under-estimated. One person under-estimated by 768 km. The CV was 219.7% and the ME = 210.10 km, showing very poor agreement with the objective data. Control drivers with MCI (n=9) mis-estimated to a significantly greater extent (-271.3±282.4 versus 53.1±193.1 km, t = 2.89, p = .01) than those without MCI (n=11).

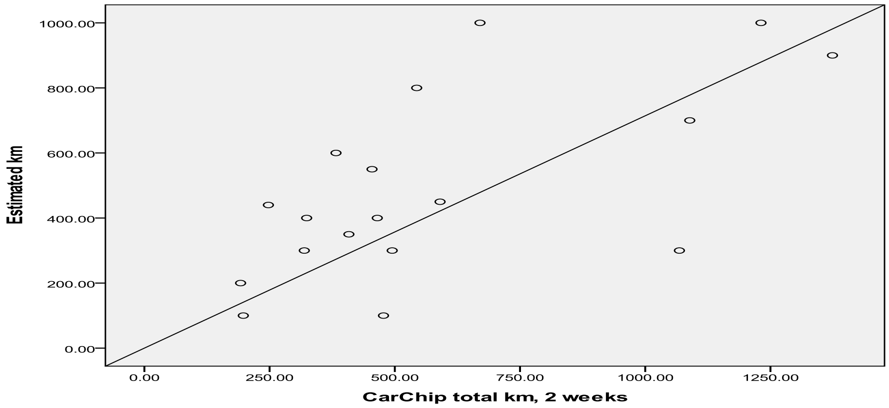

Figure 4.4 Control Group - Scatter plot of Estimated versus Actual kilometres with line of equality

Bland-Altman plots (**Figure 4.5**) show only one point falling outside the limits of agreement. Eleven controls (61%) under-estimated, while 7 over-estimated distance driven.

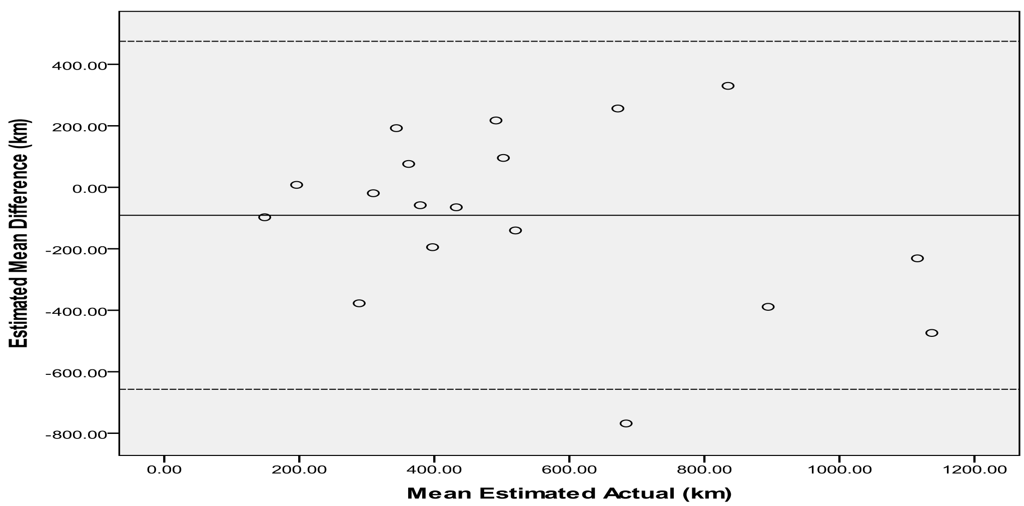

Figure 4.5 Control Group - Bland-Altman Plot with 95% limits of agreement of difference in distance (Estimated – Actual) versus average values of both measures. Note: the mean difference and line of equality are far apart (-91.07 versus 0)

4.12.2 Patterns

The modified SDF scale (10 of 14 items and collapsed responses) and the corresponding frequency index (FI) of actually driving in these 10 situations were described in Chapter Three.

Scores on both can range from 0 to 20, with higher scores indicating more self-reported and actual driving in challenging situations, respectively. The PD group had higher mean actual versus self-report scores (7.67±2.76 versus 6.5±4.09), although the difference was not significant. Thirteen PD drivers (54%) had higher FI scores, eight (33%) had higher self-report scores and three (13%) scored the same on both measures. The CV was 37% and the ME 2.6.

Actual versus self-report mean scores in controls (8.9±3.61 versus 9.0±3.92) were also not significantly different. Nine (47%) had higher FI scores, seven (37%) had higher self-report and three (16%) scored the same on both measures. The CV was 43% and the ME = 3.9.

There were no significant differences in FI scores between groups. However, the controls had significantly higher self-ratings (SDF-10) than the PD group (t = -2.03, p < .05). As scores on the FI and self-reported SDF (10 items) were generally lower than the theoretical mean of 10, neither group drove that often in challenging situations over the two-week period.

All subjects who reportedly drove in the morning and afternoon (on the DHQ) actually did so, as shown in **Table 4.27**. However, there was poor agreement in the PD group with respect to self-reported versus actual evening and night driving. Twelve of the PD drivers who said they try and avoid night driving (on the SDA) drove at least once at night over two weeks. Mean distance (km) driven at night was lower for “avoiders” (11.9±11.8) than “non-avoiders” (20.9±20.3), although not significant. In controls, only 1/20 said they try and avoid night driving when possible and there was good agreement between self-reported and actual night driving.

Table 4.27 Self-Reported and Actual Driving: Time of Day

	PD Group (n=26)			**Controls (n=19)**		
Self-report On DHQ	**Actually drove**		**κ (*p*)**	**Actually drove**		**κ (*p*)**
	No	**Yes**		**No**	**Yes**	
Morning						
No	0	1	*	0	0	*
Yes	0	25		0	20	
Afternoon						
No	0	4	*	0	0	*
Yes	0	22		0	20	
Evening						
No	0	8	-.14 (.33)	0	3	*
Yes	2	16		0	17	
Night						
No	2	13	.04 (.74)	1	1	**.44 (.047)**
Yes	1	10		1	17	

*κ not computed as there must be at least one case in each row or column

Table 4.28 shows typical or usual patterns versus actual roadways driven. In the PD group, kappa was significant for residential and freeway driving. Agreement was also good for rural roads, but poor for highway driving. In controls, agreement was poor with respect to driving on rural roads, highways and freeways. While 65% of the PD and 40% of the controls said that they try and avoid driving during rush hour on the SDA, the majority of both groups did drive during rush hour over the two weeks (92% and 95%).

Table 4.28 Self-Reported and Actual Driving: Roadways

	PD Group, n=26			Controls, n=19		
Self-report	**Actually drove**		**κ (*p*)**	**Actually drove**		**κ (*p*)**
	No	**Yes**		**No**	**Yes**	
Residential						
No	1	3	**.36 (.02)**	0	1	*
Yes	0	22		0	18	
City						
No	0	3	*	0	0	*
Yes	0	23		0	19	
Rural						
No	6	7	.31 (.09)	1	5	-.22 (.34)
Yes	2	11		5	8	
Highway						
No	0	6	-.30 (.13)	0	2	-.08 (.73)
Yes	6	14		1	16	
Freeway						
No	13	4	**.61 (.001)**	0	1	-.10 (.43)
Yes	1	8		7	11	

*κ not computed as each row and column must have at least one case

4.13 Further Associations in PD Group

4.13.1 Self-Reported Symptoms and Health

Self-reported symptoms/difficulties (as reported in the BQ) were examined in relation to functional scores and driving behaviour (self-report and actual). Drivers with PD reporting difficulty initiating movement had significantly lower PDQ-8 scores than those who did not report such difficulty ($z = -2.75$, $p < .01$). Additionally, PD drivers who reported having limited strength and movement had significantly lower Hoehn & Yahr scores ($t = -2.32$, $p < .05$) and lower ABC scores ($t = 2.86$, $p < .01$). Those experiencing stiffness had significantly higher UPDRS ($t = -2.06$, $p < .05$) and lower PDQ-8 scores ($z = -2.53$, $p < .01$). Interestingly, those who reported having balance difficulties did not have significantly lower ABC scores, but did have significantly worse left eye CS than those without balance difficulties ($t = 2.18$, $p < .05$).

Scores on the SDA were significantly higher for those reporting limited strength and movement compared to those without this issue (10.3.±4.3 versus 6.0±4.2, $t = -2.43$, $p < .05$). Otherwise, there were no significant associations. Those with balance difficulties actually drove significantly more often (days) than those without balance difficulties ($t = -2.08$, $p < .05$). No other driving indicators were significant with self-reported movement or strength problems.

There were five PD drivers who rated their health as fair: four men and one woman, average age 72.2±6.2 (range 64 to 80). MoCA scores ranged from 21 to 25 (mean 23±2.0), indicating all had MCI (<26). The most common health problems reported were heart related (by four), arthritis or osteoarthritis (by three), foot (one), hearing (one) and sleep problems (one). Compared to those who rated their health as good or excellent (n=22), this group of five had significantly worse UPDRS scores (36.9±6.0 versus 28.6±8.4, $t = 2.08$, $p < .05$), depression (3.4±.90 versus 1.7±1.9, $z = -2.50$, $p < .05$), quality of life (27.5±13.5 versus 13.6±15.1, $z = -2.05$, $p < .05$), binocular contrast sensitivity (1.71±.13 versus 1.88±.14, $z = -2.37$, $p < .05$) and response time (.695±.12 versus .585±.09 seconds, $t = 2.27$, $p < .05$). Additionally, they drove fewer kilometres (135.3±57.8 km versus 201.5±107.3 km), for a shorter duration (3 hrs:54 minutes versus 5 hrs:15 minutes) and closer to home (14.6±12.0 km versus 19.6±26.4 km), although differences were not significant.

Those with (n=7) and without MCI (n=15) in the PD group were further compared, after removing the five who rated their health as fair. The impaired group were significantly older (73.5±5.8 versus 67.0±7.3, t = -2.25, p < .05), however, there were no differences in functional or performance scores or driving (for those with driving data; missing for subject # 32). For example, those with MCI (n = 6) drove a similar distance (198.1±114.8 versus 208.3±98.9 km) and duration (5 hrs;21 minutes versus 5 hours) than those without MCI.

4.13.2 Functional Indicators

As shown in **Table 4.29**, PDQ scores (higher scores indicate poorer quality of life) were positively associated with UPDRS motor scores (greater severity), sleepiness and GDS scores.

Table 4.29 Associations between Functional Scores (n=27)

	UPDRS	ESS	GDS-15	PDQ-8	MoCA	ABC
UPDRS	-	-.05	.17	.42*	-.09	-.18
ESS	-.05	-	.32	.49**	.23	.07
GDS-15	.17	.32	-	.65**	.02	-.24
PDQ-8	.42*	.49**	.65**	-	.17	-.25
MoCA	-.09	.23	.02	.17	-	-.03
ABC	-.18	.07	-.24	-.25	-.03	-

Note: Pearson *r*(p) except for GDS-15 and PDQ-8 (Spearman rho), *p<.05; **p< .01

As shown in **Table 4.30**, scores on the GDS-15 and PDQ-8 were significantly related with DCS-N and PDA scores in the expected directions (higher night comfort and perceived abilities related to lower depression and better quality of life). Scores on the SDA were significantly related to PDQ-8 scores (greater driving avoidance related to worse quality of life).

Table 4.30 Functional Scores, Perceptions and Self-Reported Driving (n=27)

	DCS-D	DCS-N	PDA	SDF	SDA
UPDRS	-.21	-.24	-.29	-.10	.33
H & Y	-.24	-.14	-.09	.01	.15
ESS	-.25	-.22	-.31	.31	.18
GDS-15	-.31	-.49*	-.44*	-.03	.20
PDQ-8	-.32	-.42*	-.42*	.01	.40*
MoCA	.12	-.08	-.02	.10	.26

Note: Pearson *r*(p) except for DCS-N item #1, GDS-15 and PDQ-8 (Spearman rho), *p<.05

As shown in **Table 4.31**, there were no associations between functional scores and measures of actual driving. Fallers (n=11) generally drove less at night (nights, trips, distance, duration) than non-fallers (n=15), with distance approaching significance (p = .07).

Table 4.31 Functional Scores and Driving Indicators (n=26)

	UPDRS	ESS	GDS-15	PDQ-8	MoCA	ABC
Days	.15	.04	.20	.05	.22	-.05
Trips	.07	.21	.33	.09	.18	.10
Stops	-.12	.06	-.01	-.02	.32	-.13
Distance	-.21	-.01	.02	-.09	.26	.15
Duration	-.11	.03	.16	.01	.24	.02
Max Radius	-.12	.04	.11	.12	.30	-.10
Avg Radius	-.15	-.15	-.11	-.11	.16	-.05
Nights Driven	.07	.36	.36	.39	-.21	.05
Night Trips	-.10	.27	.28	.23	-.28	.06
Night Distance	-.21	.20	.10	.11	-.25	.09
Night Duration	-.16	.22	.15	.13	-.24	.32
Frequency Index	-.15	.32	-.06	-.05	.02	.13

Note: Pearson r except GDS-15, PDQ-8, stops, max and avg radius, night trips, distance and duration

4.13.3 Perceptions

Scores on the DCS-N ($\rho = .42$, $p < .05$) and PDA ($r = .41$, $p < .05$) were significantly associated with average radius, while DCS-D scores were not significantly associated with any of the driving indicators. Associations between perception scores and all the driving indicators (for both the PD and control groups) are shown in **Appendix L**.

To further examine the influence of comfort level, scores for the PD group were divided at the scale midpoint (50%), as shown below in **Table 4.32**. Those who scored above 50% on the DCS-D generally drove a greater distance and for a longer duration.While only three participants had DCS-Day scores below the midpoint, the sample was more evenly divided for DCS-Night scores. Those with higher driving comfort at night (DCS-N scores >50%) were significantly more likely to drive further from their home (average radius). They also drove, on average, a greater distance (km) and for a longer duration, although differences were not significant.

Table 4.32 Exposure and Patterns by Driving Comfort (n=26)

	DCS-Day		DCS-Night	
	≤50% n=3	>50% n=23	≤50% n=12	>50% n=14
Days	4.2±1.0	4.9±1.4	4.9±1.2	4.8±1.5
Trips	4.6±1.7	6.9±2.9	6.6±3.3	6.7±2.7
Stops	13.7±8.8	16.6±7.6	16.7±9.2	15.8±6.1
Distance	157.2±77.3	192.9±105.8	153.6±86.9	219.0±107.6
Duration	4:01:07±1:27:15	5:06:40±2:07:36	4:33:44±2:16:00	5:20:51±1:3:20
Max Radius	16.2±16.0	18.9±25.3	11.4±8.8	24.8±31.1
Avg Radius *	6.1±3.7	6.0±4.8	3.9±2.2	7.8±5.5
Nights Driven	.83±.29	1.2±.84	1.3±.89	1.0±.72
Night Trips	.83±.29	1.3±.96	1.4±1.1	1.1±.73
Night Distance	10.8±13.0	17.0±17.3	14.6±12.2	17.7±20.4
Night Duration	0:13:15±0:14:49	0:27:13±0:24:11	0:27:47±0:27:30	0:23:29±0:20:01

Note: Mean±SD, * DCS-N Average Radius significant at *p* <.05

4.13.4 Performance Scores

As shown in **Table 4.33**, DCS-D, DCS-N, PDA and SDF scores were significantly and positively associated with left eye contrast sensitivity (CS). Binocular CS scores were moderately correlated with perceptions, but not significantly. Times on the brake test were not related to perception, SDA or SDF scores.

Table 4.33 Performance, Perceptions and Self-Reported Driving (n=27)

	DCS-D	DCS-N	DCS-N Item 1	PDA	SDF	SDA
Contrast Sensitivity						
Left eye	.46*	.46*	.28	.48*	.41*	-.38
Right eye	.30	.29	.37	.19	.25	-.37
Binocular	.33	.31	.28	.27	.13	-.25
Brake Test						
Reaction Time	-.15	-.09	-.05	-.33	-.08	.28
Movement Time	.19	.13	.04	.14	.08	-.18
Response Time	.11	.13	-.05	-.20	.07	.03

Note: Pearson *r*(*p*) or Spearman *ρ*(*p*) for DCS-N item 1, Right and Binocular CS, and Movement Time. *p<.05

As shown in **Appendix E**, the PDA scale encompasses multiple driving-related abilities, thus. similar to MacDonald et al. (2008), performance scores were compared to corresponding individual items on the PDA scale. As shown in **Table 4.34**, left eye CS scores were positively related to perceived abilities to avoid curbs and medians, as well as see objects on the road at night. Other items neared significance. Additionally, slower reaction and response times on the brake test were inversely associated with PDA item 9, i.e., perceived ability to move one's foot quickly from the gas to the brake pedal (r = -.38, p > .05 and r = -.39, p > .05, respectively).

Table 4.34 Correlations between Performance Scores and PDA Items (n=27)

PDA Items	**Left CS**	**Right CS**	**Binocular CS**
1. See road signs at a distance	.34 (.08)	.10 (.63)	.07 (.74)
2. See road signs at distance (at night)	.36 (.07)	.12 (.55)	.31 (.12)
3. See your speedometer and controls	.33 (.06)	.20 (.32)	.16 (.42)
4. See pavement lines (at night)	.33 (.09)	.19 (.35)	.32 (.11)
5. Avoid hitting curbs and medians	**.42 (.03)**	.32 (.11)	.20 (.32)
7. See objects on road at night with glare from lights or wet roads	**.38 (.05)**	.09 (.69)	.37 (.06)

Note: Pearson $r(p)$ or Spearman $\rho(p)$ for Right and Binocular CS

Lastly, **Table 4.35** shows the relationship between performance scores and actual driving. Slower reaction time was significantly related to less driving at night (trips, distance, duration).

Table 4.35 Associations between Performance and Driving Indicators (n=26)

	Left CS	Right CS	Binocular CS	Reaction Time	Movement Time	Response Time
Days	-.27	-.28	-.23	-.33	.01	-.30
Trips	-.05	-.13	-.10	-.30	-.02	-.29
Stops	-.02	-.21	-.04	-.31	-.20	-.29
Distance	.20	.10	.01	-.12	-.12	-.24
Duration	-.02	-.17	-.11	-.23	-.09	-.24
Max Radius	.16	.22	-.01	.15	-.14	.06
Avg Radius	.24	.30	.12	.32	-.02	.21
Nights Driven	-.04	-.04	-.08	-.38	.07	-.03
Night Trips	.03	-.12	-.05	-.46*	.07	-.17
Night Distance	.12	.22	-.08	-.54**	.17	-.23
Night Duration	.08	.10	-.05	-.58**	.09	-.29
Frequency Index	.39	.25	.12	-.02	.04	.01

Note: Pearson *r*(*p*) except for Right CS, movement time, stops, max and avg radius, night trips, distance and duration; $*p < .05$, $**p < .02$.

Chapter 5: Discussion

5.1 Introduction

Drivers can self-regulate by modifying how much they drive, when and where they drive, and at the extreme by giving up driving completely. Only two studies have examined self-regulatory practices in drivers with PD via self-report (Adler et al., 2000; Wood et al., 2005). The aim of this study was to objectively examine the extent to which drivers with PD restrict their driving exposure and patterns relative to age-matched controls, and to explore possible reasons for such restrictions (trip purposes, perceptions, disease severity and symptoms). A sample of 27 drivers with PD and 20 age-matched control drivers was recruited from the Kitchener-Waterloo region and driving was monitored for a two week period (between October, 2009 and August, 2010) using electronic devices.

This chapter begins by discussing the correspondence between self-report and objective driving data. The extent to which PD drivers restrict their driving exposure and patterns compared to controls, as well as comparison of trip purposes is discussed next, followed by factors that may be associated with self-regulatory practices. The primary study limitations are then addressed, although various limitations are considered throughout the chapter. The final section presents the conclusions of this study and directions for future research.

5.2 Self-Report and Actual Driving

Except for one person who stopped driving between the first and second assessments, all other participants had CarChip data. When these participants were asked: "can you estimate the number of kilometres you drove over the last two weeks, 87% of the sample (22 PD and 18 controls) gave an estimate. Mean estimates by both groups were lower than actual km driven (significant in the PD group). However, paired-t tests do not account for random differences above and below the mean (Altman & Bland, 1983; Bedard, Martin, Krueger & Brazil, 2000). Using Bland-Altman plots to show extent of agreement, both groups mis-estimated distance driven over the two weeks.

The coefficient of variance (90% in PD and 220% in controls) and measurement error (94km in PD and 220km in controls) were substantial and larger than found in the one-week studies by Blanchard et al. (2010) (CV = 44.5%; ME = 77.5 km) and Huebner et al. (2006) (CV = 34%; ME = 110 km), respectively, possibly due to the longer recall period. Neither study assessed cognitive functioning of participants. As one might be expected, those with MCI may have more difficulty with recall and mis-estimate to a greater extent than those without MCI. This was found to be the case for the control group, but surprisingly not for the PD group.

Substantial variation and measurement error was also found between self-reported (usual) versus actual frequency of driving in challenging situations, although this may simply reflect a lack of opportunity or need to drive in these situations over the short (two week) period. Self-reports of driving in the morning and afternoon, as well as certain roadways (e.g., residential and city streets) were quite consistent with objective measured patterns. Agreement was not as good with respect to driving on highways (for the PD group) and during rush hour (for both groups).

The present sample of PD drivers reported a preference to drive with a passenger compared to controls, consistent with prior survey findings (Adler et al., 2000; Wood et al., 2005). Based on their trip logs, about 90% of the sample drove with a passenger at least once over the two weeks; the PD group slightly more so when adjusting for total trips. Further research is needed to examine whether passengers assist or distract drivers with PD.

5.3. Exposure

Drivers with PD drove significantly less overall (trips, km, duration) compared to the control group. When adjusted for the number of days driven, the PD group still made significantly fewer trips than controls. However, when adjusting for number of days and trips, group differences in km and duration were no longer significant. In fact, the PD group made slightly more stops on average per trip than controls.

Although the sample was primarily urban drivers (73%), there were some interesting differences between urban (n=19) and rural (n=7) PD drivers. The rural group drove fewer days and made fewer trips, although they drove a significantly greater distance and further from home. Rural drivers may combine errands and activities to save time and gas (Johnson, 2002), and possibly to conserve energy in the case of drivers with PD. Conversely, longer trips may be more exhausting, unless drivers take breaks (e.g., stopping for coffee). Studies using GIS are needed to look at location of services relative to the driver's residence, as well as where drivers make stops to develop a better understanding of route planning.

The control group drove substantially more (km) and further from home than Blanchard & Myers' (2010) and Trang's (2010) samples and there were no "low mileage drivers (≤3000km) in this study. As shown in **Appendix M**, their samples were considerably older and included a higher proportion of women. Both studies found that older men drove more than older women. Average driving distance was considerably higher in Huebner et al.'s (2006) Winnipeg sample (340±159), which was younger (average age 73) and predominately male (70%).

5.4 Patterns

In addition to reduced exposure, the PD group showed more restricted driving patterns. They drove significantly less overall at night than controls (nights, trips, distance and duration).

When adjusted for the number of opportunities to drive, the PD group still drove proportionately less at night than controls. Nonetheless, a large proportion of both groups (89% of PD and 90% of controls) drove at night at least once over the two week period. A large proportion of Trang's (2010) sample (89%) also drove at least once at night over a two-week monitoring period, compared to only 28% of Blanchard & Myers' (2010) monitored for one week. Men in both our PD and control groups drove more at night (trips, distance and duration) consistent with prior findings by Blanchard and Trang. However, gender comparisons were not significant in this study likely due to the small number of women drivers.

Compared to controls, the PD group made significantly fewer trips on weekdays and drove fewer kilometres on week-ends when adjusted for the number of days driven. Several control subjects made fairly long trips to cottages and to visit family/relatives on weekends. Conversely, none of the PD drivers made long trips, consistent with the survey findings of Adler et al. (2000). Although not significant, the PD drivers had a lower average maximum radius than controls, supporting the notion that they may drive closer to home in familiar areas to reduce cognitive strain (e.g., Stolwyk et al., 2005).

The PD group was also significantly less likely to drive on days with bad weather. However, over the 10 month monitoring period (644 days), there were only 132 days (21%) of inclement weather (primarily rain) and few weather advisories. Even during the winter months, conditions were relatively mild, compared to the period (from November, 2008 to March, 2009) when Trang conducted her winter driving study with older adults in the same region. As noted by Trang (2010), future studies need to consider severity of conditions and acquisition of weather and traffic information to better understand strategic driving decisions (trip and route planning).

For instance, people may postpone trips, wait to go out until weather and/or road conditions improve, shorten their trips or take alternate routes (Trang, 2010).

5.5 Trip Purposes

Most trips by both groups were for shopping and errands, followed by social and entertainment purposes, consistent with prior findings (Blanchard, 2008; Trang, 2010). In the PD group, medical appointments were associated with the number of days driven, trips and stops. Active leisure was also associated with number of trips in the PD group, likely influenced by the nine individuals who were concurrently in the MDRC exercise program three days a week. When asked if they combined shopping or errands on these days, most said “no”, that they were too tired to do so. Instead, they preferred to do their shopping and errands on their non-exercise days, often making several stops in a single trip (e.g., trip chaining). This suggests that at least some drivers with PD may strategically plan their trips to minimize fatigue.

Comparatively, in the control group, active leisure activities were associated with days and nights driven, trips (overall and at night) and night duration, as activities such as bowling and curling often went into the evening or were in the evening. Several participants were also employed, accounting for the significant associations between trips (overall and at night), km and stops. Similarly, volunteer work was associated with total km and radius.

Most participants said they would cancel discretionary trips (e.g., shopping, social activities) if the weather was bad, if they felt ill or did not feel like driving. Blanchard (2008) found that personal level of commitment was a strong indicator of whether trips were postponed or cancelled. Drivers with PD said they were reluctant to miss a medical appointment or an exercise class (for PD exercisers). Circumstances (e.g., appointments, commitments) may dictate where and when people actually drive, even if they prefer not to (Blanchard & Myers, 2010).

5.6 Factors Related to Self-Regulation

Of the 128 individuals with PD who were screened at the MDRC, 35% had quit driving, on average four years after diagnosis. As suggested by Cubo et al. (2010), drivers with PD may quit at an earlier age. Compared to current drivers, former drivers were older, more likely to be women and had worse disease severity (particularly freezing symptoms), consistent with prior studies (e.g., Cubo et al., 2010; Meindorfner et al., 2005). The former drivers we surveyed cited disease progression as the primary reason for cessation, similar to Meindorfner et al. (2005).

The present study examined a number of factors that might be associated with restricted driving patterns in individuals with PD who are still driving. The findings are discussed with respect to symptoms of PD, cognitive impairment, driver perceptions and performance scores.

5.6.1 Symptoms of PD

Our sample of PD drivers had greater disease severity (UPDRS motor score of 30.1±8.6) than found by prior researchers that have used this measure (see **Appendix N)**, which may be explained in part by the present sample being older (thus possibly having PD longer). Quality of life scores were strongly associated with UPDRS motor scores and depression scores. The PD group had higher depression scores and rated their quality of life as poorer than controls. Excessive daytime sleepiness scores were not different between groups.

Driving cessation has been prospectively related to activity restriction (Marottoli et al., 2000) and depression (Marottoli et al., 1997) in older drivers in general. We expected that depression might also be associated with reduced driving exposure. Although depression affects nearly 40% of individuals with PD (Cummings, 1992), none of our PD drivers were depressed according to scores on the GDS. Additionally, all were still driving at least 3x per week. There is likely a reciprocal relationship between depression and activity restriction (including driving), which requires further examination in drivers with PD and older drivers in general.

5.6.2 Cognitive Impairment

To our knowledge, this was the first to use the MoCA as a screening tool for mild cognitive impairment (MCI) in PD drivers. The MoCA is considered more challenging and has shown greater sensitivity in detecting MCI than the MMSE in persons with PD (Zadikoff et al., 2008; Zazem et al., 2009).

Our sample of PD drivers scored significantly worse on the MoCA than controls. An unexpected finding was that 74% of PD and 45% of controls were classified as having MCI (scores ≤ 26). Even more surprising was that 26% of PD and 5% of controls were classified as possibly having dementia (scores ≤ 21). Those with MCI (both groups) rated their ability to make quick driving decisions (one of the PDA items) better than those without MCI, which is concerning. There were no differences in comfort scores.

In the group of PD drivers with MCI, only five who rated their health as fair. Compared to the other 22 who rated their health as good or excellent, these five drivers had moderate to severe disease severity (UPDRS motor score of 36.9±6.0), worse depression, quality of life, contrast sensitivity and response times, as well as lower comfort scores and perceived driving abilities. These five drivers also drove fewer km, for a shorter duration and closer to home, possibly due to a greater recognition of worsening symptoms associated with PD.

5.6.3 Driver Perceptions

Compared to controls, the PD group had significantly lower night driving comfort scores and poorer perceptions of their driving abilities. Prior studies with PD drivers have shown mixed results: one study found drivers with PD had higher confidence than controls (Madeley et al., 1991), while another did not (Wood et al., 2005). However, neither study reported how they assessed confidence. A few studies have shown drivers with PD over-estimate their driving abilities compared to on-road performance (Wood et al., 2005) and ratings of a driving instructor and psychologist (Heikkila et al., 1998), respectively.

Compared to prior studies with older drivers using the same scales (DCS and PDA), our younger control group had substantially higher DCS and PDA scores, as shown in **Appendix M**. Conversely, DCS-Day, DCS-Night and PDA scores for the PD group were similar to the scores for the much older samples employed by Blanchard (2008) and Trang (2010).

In contrast to previous studies with older drivers (e.g., Blanchard & Myers, 2010; Trang, 2010), significant associations between perception scores and indicators of actual driving did not emerge in this study, possibly due to the small sample size and heterogeneity. For instance, one PD participant (a woman, aged 75, who used a walker) drove nearly 500km over the two weeks although her driving comfort scores were low (42% in the day and 45% at night, respectively). She was a sole driver who lived in a rural area and was also in the MDRC exercise program. People who live in rural areas and have no other driver in the household may need to drive despite low comfort level. Alternatively, another PD participant (man, aged 74, urban dweller and MDRC exerciser) had very high day (95%) and night (91%) comfort scores, yet only drove 228 km over the two weeks. This individual made fairly short trips, within a limited radius, and may also have shared driving with his spouse. Thus, other factors (such as location of residence and having another driver in the household), in addition to comfort level, must be considered.

5.6.4 Performance Scores

Older drivers in general who recognize declines in vision may be more likely to self-restrict their driving (Satariano et al., 2004). Our PD group had poorer contrast sensitivity (CS) than controls, particularly in the right eye. One control and two PD subjects had monocular deficits, defined as CS scores below 1.25 (Owsley et al., 2001). Although none of our sample was considered to have impaired binocular CS (below 1.25) in the PD group, scores were negatively associated with driving at night. Binocular deficits may be noticeable to drivers, even if not in the impaired stage.

On the brake test, the PD group had significantly worse response times, as well as reaction and movement times, in general, compared to controls. Simulator studies have found that drivers with PD have worse reaction time (Stolwyk et al., 2006a, b) and they have more difficulty moving their foot from one pedal to another (Wood et al., 2005) than controls. In any case, these measures may not capture reaction and responses in real-world driving situations. For instance, in our apparatus, the pedal angles were higher and the distance between the brake and gas pedals were larger than in most vehicles. Unfortunately, no adjustments could be made to the brake test equipment.

We actually measured braking and accelerations using the CarChip data. There were no differences between groups with respect to hard/extreme braking or hard accelerations. The control group had significantly more extreme accelerations (adjusted for number of trips), possibly due to more highway and freeway driving (i.e., having to quickly enter and merge). However, there were relatively few occurrences of these behaviours in the short study period.

5.7 Limitations

The primary limitation of the present study is the small sample size due to part to challenges recruiting volunteer drivers with PD. This precluded meaningful comparisons between men and women drivers and other sub-groups (e.g., rural versus urban drivers).

The present sample was well-educated (70% PD and 75% control having completed college or university) and most considered their health as good or excellent. It is well recognized that volunteers for driving studies in general (e.g., Myers et al., 2008; Rudman et al., 2006), and those with PD populations (e.g., Klimkeit et al., 2009), tend to be well-educated, healthy and motivated. Fear of being reported to authorities and possibly losing one's driving license is a deterrent to participation even for healthy older drivers. After screening 128 PD patients, only 27 were eligible and willing to participate. More than half of those who did not wish to participate were fearful of being reported to licensing authorities and/or tracked by the devices.

All PD participants were recruited from the MDRC, a research facility located in Waterloo which adds to the selection bias (i.e., patients come for innovative programs such as the tailored exercise program and agree to be approached for research studies). As the MDRC exercise program has been shown to improve mobility and functioning, we initially tried to recruit patients before they started the exercise program, however, this proved to be difficult.

While we achieved our goal of recruiting 20 healthy older drivers, four of the controls had previously participated in Trang's (2010) winter study, thus were already familiar with the electronic devices. Nonetheless, three controls reported being distracted by the devices, while one PD driver said she deliberately drove slower as she thought the Otto was tracking her speed. The majority of the sample (94%), however, reported no effects on their driving behaviour, while three-quarters said their driving was fairly typical over the two weeks.

The present study may have included more active drivers (criteria of currently driving at least 3x/week), although this is impossible to determine as prior studies with PD drivers have not examined amount of driving (Klimkeit et al., 2009). The criteria of driving at least 3x/week was recommended by Candrive in order to capture more instances of driving behaviour (e.g., night).

Although our sample may not have captured drivers who are self-restricting to a greater extent, only two individuals with PD screened were ineligible due to driving less than 3x/week.

5.8 Conclusion and Directions for Future Research

As described in the various models in Chapter One, driver decisions can be influenced by multiple factors (e.g., age, gender, perceptions, health conditions) and changes in driving behaviour may occur as a result of circumstance (e.g., retirement) and not simply a recognition of declining abilities (Eby & Molnar, 2009). Drivers' awareness or insight into their impairments is a critical factor in determining self-regulatory behaviour (e.g., Eby & Molnar, 2003; Charlton et al., 2006), and ultimately the effectiveness of such practices on crash reduction (e.g., Baldock et al., 2006). Studies on PD drivers to date have failed to consider driving exposure, context or the capacity of this population to self-regulate (Klimkeit et al., 2009).

Overall, the findings suggest that drivers with PD show more restricted driving exposure and patterns than age and gender-matched controls from the same region, assessed at the same time period. Although a two-week monitoring period offers only a snapshot of driving behaviour, it is noteworthy that 19% of the sample (all PD drivers) experienced problems. Four people admitted to being involved in a minor accident, while one actually lost his license.

A substantial proportion of not only the PD sample (74%), but also the control group (45%), were classified as having MCI and 26% of the PD and 5% of the controls may have possible dementia. Prior studies with older drivers have often not screened for cognitive impairment and no studies to date have looked specifically at PD related dementia and its impact on driving safety and behaviour (Uc et al., 2009b). The high sensitivity of the MoCA (Dalrymple-Alford et al., 2010) may be a factor in the large proportion of controls in this study classified as having MCI. As MCI may not be suspected in otherwise healthy older drivers

(Dobbs, 2008; Hopkins et al., 2004), clinicians, licensing authorities and researchers should air on the side of caution and screen for cognitive impairment. As cognitive and physical problems can develop independently and progress at different rates, it is critical both are assessed.

Consistent with the findings of Blanchard et al. (2010) and Huebner et al. (2006), self-estimates of exposure were inaccurate, warranting the continued use of objective measures. While a few studies have used instrumented vehicles to assess performance (errors and crashes in PD drivers (e.g., Rizzo et al., 2010; Uc et al., 2009b), no studies have concurrently examined self-regulatory practices (exposure and patterns and performance (driving errors)). The advantage of using instrumented vehicles is the collection of real time data into accident causing behaviours (e.g., following distance, lane changes, braking patterns), near misses and traffic violations (Rizzo et al., 2010). In addition to expense, however, the presence of cameras and sensors are obtrusive and may affect driving behaviour. Even in the present study, one person deliberately slowed down due to the awareness the devices were tracking her speed.

The present study findings need to be replicated with larger samples to examine the relative influence of driver characteristics (gender, rural versus urban), perceptions, depression, cognition and symptoms of PD on self-regulatory practices using regression models. Additionally, use of medications should be examined. Longitudinal studies are required to examine changes in self-regulatory practices (both driving restriction and cessation) as PD progresses. Whether self-regulatory practices are effective in reducing crash involvement is currently unknown (e.g., Blanchard & Myers, 2010; Charlton et al., 2006; Lindstrom-Forneri et al., 2010). To answer this question, driver records (from the provincial licensing authorities) are required. The ongoing Candrive study which is following 1,000 drivers aged 70+ for several years is attempting to answer this question. The Candrive study is using electronic devices (with greater memory capacity than those use in the present study) to examine changes in driving (as well as cessation) as participants develop various medical conditions. Unfortunately, the Candrive study is unlikely to include a sufficient number of senior drivers who develop PD.

In summary, this was the first study to examine naturalistic driving exposure and patterns in drivers with PD, compared to an age-matched control group. Consistent with findings by Blanchard et al. (2010) and Huebner et al. 2006), self-estimates of exposure were shown to be inaccurate, warranting the continued use of objective measures. Additionally, this study examined a number of factors that may be associated with driving restrictions. Overall, drivers with PD had lower exposure, more restricted driving patterns, lower comfort levels and poorer perceived driving abilities than controls. The findings also provide new insight on the importance of examining cognitive impairment in both drivers with PD and in healthy older drivers.

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Appendix A: Studies Comparing Drivers with PD to Controls

Authors (type of study)	**PD Sample (N, sex, age)**	**Study Criteria for PD**	**Control Sample**	**Results (PD versus controls):**
Adler et al. (2000) (survey)	N = 89 (56 ♂, 33♀) Mean age 72.7	NONE	N = 423 (170 ♂, 241 ♀) Mean age 68.8	1) no difference in MMSE scores 2) 2.5x higher crash rate 2) drove less (km) past 5 years 3) drove less often at night 4) drove less in peak traffic 5) less long distance trips 6) less likely to drive alone
Cordell et al. (2008) (open road + clinical tests)	N = 53 (41♂, 12 ♀) Age 69.3±8.3	**Inclusion:** 1) between ages 60 & 80 2) living in community 3) drive 4 hours/week **Exclusion:** 4) ≥ 5 demerits past 2 yrs 5) < 26 on MMSE 6) VA < 20/40 on Snellen	N = 129 (104 ♂, 25 ♀) Age 72.9±7.1 Same criteria for controls	1) worse driving performance: - at T-junctions -using rear and side mirrors -maintaining steady speed -delayed decision making -impaired judgement 2) UPDRS (ADL) and Timed Up and GO test associated with driving performance in PD group
Devos et al. (2007) (open road, simulator + screening battery)	N = 40 (33 ♂, 7 ♀) Age 61.6±9.4 (44 to 75)	**Inclusion**: 1) valid driver's license 2) H & Y (stage 1-3) 3) 1 or less on clinical dementia rating (CDR) 4) binocular VA of 10/20 on Snellen **Exclusion:** 5) deep brain implants 6) unpredictable motor fluctuations	N = 40 (31 ♂, 9 ♀) Age 62.8±7.6 (51 to 79) Criteria 1 & 4	1) worse performance on simulator -more traffic offenses and accidents 2) did not perform worse on road test -72.5% of PD considered safe to drive 3) disease duration, CS, CDR and UPDRS (motor) scores predicted 90% of pass/fails on road test (PD group)

Appendix A Continued….

Authors (type of study)	**PD Sample (N, sex, age)**	**Study Criteria for PD**	**Control Sample**	**Results (PD versus controls):**
Dubinsky et al. (1991) (survey)	N = 150 Age 67.8±8.8	**Inclusion:** 1) 2 of 4 cardinal symptoms 2) history of PD progression 3) response to levodopa **Exclusion:** 4) other causes of Parkinsonism	N = 100 Age 64.6±9.4 **Inclusion:** 1) spouse w. PD 2) age ≥ 45 **Exclusion:** 3) neurological disorder	1) lower MMSE scores 2) worse disability (Schwab & England) 3) fewer miles/month 4) more accidents per mile driven
Grace et al. (2005) (open road + neuropsychological battery)	N = 21 (14 ♂, 7 ♀) Age 68.1±8.5 (45 to 83)	**Inclusion:** 1) valid license 2) currently driving 3) diagnosed by neurologist **Exclusion:** 4) other neurological conditions 5) dementia 6) psychiatric disorders	N = 21 (10 ♂, 11 ♀) Age 69±10.4 (46 to 85) Criteria 1 & 2	1) impaired driving performance -difficulty turning head 2) lower MMSE scores 3) Driving performance (PD) was related to: -disease severity (H & Y) -Trails Making B test -drawing test (Rey-Osterrieth Test) -Delayed Recall (Hopkins Verbal Test) -Motor symptoms (axial rigidity + postural instability) **No information on controls**
Heikkila et al. (1998) (open road)	N = 20 20 ♂ Age 59±11 (35 to 73)	**Inclusion:** H & Y (stage 1 to 3)	N = 20 20 ♂ Age 55±6	1) worse driving performance: more -errors overall -driving in traffic -left hand turns -parking, reversing 2) H & Y, MMSE scores, PD duration, meds not associated with performance

Appendix A Continued….

Authors (type of study)	**PD Sample (N, sex, age)**	**Study Criteria for PD**	**Control Sample**	**Results (PD versus controls):**
Madeley et al. (1990) (simulator)	N = 10 (7 ♂, 3 ♀) Age 54.6 (38 to 64)	NONE	N = 10 (7 ♂, 3 ♀) Age 55.9 (38 to 65)	1) worse driving performance -worse reaction time -missed red lights -worse steering ability
Stolwyk et al. (2005) (simulator – impact of external cues on driving behaviour)	N = 18 (14 ♂, 4 ♀) Age 67.2±6.5 (54 to 77)	**Inclusion:** 1) valid license 2) currently driving	N = 18 (14 ♂, 4 ♀) Age 67.1±6.5 (53 to 77) Same criteria as controls	1) worse driving performance -approached traffic signals and curves more slowly -late decelerations, difficulty stopping -maintaining lateral lane position -more reliant on external cues (e.g., road signs) -more difficulty in unfamiliar areas -regardless of speed reduction – still made more errors
Stolwyk et al. (2006a) (simulator + neuropsychological battery)	N = 18 (14 ♂, 4 ♀) Age 67.6±6.5 (55 to 77)	**Inclusion:** 1) valid license 2) currently driving	N = 18 (14 ♂, 12 ♀) Age 67.1±6.5 (54 to 78) Same criteria as controls	1) higher depression scores 2) higher anxiety scores 3) lower MMSE scores 4) worse executive function (UFOV and Trails Making Test B) 5) impaired driving performance -reacting to road obstacles -maintaining lane positioning 6) performance (PD) related to: -Trails B, Brixton, Symbol Digit test -Wechsler Adult Intelligence Scale – Block Design and Picture Completion

Appendix A Continued….

Authors (type of study)	PD Sample (N, sex, age)	Study Criteria for PD	Control Sample	Results (PD versus controls):
Stolwyk et al. (2006b) (simulator – effect of concurrent tasks)	Same as Stolwyk et al. (2006a)	Same as Stolwyk et al. (2006a)	Same as Stolwyk et al. (2006a)	1) worse driving performance overall -difficulty with concurrent tasks -difficulty at intersections -difficulty navigating curves 2) lower MMSE scores
Susuki et al. (2008) (interview + survey)	N = 188 (85 ♂, 103 ♀) Age 66.4±8.7	**Inclusion:** 1) diagnosed PD 2) bradykinesia + 1 other symptom (tremor, rigidity or postural instability)	N = 144 (64 ♂, 80 ♀) Age 65.1±6.8	1) more sleep episodes 2) PD with EDS had greater disease severity, depression and medication use 3) medications not related to EDS 4) mental state, dosage of meds + ESS scores predictive of sleep episodes
Uc et al. (2007) (open road: observer and instrumented vehicle + neuropsychological battery)	N = 77 (65 ♂, 12 ♀) Age 65.9±8.6	**Inclusion:** 1) had a valid license 2) currently driving	N = 152 (75 ♂, 77 ♀) Age 65.3±11.5 Same criteria as controls	1) impaired driving performance -more incorrect turns -got lost -more at fault safety errors 2) worse on clinical tests -visual (CS and VA) -cognitive (UFOV, CFT, Trails A/B, Delayed Recall, MMSE) -depression scores (GDS) 3) driving performance (PD) predicted by: UFOV, Trails Making A/B, CS, VA, CFT + MMSE scores

Appendix A Continued….

Authors (type of study)	PD Sample (N, sex, age)	Study Criteria for PD	Control Sample	Results (PD versus controls):
Uc et al. (2009a) (simulator)	N = 67 Age 66.2±9.0	**Inclusion:** 1) had a valid license 2) currently driving (> 10 years)	N = 51 Age 64.0±7.2 Same criteria as controls	1) more difficulty driving in fog -more accidents, more lane violations -longer reaction time, drove faster 2) poor performance (PD) in fog predicted by scores on: -CS -visual perception (UFOV) -visual cognition (Blocks, CFT) -MMSE scores -ADL's (Schwab-England Scale, UPDRS)
Uc et al. (2009b) (open road in instrumented vehicle with observer) + neuropsychological battery)	N = 84 (69 ♂, 15 ♀) Age 67.3±7.8	**Inclusion:** 1) had a valid license 2) currently driving (> 10 years)	N = 182 (92 ♂, 90 ♀) Age 67.6±7.5 Same criteria as controls	1) worse driving performance -lane keeping + changing -speed control + turning -missed more stop signs 2) performance (PD) related to: -CS + VA -UFOV -motion test (perception) -CFT (visual memory)

Appendix A Continued....

Authors (type of study)	PD Sample (N, sex, age)	Study Criteria for PD	Control Sample	Results (PD versus controls):
Vaux et al. (2010) (simulator + visual and cognitive battery)	N = 8 (6 ♂, 2 ♀) Mean Age 61.9	NONE	N = 18 (11 ♂, 7 ♀) Mean Age 69.7	1) worse driving performance -maintaining attention -detecting collisions/objects 2) lower scores on clinical tests -CS + VA -UFOV, motion test line orientation -CFT + Blocks test -MMSE, GDS and ESS -Balance + Speed (Walking & CFT test) 3) performance (PD) related to: -CS + VA -UFOV + motion test -CFT + MMSE scores
Wood et al. (2005) (closed road)	N = 25 (21 ♂, 4 ♀) Age 63.7±6.8	**Exclusion:** 1) dementia	N = 21 (18 ♂, 3 ♀) Age 65.2±8.6	1) worse driving performance -difficulty lane keeping -difficulty viewing blind spots -difficulty navigating intersections 2) drove fewer km (self-report) 3) drove less alone (self-report) 4) no difference in confidence ratings
Zesiewicz et al. (2002) (simulator)	N = 39 (24 ♂, 14 ♀) Age 63.8±11.5	**Inclusion:** 1) diagnosed PD 2) bradykinesia + 1 other symptom (tremor, rigidity) 3) responsive to PD drugs	N = 25 (9 ♂, 16 ♀) Age 65.6±10.3	1) more accidents than controls 2) PD group - accidents associated with: - older age - lower MMSE scores - worse H & Y scores - higher UPDRS scores

Note: Values are Mean±SD and Range (where provided); CS = Contrast Sensitivity; CFT = Complex Figure Test; EDS = Excessive Daytime Sleepiness; ESS = Epworth Sleepiness Scale; GDS = Geriatric Depression Scale; H + Y = Hoehn and Yahr scale; MMSE = Mini Mental State Exam; UPDRS = Unified Parkinson's disease Rating Scale; UFOV = Useful Field of View

Appendix B – Recruitment Materials for PD Group

Screening Form for MDRC Driving Study

To see if you are eligible for our current driving study, please complete this form.

Name: ______________________________ Date: ____________________

Age:__ 55+ Gender: ___ Male or ___ Female

1. **Do you currently drive**? □ **yes** □ no

If no, please skip to part 2 on next page.

2. Do you have a **valid driver's license?** □ **yes** □ no

3. Do you drive a **car, mini van or SUV?** □ **yes** □ no

4. Do you usually drive **3 times a week** or more? □ **yes** □ no

5. Is your car (or van) **1996 or newer**? □ **yes** □ no

6. Is it a **hybrid**? (hybrid runs on electricity as well as gas) □ yes □ **no**

7. Do you **live** in Kitchener or Waterloo? □ **yes** □ no

   If no, where do you live?__________________________

8. Have you ever had a **stroke**? □ yes □ **no**

9. Do you have **glaucoma** or **macular degeneration**? □ yes □ **no**

10. Do you have **sleep apnea**? □ yes □ **no**

11. Do you suffer from **schizophrenia?** □ yes □ **no**

12. Are you currently taking **anti-anxiety medication**? □ yes □ **no**

Part 2. ***If you do <u>not</u> currently drive, please answer the following:***

1. Did you **used to** drive? ____ Yes ____No (I have never driven)

2. If so, **when did you stop**? ________________________ (approx date: month/year)

3. What is the **main reason** you stopped driving? ______________________________

Thank you for completing this form.

Please return to Dr. Almeida.

If you *meet the criteria* (e.g., age 55+; currently driving at least 3 times a week)

Dr. Almeida will give you a **letter** describing this study and answer any questions you may have.

If you interested in taking part, Dr. Almeida will book an appointment.

It is important to note that if you agree to take part <u>none</u> of the driving or any other information you provide will be reported to licensing authorities.

Section below for completion by Dr. Almeida:

New Assessment ____ or Re-assessment ____

Exercise participant? ______ Yes ______ No If yes, current ___ or prior ____

Notes:

Letter of Information on Driving Study

Version for drivers with PD (given by Dr. Almeida or staff)

Dear Driver,

My name is Alex Crizzle and I am a graduate student in the Department of Health Studies and Gerontology at the University of Waterloo and this study is for my doctoral dissertation. My supervisor (Dr. Anita Myers) and I are working closely with Dr. Almeida and the Movement Disorders Research and Rehabilitation Centre (MDRC) at Wilfrid Laurier University. The purpose of our study is to learn more about the impact of Parkinson's related symptoms on driving patterns. For instance, some people may have considerable fatigue, which may affect how much they drive or when, others may not.

For this study we are recruiting and comparing two groups: drivers with and without Parkinson's. We are looking for volunteers aged 55 years and older, who normally drive at least 3 times a week and live in the Kitchener-Waterloo (K-W) area.

Understandably, some people may be hesitant to participate in driving studies due to possible concerns of being reported or losing their license. Please rest assured that we are not looking at speeding or other infractions, and whatever you tell us (e.g., if you have had a collision), will be kept totally confidential. Participation in this study is **completely voluntary and will, in no way, affect your license renewal now or in the future. No information you provide or that recorded by the in-vehicle electronic devices will be shared with any driving authorities or physicians.** Furthermore, the decision to participate (or not), withdraw from participation, or declining to respond to questions will **not** have an impact in your involvement in programs at the MDRC now or in the future.

Participation in this study involves a **two week commitment**, with two visits scheduled at the MDRC. We will need to schedule a two week period when you will be in the K-W area most of the time; a few day or week-end trips out of town are okay.

This study has 3 parts:

1. An initial meeting to obtain background information and install the temporary electronic devices, described below, in your car (about 45 to 60 minutes).

2. Driving as usual for two weeks and completing trip logs (checklist).

3. A follow up interview and some driving related questionnaires (about 1 hour).

If you agree to participate, an initial appointment will be made for you at the MDRC. Please come in the car (or minivan) you will be driving over the study period and bring your reading glasses (if needed) to complete the questionnaires and forms.

I will explain the study, answer your questions, obtain some background information (basic demographic and health related questions), administer some assessment tools (memory, sleepiness, depression and vision) and show you how to complete the trip logs. This should take no longer than **45 to 60 minutes**. Light refreshments will be provided.

With your permission, I will then install two removable devices in your car. One is a CarChip® which is a small device that plugs into a port under your steering wheel. The other is a Global Positioning System (GPS) unit, called the Otto, which is tiny (fits into the palm of your hand) and is mounted on your dashboard using a sticky pad. Together, these devices store data from your car's computer, including: driving time, distance traveled and general locations (using GPS and local maps). The Otto will not block your view and neither device affects your car in any way. You should not have to do anything with these over the two week period, however I will go over some things you might experience (e.g., an LCD light coming on) and give you a sheet of information.

Over these two weeks, we will ask you to fill out a trip log (like a checklist) that will be left in your car to confirm the identity of the driver of each trip (in case someone else drives your car), number of passengers and where you went (e.g., grocery shopping) on each trip. Each entry should take less than 30 seconds, in total about **5 minutes each day.**

A second meeting at the MDRC will be arranged to collect the devices and trip logs. You will also be asked to complete a few short questionnaires on your usual driving habits, comfort level and a brief interview about your experiences over the past two weeks. Your reaction time will also be assessed on a simulator task by measuring the time from seeing a light to moving your foot from the gas pedal to the brake pedal. This visit should take about **1 hour**. You will also be asked to complete three of the scales again at home about a week later and mail these back in a stamped, addressed envelope.

Participation is totally voluntary. You can decide whether you want to complete any aspect of the study or withdraw at any time. Your name will only appear on the consent form which will be kept in a locked cabinet and separate from the data, and used only to contact you with your permission. All consent forms, electronic, and paper data will be kept secure and confidential and will be destroyed five years after the study has ended. To maintain confidentiality, no individual will be identified by name in my dissertation or resulting publications. Results will be summarized across all participants and used to help us and other researchers better understand issues important to drivers.

Your written consent to participate is required. This project has been reviewed and has received ethics clearance from the Office of Research Ethics at the University of Waterloo and the Research Ethics Board at Wilfrid Laurier University. Keep this letter and if you have any questions contact the MDRC at 519-884-0710, extension 3924 #.

If you have concerns about your participation in this study, you can contact Dr. Robert Basso of the Research Ethics Board at the Wilfrid Laurier University at 519-884-1970, extension 5225. Or you can contact Dr. Susan Sykes of the Office of Research Ethics at the University of Waterloo at 519-888-4567, extension 36005.

If you are interested in participating, please schedule an appointment with Dr. Almeida. If unsure of your schedule over the next few weeks, please call the MDRC at 519-884-0710, extension 3924 #, leave a message and a staff member will call you to book a time.

Sincerely,

Alex Crizzle, PhD Candidate
Department of Health Studies and Gerontology
University of Waterloo

MDRC Appointment Cards

Note: given to participants by Dr. Almeida or staff
(printed in colour)

Appointment # 1 at MDRC for Driving Study

[NAME] ______________________

Date: ____________________ Time:____________________

Appointment # 2 at MDRC for Driving Study

[NAME] ______________________

Date: ____________________ Time:____________________

Appendix C: Recruitment Materials for Control Group

University of Waterloo

Men/Women 55+ Needed for Driving Study

Researchers at the Universities of Waterloo and Wilfrid Laurier (WLU) are looking for volunteers to take part in a study looking at healthy older drivers, compared to those who have Parkinson's. Specifically we are looking for volunteers (men and women, aged 55 or older) who normally drive at least 3 times a week, live in the Kitchener-Waterloo (K-W) area, and who do not have Parkinson's or any other neurological disorder (such as stroke).

Participation in this study involves a two week commitment, with two visits scheduled at your convenience at a research centre on Hickory Street, between University Ave and Columbia. Parking is free and refreshments will be provided. The first visit will take about 45 minutes and involve collecting some background information, a vision test and some puzzle like tasks. The second visit will take about 60 minutes and involve an interview, ratings of driving perceptions and patterns and a brake reaction time task. In between the visits, you simply drive as usual (with small electronic devices installed in your vehicle to record data such as distance). All information is totally confidential and will not affect your license in any way (or be reported to the ministry). We will be pleased to explain the tools we are using or anything you may want to know about Ontario's requirements for older drivers

For more information about the study, please contact **Alex Crizzle** (PhD Candidate) by phone **(416) 876-7773** or e-mail **amcrizzl@uwaterloo.ca. Take a copy of the flyer or one of the detachable tags below.** This project was reviewed and received clearance from University of Waterloo's Office of Research Ethics and Wilfrid Laurier University's Research Ethics Board.

Alex Crizzle
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Permission to Contact for KW Driving Study
for healthy older drivers

Project Title: Self-Regulatory Driving Behaviour, Perceived Abilities and Comfort Level of Older Men with Parkinson's disease compared to an Age-matched Healthy Group of Drivers.

We are looking for volunteers to take part in a study being conducted by Mr. Alex Crizzle under the supervision of Dr. Anita Myers in the Department of Health Studies & Gerontology, University of Waterloo, in collaboration with Wilfrid Laurier Univeristy (WLU).

The purpose of this study is to learn more about driver perceptions and driving patterns in healthy older adults when compared to those with neurological conditions such as Parkinson's.

Specifically we are looking for volunteers, men, aged 65 years and older, who normally drive at least 3 times a week, live in the Kitchener-Waterloo (K-W) area, and who do <u>not</u> have Parkinson's or any other neurological disorder (such as stroke).

Participation in this study involves a two week commitment, with two visits scheduled at your convenience at a Wilfrid Laurier University research center located on Hickory street (between University Avenue and Columbia). Parking is free and light refreshments will be provided. The visits will involve some interesting assessments (such as brake reaction time and puzzle like tests), as well as brief questionnaires on your driving habits, patterns and perceptions. In between the two visits you will simply drive as usual with two small electronic devices inserted in your vehicle. You don't have to do anything with these devices, they simply record information such as distance and duration of driving trips.

We will schedule a time when you will be in the K-W area during the study period (between September, 2009 and February, 2010) at your convenience.

I give my permission for Alex Crizzle to contact me about this study. I understand that I am under no obligation to participate and all information will be kept totally confidential and not be given to anyone or used for any other purpose.

Name (print):__________________ Signature:_________________ Date:_________

Phone number:______________________ Age:________

Best days and times to call: ___Monday (__ am or __ pm); ___Tuesday (__ am or __ pm);

___Wednesday (__ am or __ pm); ___Thursday (__ am or __ pm); ___Friday (__ am or __ pm);

___ Weekend (__ am or __ pm)

Initial Screening Interview Script

Name: ________________________________ Date: ____________________________

Phone #: _____________________________

Recruited from: ____________________

Permission to call them ___ or they initiated the call and left message: ___

Attempts to Contact: If **someone else answers**, ask for a good time to call back to reach person. If **answering service,** leave message (name, calling from UW, purpose of call) and say you will call back, or they can call you (number) with the best times to reach them.

1. Date: ______________________________

   Reached: ___Subject ___Other Note: ____________________________________

2. Date: ______________________________

   Reached: ___Subject ___Other Note: ____________________________________

3. Date: ______________________________

   Reached: ___Subject ___Other Note: ____________________________________

4. Date: ______________________________

   Reached: ___Subject ___Other Note: ____________________________________

5. Date: ______________________________

   Reached: ___Subject ___Other Note: ____________________________________

6. Date: ______________________________

   Reached: ___Subject ___Other Note: ____________________________________

Script

Hello [*person's name*], my name is Alex Crizzle and I am a graduate student at the University of Waterloo, working with Dr. Anita Myers.

On [*date*], I came to talk to your group [*Name of Group or Centre*] [Or posted flyers] about our driving study. I'm calling with your permission [or you left a message for me to call] to tell you more about the study and to answer any questions you might have. If you're interested, I'll ask you a few questions to see if you're eligible and available for this particular study and we can schedule a meeting. This will take ~ **20 minutes**. Is this a good time? ___No ___Yes
(If no)*...*I can call back later. When is a **better time**?______________________________
Thank you and I look forward to talking with you then.

(If yes)… My name is Alex Crizzle and I am a graduate student in the Department of Health Studies and Gerontology at the University of Waterloo, and this study is for my doctoral dissertation. My supervisor (Dr. Anita Myers) and I are working closely with Dr. Almeida and the Movement Disorders Research and Rehabilitation Centre (MDRC) at Wilfrid Laurier University. The purpose of our study is to examine and compare driver perceptions in relation to driving behaviour (exposure and patterns) in healthy older drivers and those with neurological conditions, such as Parkinson's disease. My study will run from September 2009 to August 2010.

At the end of the study, you will receive a letter of appreciation, as well as a booklet on either winter driving (from the Transportation Health and Safety Association of Ontario), how to drive on ice and snow, or driving in wet weather (both from the American Automobile Association).

If you agree to participate, I will make an **appointment** at the research centre we are using for the study located on Hickory Street (between University and Columbia). I will then explain the study, ask you to complete some questionnaires, conduct some assessments (e.g., vision, puzzle like memory tasks, sleepiness index) and show you how to fill out the activity trip logs. Our meeting should take no longer than **45 minutes**. Light refreshments will be provided.

With your permission, I will then **install two removable devices in your car**. One is a **CarChip** that plugs into a port usually under your steering wheel. The other is a Global Positioning System (GPS) unit called the **Otto Driving Companion**. The Otto can fit into the palm of your hand and will be mounted on your dashboard in an unobtrusive spot. Together, these devices store data from your car's computer from the time the car is turned on such as date and time, distance traveled, and locations (using the GPS system and local maps). You will <u>not have to do anything with</u> these devices. The devices will <u>not interfere</u> with your car's function <u>nor damage</u> your car. And don't worry; we will not report any speeding or other infractions.

Then we will ask you to drive as usual over the next **two weeks** and complete a brief checklist (or log) for each car trip to help us with the vehicle information. I will explain these during our first meeting.

A **final meeting** will be arranged at the same centre two weeks later to collect these trip logs and remove the vehicle devices. During this meeting which should take **60 minutes**, I will ask you to complete a questionnaire about your usual driving habits, ask you to rate your comfort level and abilities, assess your reaction time (brake simulator task), and ask about your driving experience over the past two weeks. Again, light refreshments will be provided

Participation in this study is completely **voluntary** and will in no way affect your license renewal now or in the future. **None of the information** you provide or which is recorded by the electronic devices **will be shared** with any driving authorities. You **may decide** whether you want to complete any aspect of the study or withdraw at any time. **Your name** will only appear on the consent forms, which will be kept in a locked cabinet and separate from the data, and used only to contact you with your permission. All consent forms, electronic, and paper data will be kept secure and confidential and destroyed five years after the study has ended. **To maintain confidentiality**, no individual will be identified by name in my thesis or resulting publications.

Results will be summarized across all the study participants to help us and other researchers to better understand issues important to older drivers and the potential utility of road safety tools.

When we meet, I will give you a **letter with all the information on this study for you to keep.**

Do you have any questions at this point?
Are you still **interested in participating**? ___No ___Yes

(If no)… Would you like to **hear about** any of our studies in the future? ___No ___Yes

If so, do we have **your permission** to contact you about these studies? ___No ___Yes

(If yes) Great. Now, a few questions to **make sure you are eligible for this particular study.**

1. How **old** are you? ______ **Birthdate** (dd/mm/yy)? __________________
2. Do you live in the **K-W region**? ___No ___Yes In K-W specifically? ____

   If not… What area (city) do you live in? ____________________________________
3. Are you a **current driver**? ___No ___Yes
4. Just to confirm, you have a **valid Ontario driver's license**? ___No ___Yes

   G class licenses are for passenger vehicles. Do you have another type of license (e.g., R-W, motorcycle)? ____
5. Do you **drive <u>at least three times a week</u>**? ___No ___Yes

   If not, how often? ________
6. Are you the **only driver** in your household? ___No ___Yes

   If no, are you the primary driver (most ≥ 70% of the time)? ___No ___Yes
7. How **many vehicles** do you have? ________
8. If more than one, do you **use one vehicle most of the time**? ____ Yes ___ No
9. What is the **year and make** of your car(s)? ______________________________
10. Is your car a **hybrid**? (alternates between gas and electrical) _____No _____Yes

<u>Explanation note:</u> I needed to ask those questions as the data loggers do not work in some vehicles. Your vehicle is fine for this study, which is great.

<u>Note:</u> *Primary vehicle must be a **car** (not a truck), **1996** or newer, **non hybrid.***

<u>Note:</u> If > one car, ask if person would be willing to drive <u>one car</u> (that's eligible) over the two week study period. Explain we only have 15 sets of equipment.

Not eligible** if: < **65+**, **no license**, drive < 3x/**week, not primary driver, and not in KW area

Ask permission to continue with interview (especially if near the cut-offs) for potential inclusion in this study or participation in future studies.

11. a) Do you have any **vision problems** that make it difficult for you to drive in certain conditions? ___No ___Yes: If so, what sort of problems?__________________________

____

b) In what sorts of **conditions do you find it hard to see** when driving? ________________

____

12. Have you had or are scheduled to have **cataract surgery**? ___No ___Yes

If yes, when? ________________________

As the purpose of our study is to compare drivers with Parkinson's disease to healthy older drivers, I must ask the following questions:

13. Do you have any **neurological conditions** (e.g., PD, Dementia, Alzheimer's, Stroke)?

___No ___Yes

If yes, what? _________________________

14. Have you ever had a **stroke or transient ischemic attack** (TIA)? ___No ___Yes

15. Have you ever had a **heart attack**? ___No ___Yes

16. Do you have other **heart conditions** (arrhythmias, congestive heart failure)?

___No ___Yes

16. Do you have **glaucoma or macular degeneration**? ___No ___Yes

17. Do you suffer from **schizophrenia**? ___No ___Yes

18. Do you have untreated **sleep apnea**? ___No ___Yes

19. Are you currently taking **anti-anxiety medication**? ___No ___Yes

Note: If not eligible for the study due to health reasons, explain why and ask if they might be interested in future studies.

Part B: Scheduling

Now let's try and arrange a meeting.

<u>If available now</u>, schedule:

First meeting: Date ____________________ Time ____________

Second meeting: Date ____________________ Time ____________

I would like to meet with you at a Wilfrid Laurier research center. The center is located at what used to be a school on 66 Hickory Street West, Waterloo. Hickory Street is a side street off Hazel. Hazel runs between University avenue and Columbia street, west of King Street.

Are you familiar with this location? Do you need directions?

Parking is available at the back of the center and is free of charge. The entrance to the center is also at the back where the parking lot is. Please enter the center doors and I'll meet you in the seating area, directly in front of you as soon as you enter the center.

Notes: 1. tell them **they must come <u>in their car</u> (primary vehicle to be used in the study).**

2. ask them to bring their prescription medications to the first visit (reason, we need to compare the two groups and many people do not know the names of their medications).

Reminder again when calling a day before to confirm the first visit.

I will give you my **number** (if don't have the flyer), in case you need to call me to change the appointment.

And we usually call people to **remind** them the day before, is that okay? ___ Yes ___ No

---

This concludes our telephone interview.
I look forward to seeing you on __________________[*<u>date</u>*].

Let me give you my number (if don't have the flyer), in case you need to call me to change the appointment. And again, we usually call people to remind them the day before.

Thank you so much for taking the time to answer these questions and your willingness to participate. Have a great day.

Letter of Information on Driving Study

(Version for healthy older drivers)

Dear Driver,

My name is Alex Crizzle and I am a graduate student in the Department of Health Studies and Gerontology at the University of Waterloo, and this study is for my doctoral dissertation. My supervisor (Dr. Anita Myers) and I are working closely with Dr. Almeida and the Movement Disorders Research and Rehabilitation Centre (MDRC) at Wilfrid Laurier University. The purpose of our study is to learn more about the impact of various symptoms resulting from Parkinson's on driving patterns. For instance, some people may experience considerable fatigue, which in turn may affect driving frequency or duration, while others may not.

Understandably, some individuals may be hesitant to participate in research on driving due to concern of being reported and potentially losing their license. Please rest assured that we are not looking at speeding or other infractions, and whatever you tell us (e.g., if you have had a collision), will be kept totally confidential. **Participation in this study is completely voluntary and will, in no way, affect your license renewal now or in the future. No information you provide or that recorded by the in-vehicle electronic devices will be shared with any driving authorities or physicians.**

For this study, we are looking for volunteers, men and women aged 55 years and older, who normally drive at least 3 times a week, are the primary driver of the vehicle (if sharing a car with someone else) and live in the Kitchener-Waterloo (K-W) area. We are recruiting two groups for this study: those with and without Parkinson's.

However, if you have suffered a stroke (including TIA's) or a heart attack or if you have any type of progressive disorders, such as dementia, macular degeneration or glaucoma, you are not eligible to participate in this study. Also, if you have diagnosed anxiety and are currently taking anti-anxiety medications, you are also not eligible to participate in this study.

Participation in this study involves a two week commitment, with two visits scheduled at your convenience at the MDRC between the period of March, 2010 and May, 2010. We will need to schedule a two week period when you will be in the K-W area.

This study has 3 parts:

1. An initial meeting to obtain background information and install the temporary electronic devices, described below, in your car (about 45 minutes).

2. Driving as usual for two weeks and completing trip logs (checklist).

3. A follow up interview and some driving related questionnaires (about 60 minutes).

If you agree to participate, an initial appointment will be made for you at the MDRC. I will then explain the study, answer your questions, obtain some background information (basic demographic and health related questions), administer some assessment tools (memory, sleepiness, depression and vision) and show you how to complete the trip logs. This should take no longer than **45 minutes**. Light refreshments will be provided.

With your permission, I will then install two removable devices in your car. One is a CarChip® which is a small device that plugs into a port under your steering wheel. The other is a Global Positioning System (GPS) unit, called the Otto, which is tiny (fits into the palm of your hand) and is mounted on your dashboard. Together, these devices store data from your car's computer, including: time the car is turned on, distance traveled, and locations (using the GPS system and local maps). You will not have to do anything with these devices, nor will they block your view or affect your car. **However, it is important you do not service your car over the two week period as mechanics may dislodge and not replace the devices.**

Over these two weeks, we will ask you to fill out a trip log (like a checklist) that will be left in your car to confirm the identity of the driver of each trip (in case someone else drives your car), number of passengers and where you went (e.g., grocery shopping) on each trip. Each entry should take less than 30 seconds, in total about **5 minutes each day.**

At the end of the two week monitoring period, I will arrange a second meeting at the MDRC to collect the devices and trip logs. I will also ask you to complete a few short questionnaires on your usual driving habits, comfort level and conduct a brief interview about your experiences over the past two weeks. Your reaction time will also be assessed on a simulator task by measuring the time from seeing a light to moving your foot from the gas pedal to the brake pedal. This visit should not take more than **60 minutes**.

Participation is totally voluntary. You can decide whether you want to complete any aspect of the study or withdraw at any time. Your name will only appear on the consent forms, which will be kept in a locked cabinet and separate from the data, and used only to contact you with your permission. All consent forms, electronic, and paper data will be kept secure and confidential and will be destroyed five years after the study has ended. To maintain confidentiality, no individual will be identified by name in my dissertation or resulting publications. Results will be summarized across all the study participants. Information gathered will help us and other researchers to better understand issues important to older drivers.

Your written consent to participate is required. This project has been reviewed and has received ethics clearance from the Office of Research Ethics at the University of Waterloo and the Research Ethics Board at Wilfrid Laurier University. Keep this letter and if you have any questions please contact me at 519-888-4567, extension 36810.

If you have concerns about your participation in this study, you can also contact Dr. Susan Sykes of the Office of Research Ethics at the University of Waterloo at 519-888-4567, extension 36005 or by email at ssykes@uwaterloo.ca. You can also contact Dr. Robert Basso of the Research Ethics Board at the Wilfrid Laurier University at 519-884-1970, extension 5225 or Dr. Quincy Almeida (director of the MDRC) at 519-884-0710, ext 3924.

Sincerely,

Alex Crizzle, PhD Candidate
Department of Health Studies and Gerontology
University of Waterloo

Appendix D: First Visit Materials and Tools

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Checklist for Assessment 1

Name: ________________________________ Date: _________________________

ID: _________________________ Group: ________________________

Time In: _______________________ Time Out: _____________________

Check box once completed: Researcher comments/notes:

Study Information Letter (Control Group only)	□	
Consent form	□	
Back Quest.	□	
ESS	□	
GDS-15	□	
PDQ-8	□	
MoCA	□	
Lux reading	□	***Note: reading_____***
Pelli-Robson	□	
Trip Logs/clipboard	□	
FAQ sheet	□	
Install CarChip	□	Carchip Number: ______
Install Otto	□	Otto Number: ______
Odometer Reading	□	Adapter Number: ______
		Otto Connecting Wire Number: ______

UNIVERSITY OF
Waterloo

Consent for Participation

Note: Same for Both Groups

Project Title: Self-Regulatory Driving Behaviour, Perceived Abilities and Comfort Level of Older Men with Parkinson's Disease compared to an Age-matched Healthy Group of Drivers

This study being conducted by Mr. Alex Crizzle under the supervision of Dr. Anita Myers has been explained to my satisfaction and I have had the opportunity to ask questions. I understand that my participation is totally voluntary and will in no way affect my license renewal now or in the future and that I may withdraw from the study at any time. I choose whether to or not to complete the questionnaires, monitoring of driving behaviour, rating forms, interview and abilities tasks.

I understand that all information collected will be kept totally confidential by the researcher. I also understand that the results will be summarized across all older drivers who have taken part in this study. No individual will ever be identified by name and any quotes used in reports will be anonymous. Consent forms will be kept secure (in a locked cabinet), separate from the data. All consent forms and questionnaires will be destroyed five years after the study has ended.

____

I understand that this project has reviewed and received ethics clearance from the Office of Research Ethics at the University of Waterloo and the Research Ethics Board at Wilfrid Laurier University. If I have any questions or concerns regarding my involvement, I know that I can contact the researcher or the Office of Research Ethics (numbers are in the letter of information I have been given).

Participant's name (please print):
____

Participant's signature: _________________________Date: _______________

Researcher's signature: ___________________________Date: _______________

Background Questionnaire

Version for both groups

(note: 14 point font and 1.5 line spacing will be used for questionnaire)

Part A. Background

1. Are you? ___ male or ___ female

2. Your **age**: _____

3. Did you **complete**: high school? ___ No ___ Yes

   college or university? ___ No ___ Yes

4. Do you **live in**? ____ a private home ____ apartment or condo or

   ____ a retirement or seniors' complex

5. Do **you live**? ___ alone ___ with spouse or partner

   ___ with family members or ___ with roommates (not related)

6. Are you **currently employed** (including self-employment)? ___ No ___ Yes

   If yes, are you employed ___ full time or ___ part time?

7. How would you describe your **financial situation**? (Choose one)

__ I can meet my needs and still have enough money left to do most things I want

__ I have enough money to do many things I want if I budget carefully

__ I have enough to meet my needs but have little left for extras

__ I can barely meet my needs but have nothing left for extras

Part B. Now, please answer a few questions about your health and activities.

1. **Overall,** would you say your health is:

   ___Excellent ___Good ___Fair ____Poor

2. Do you **ever use** a cane or walker outdoors? ___ No ___ Yes

3. Are you **able to walk a quarter of a mile**? ___ No ___ Yes

4. How many days in an **average week** do you do at least 30 minutes of moderate **physical activity** (e.g., a brisk walk)? _____ (# of days)

5. Are you in any organized **exercise** classes or activities (such as curling, golfing or bowling)? ___ No ___ Yes: # days/week_____

6. In the past year, have **you fallen** (ended up on the ground or floor)? __ No ___ Yes
   If yes, have you fallen more than once? ___ No ___ Yes
   were you injured as a result of the fall(s)? ___ No ___ Yes
   did you have trouble getting up? ___ No ___ Yes

7. Have you been **diagnosed** with any of the following? (check all that apply)
   ____ arthritis, rheumatism or osteoporosis
   ____ Multiple Sclerosis, stroke (**circle** which ones)
   ____ high blood pressure, cholesterol or heart problems
   ____ diabetes
   ____ asthma or other breathing problems
   ____ back problems or ___ foot problems
   ____ hearing problems
   ____ cataracts, glaucoma or macular degeneration (**circle** which ones)
   ____ sleeping disorders (e.g., insomnia, sleep apnea, restless leg syndrome)
   ____ other(s) (specify: ____)

8. Do you **experience any of the following difficulties**? (Check all that apply)

   Staying awake or remaining alert? ___ No ___ Yes
   Keeping your balance? ___ No ___ Yes
   Initiating movement? ___ No ___ Yes
   Persistent pain? ___ No ___ Yes
   Limited strength or movement ? ___ in torso/hips ___ in legs/feet
   Lack of feeling or sensation? ___ upper body ___ lower body
   Stiffness? ___ in your neck ___ in your spine/back
   Involuntary movement (e.g., shaking/twitches)? ___ upper body ___ lower body

9. Have you ever had **cataract surgery**? ___ No ___ Yes
   If yes, how long ago? ____ within the past year ___ over a year ago

10. Do you wear **prescription glasses or contacts for driving**?
    ___ All the time ___ Sometimes ___ Never

11. Compared to others your age, **would you say that your eyesight is**:
    ____Better than most ___About the same ___Worse than most

12. Do you wear a **hearing aid** when driving?

___No ___Some of the time ___Most of the time

13. When did you **last visit your neurologist (PD) or general practitioner (control)**?

___Within past 6 months ___ Past year ___More than a year ago

Epworth Sleepiness Scale

How likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired? This refers to your usual way of life in recent times. Even if you have not done some of these things recently try to work out how they would have affected you. Use the following scale to choose the most appropriate number for each situation:

0 = would never doze

1 = slight chance of dozing

2 = moderate chance of dozing

3 = high chance of dozing

(Answer each question 0, 1, 2, or 3)

Situation	**Chance of Dozing**
1. Sitting and Reading	______
2. Watching TV	______
3. Sitting, inactive in a public place (e.g., a theatre or meeting)	______
4. As a passenger in a car for an hour without a break	______
5. Lying down to rest in the afternoon when circumstances permit	______
6. Sitting and talking to someone	______
7. Sitting quietly after a lunch without alcohol	______
8. In a car, while stopped for a few minutes in traffic	______
Total Score	______

Score:
0-10 Normal Range
10-12 Borderline
12-24 Abnormal

Geriatric Depression Scale-15

Name: **Date:**

Please circle the best answer for how you have felt over the past week:

1. Are you basically satisfied with your life?	YES / **NO**
2. Have you dropped many of your activities and interests?	**YES** / NO
3. Do you feel that your life is empty?	**YES** / NO
4. Do you often get bored?	**YES** / NO
5. Are you in good spirits most of the time?	YES / **NO**
6. Are you afraid that something bad is going to happen to you?	**YES** / NO
7. Do you feel happy most of the time?	YES / **NO**
8. Do you often feel helpless?	**YES** / NO
9. Do you prefer to stay at home, rather than going out and doing new things?	**YES** / NO
10. Do you feel you have more problems with memory than most?	**YES** / NO
11. Do you think it is wonderful to be alive now?	YES / **NO**
12. Do you feel pretty worthless the way you are now?	**YES** / NO
13. Do you feel full of energy?	YES / **NO**
14. Do you feel that your situation is hopeless?	**YES** / NO
15. Do you think that most people are better off than you are?	**YES** / NO

Answers in **bold** indicate depression. Score 1 point for each bolded answer.

A score > 5 points is suggestive of depression.

A score > 10 points is almost always indicative of depression.

A score > 5 points should warrant a follow-up comprehensive assessment.

Parkinson's disease Questionnaire (PDQ-8)

Due to having Parkinson's disease, how often during the last month have you…

	Never	Occasionally	Sometimes	Often	Always
Had difficulty getting around in public?					
Had difficulty dressing yourself?					
Felt depressed?					
Had problems with your close personal relationships?					
Had problems with concentration difficulties?					
Felt unable to communicate with people properly?					
Had painful muscle cramps or spasms?					
Felt embarrassed in public due to having PD?					

All questions on the PDQ-8 are coded the same way. Data is entered using the following codes:
0 = Never
1 = Occasionally
2= Sometimes
3 = Often
4 = Always

The PDQ-8 is scored by summing the scores of all questions and dividing by the total score possible (32).

PDQ-8

Note: adapted for control group

How often during the last month have you…..

	Never	Occasionally	Sometimes	Often	Always
Had difficulty getting around in public?					
Had difficulty dressing yourself?					
Felt depressed?					
Had problems with your close personal relationships?					
Had problems with concentration difficulties?					
Felt unable to communicate with people properly?					
Had painful muscle cramps or spasms?					
Felt embarrassed in public?					

All questions on the PDQ-8 are coded the same way. Data is entered using the following codes:
0 = Never
1 = Occasionally
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4 = Always

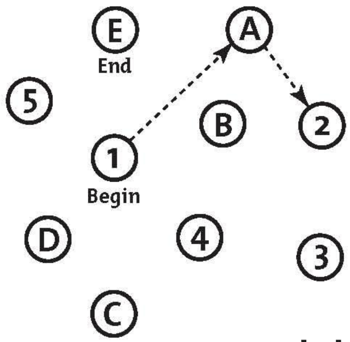
The PDQ-8 is scored by summing the scores of all questions and dividing by the total score possible (32).

Montreal Cognitive Assessment (MoCA)

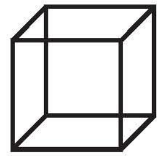
MONTREAL COGNITIVE ASSESSMENT (MOCA)

NAME :
Education : Date of birth :
Sex : DATE :

			POINTS
VISUOSPATIAL / EXECUTIVE	Copy cube	Draw CLOCK (Ten past eleven) (3 points)	



[ ]

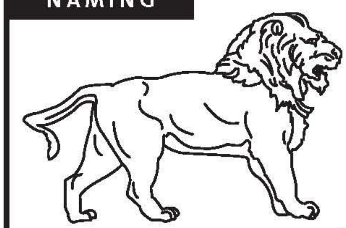


[ ]

[ ] Contour [ ] Numbers [ ] Hands

__/5

NAMING



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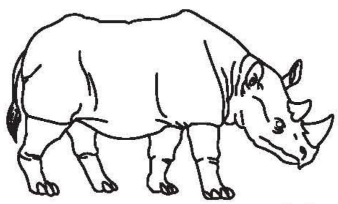

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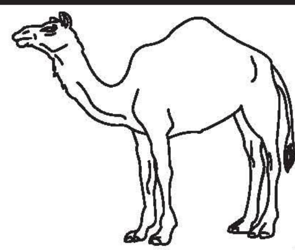

[ ]

__/3

MEMORY

Read list of words, subject must repeat them. Do 2 trials. Do a recall after 5 minutes.

	FACE	VELVET	CHURCH	DAISY	RED
1st trial					
2nd trial					

No points

ATTENTION

Read list of digits (1 digit/ sec.). Subject has to repeat them in the forward order [ ] 2 1 8 5 4
Subject has to repeat them in the backward order [ ] 7 4 2

__/2

Read list of letters. The subject must tap with his hand at each letter A. No points if ≥ 2 errors
[ ] F B A C M N A A J K L B A F A K D E A A A J A M O F A A B

__/1

Serial 7 subtraction starting at 100 [ ] 93 [ ] 86 [ ] 79 [ ] 72 [ ] 65
4 or 5 correct subtractions: **3 pts**, 2 or 3 correct: **2 pts**, 1 correct: **1 pt**, 0 correct: **0 pt**

__/3

LANGUAGE

Repeat : I only know that John is the one to help today. [ ]
The cat always hid under the couch when dogs were in the room. [ ]

__/2

Fluency / Name maximum number of words in one minute that begin with the letter F [ ] ____ (N ≥ 11 words)

__/1

ABSTRACTION

Similarity between e.g. banana - orange = fruit [ ] train – bicycle [ ] watch - ruler

__/2

DELAYED RECALL

Has to recall words WITH NO CUE	FACE [ ]	VELVET [ ]	CHURCH [ ]	DAISY [ ]	RED [ ]	Points for UNCUED recall only
Optional: Category cue						
Optional: Multiple choice cue						

__/5

ORIENTATION

[ ] Date [ ] Month [ ] Year [ ] Day [ ] Place [ ] City

__/6

© Z.Nasreddine MD Version 7.0 www.mocatest.org Normal ≥ 26 / 30

TOTAL __/30
Add 1 point if ≤ 12 yr edu

Administered by: ____________________

Montreal Cognitive Assessment (MoCA) Administration and Scoring Instructions

The Montreal Cognitive Assessment (MoCA) was designed as a rapid screening instrument for mild cognitive dysfunction. It assesses different cognitive domains: attention and concentration, executive functions, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. Time to administer the MoCA is approximately 10 minutes. The total possible score is 30 points; a score of 26 or above is considered normal.

1. Alternating Trail Making:
Administration: The examiner instructs the subject: "Please draw a line, going from a number to a letter in ascending order. Begin here [point to (1)] and draw a line from 1 then to A then to 2 and so on. End here [point to (E)]."

Scoring: Allocate one point if the subject successfully draws the following pattern:
1 −A- 2- B- 3- C- 4- D- 5- E, without drawing any lines that cross. Any error that is not immediately self-corrected earns a score of 0.

2. Visuoconstructional Skills (Cube):
Administration: The examiner gives the following instructions, pointing to the **cube**: "Copy this drawing as accurately as you can, in the space below".

Scoring: One point is allocated for a correctly executed drawing.

- Drawing must be three-dimensional
- All lines are drawn
- No line is added
- Lines are relatively parallel and their length is similar (rectangular prisms are accepted)

A point is not assigned if any of the above-criteria are not met.

3. Visuoconstructional Skills (Clock):
Administration: Indicate the right third of the space and give the following instructions: "Draw a **clock**. Put in all the numbers and set the time to 10 after 11".

Scoring: One point is allocated for each of the following three criteria:

- Contour (1 pt.): the clock face must be a circle with only minor distortion acceptable (e.g., slight imperfection on closing the circle);

- Numbers (1 pt.): all clock numbers must be present with no additional numbers; numbers must be in the correct order and placed in the approximate quadrants on the clock face; Roman numerals are acceptable; numbers can be placed outside the circle contour;

- Hands (1 pt.): there must be two hands jointly indicating the correct time; the hour hand must be clearly shorter than the minute hand; hands must be centred within the clock face with their junction close to the clock centre.

A point is not assigned for a given element if any of the above-criteria are not met.

4. Naming:
Administration: Beginning on the left, point to each figure and say: "Tell me the name of this animal".

Scoring: One point each is given for the following responses: (1) camel or dromedary, (2) lion, (3) rhinoceros or rhino.

5. Memory:
Administration: The examiner reads a list of 5 words at a rate of one per second, giving the following instructions: "This is a memory test. I am going to read a list of words that you will have to remember now and later on. Listen carefully. When I am through, tell me as many words as you can remember. It doesn't matter in what order you say them". Mark a check in the allocated space for each word the subject produces on this first trial. When the subject indicates that (s)he has finished (has recalled all words), or can recall no more words, read the list a second time with the following instructions: "I am going to read the same list for a second time. Try to remember and tell me as many words as you can, including words you said the first time." Put a check in the allocated space for each word the subject recalls after the second trial.
At the end of the second trial, inform the subject that (s)he will be asked to recall these words again by saying, "I will ask you to recall those words again at the end of the test."

Scoring: No points are given for Trials One and Two.

6. Attention:
Forward Digit Span: Administration: Give the following instruction: "I am going to say some numbers and when I am through, repeat them to me exactly as I said them". Read the five number sequence at a rate of one digit per second.
Backward Digit Span: Administration: Give the following instruction: "Now I am going to say some more numbers, but when I am through you must repeat them to me in the backwards order." Read the three number sequence at a rate of one digit per second.

Scoring: Allocate one point for each sequence correctly repeated, (N.B.: the correct response for the backwards trial is 2-4-7).

Vigilance: Administration: The examiner reads the list of letters at a rate of one per second, after giving the following instruction: "I am going to read a sequence of letters. Every time I say the letter A, tap your hand once. If I say a different letter, do not tap your hand".

Scoring: Give one point if there is zero to one errors (an error is a tap on a wrong letter or a failure to tap on letter A). MoCA Version November 12, 2004 © Z. Nasreddine MD www.mocatest.org 3

Serial 7s: Administration: The examiner gives the following instruction: “Now, I will ask you to count by subtracting seven from 100, and then, keep subtracting seven from your answer until I tell you to stop.” Give this instruction twice if necessary.

Scoring: This item is scored out of 3 points. Give no (0) points for no correct subtractions, 1 point for one correction subtraction, 2 points for two-to-three correct subtractions, and 3 points if the participant successfully makes four or five correct subtractions. Count each correct subtraction of 7 beginning at 100. Each subtraction is evaluated independently; that is, if the participant responds with an incorrect number but continues to correctly subtract 7 from it, give a point for each correct subtraction. For example, a participant may respond “92 – 85 – 78 – 71 – 64” where the “92” is incorrect, but all subsequent numbers are subtracted correctly. This is one error and the item would be given a score of 3.

7. Sentence repetition:

Administration: The examiner gives the following instructions: “I am going to read you a sentence. Repeat it after me, exactly as I say it [pause]: **I only know that John is the one to help today.”** Following the response, say: “Now I am going to read you another sentence. Repeat it after me, exactly as I say it [pause]: **The cat always hid under the couch when dogs were in the room.**”

Scoring: Allocate 1 point for each sentence correctly repeated. Repetition must be exact. Be alert for errors that are omissions (e.g., omitting "only", "always") and substitutions/additions (e.g., "John is the one who helped today;" substituting "hides" for "hid", altering plurals, etc.).

8. Verbal fluency:

Administration: The examiner gives the following instruction: “Tell me as many words as you can think of that begin with a certain letter of the alphabet that I will tell you in a moment. You can say any kind of word you want, except for proper nouns (like Bob or Boston), numbers, or words that begin with the same sound but have a different suffix, for example, love, lover, loving. I will tell you to stop after one minute. Are you ready? [Pause] Now, tell me as many words as you can think of that begin with the letter F. [time for 60 sec]. Stop.”

Scoring: Allocate one point if the subject generates 11 words or more in 60 sec. Record the subject’s response in the bottom or side margins.

9. Abstraction:

Administration: The examiner asks the subject to explain what each pair of words has in common, starting with the example: “Tell me how an orange and a banana are alike”. If the subject answers in a concrete manner, then say only one additional time: “Tell me another way in which those items are alike”. If the subject does not give the appropriate response (fruit), say, “Yes, and they are also both fruit.” Do not give any additional instructions or clarification.
After the practice trial, say: “Now, tell me how a train and a bicycle are alike”. Following the response, administer the second trial, saying: “Now tell me how a ruler and a watch are alike”. Do not give any additional instructions or prompts.

MoCA scores			
	Normal Controls (NC)	Mild Cognitive Impairment (MCI)	Alzheimer's Disease (AD)
Number of subjects	90	94	93
MoCA average score	**27.4**	**22.1**	**16.2**
MoCA standard deviation	2.2	3.1	4.8
MoCA score range	25.2 - 29.6	19.0 – 25.2	21.0 – 11.4
Suggested cut-off score	**≥26**	**<26**	**<26 Ψ**

Ψ Although the average MoCA score for the AD group is much lower than the MCI group, there is overlap between them. The suggested MoCA cut-off score is thus the same for both. The distinction between AD and MCI is mostly dependent on the presence of associated functional impairment and not on a specific score on the MoCA test.

Sensitivity and Specificity (%) MoCA and MMSE			
Cut-off	≥ 26	< 26	< 26
Group (n)	Normal Controls (90)	Mild Cognitive Impairment (94)	Alzheimer Disease (93)
MoCA	**87**	**90**	**100**
MMSE	100	18	78

MoCA Items Average scores

	NC		MCI		AD	
	AVG	SD	**AVG**	SD	**AVG**	SD
Trails	**0.87**	0.34	**0.56**	0.50	**0.27**	0.45
Cube	**0.71**	0.46	**0.46**	0.50	**0.25**	0.43
Clock	**2.65**	0.65	**2.16**	0.82	**1.56**	0.98
Naming	**2.88**	0.36	**2.64**	0.58	**2.19**	0.82
Memory	**3.73**	1.27	**1.17**	1.47	**0.52**	1.03
Digit span	**1.82**	0.44	**1.83**	0.43	**1.49**	0.62
Letter A	**0.97**	0.18	**0.93**	0.26	**0.67**	0.47
Serial 7	**2.89**	0.41	**2.65**	0.65	**1.82**	1.12
Sentence rep	**1.83**	0.37	**1.49**	0.71	**1.37**	0.80
Fluency F	**0.87**	0.34	**0.71**	0.45	**0.32**	0.47
Abstraction	**1.83**	0.43	**1.43**	0.68	**0.99**	0.80
Orientation	**5.99**	0.11	**5.52**	0.84	**3.92**	1.73
Total*	**27.37**	2.20	**22.12**	3.11	**16.16**	4.81

SD=Standard Deviation. AVG=Average
*Total is adjusted for education

Trip Logs

University of Waterloo: Trip Log EXAMPLE

Note: 13 pt font and 1.5 spacing will be used for the actual logs and examples.

Date: October 6, 2008 **Time of Day:** 9:24_____ **am / pm** (circle one)

Driver: ______Me_____________ (If you are **not** in the study, note "NP")

Number of Passengers: □ 0 ☑ 1 □ 2 □ 3 □ 4

Relation of Passengers: (Check all that apply) □ Partner ☑ Friend □ Grandchild □ Other relative □ Other

I drove (check one): ☑ The entire trip □ Only the way there □ Only the way home

If you drove only one way, what is your relationship (e.g. friend, spouse) to the person **who drove** the other way? □ Partner □ Friend □ Grandchild □ Other relative □ Other

Please note the weather conditions of your trip (e.g. sunny, foggy, rainy, thunderstorm, etc.)
______Sunny, light rain on the way home____________________________________

Did you listen to the radio/music during the trip: □ Yes ☑ No

Check the number of stops you made and **note** the purpose of each one (consider home as the last stop):

Stops	Time of Medication	Arrival Time	Purpose	Location
☑ 1	9:00am	9:30	Grocery shopping	Sobey's @ Highland & Belmont
□ 2		9:50	Pharmacy	Shoppers @ Highland & Westmount
☑ 3		10:05	Rent video	Blockbuster @ Fischer-Hallman & Highland
☑ 4		10:15	Home	
□ 5				
□ 6				
□ 7				

Trip Log Instructions

Please leave these logs in **this** vehicle and fill out a separate one after **each** driving trip. In addition to the date and time you left home, we need the following information.

Driver: Please identify whether **you** drove the vehicle for each trip. If "other", just put in **NP** (non-participant) and note the time of day. The rest of the log does not have to be completed.

Number of passengers: check the number of different passengers you had in your car **at any point** on the trip. For example, if you left home with your partner, dropped him/her off and then picked up your grandchild before returning home, you had two passengers in your car.

Relation of passenger: Identify your relationship with each passenger (e.g., partner). If you had more than one passenger, check all that apply.

More than one driver on the trip: Please indicate whether you drove the entire way or shared the driving. If someone else drove part of the way, indicate **your relationship** to this person.

Weather conditions: Please describe the weather conditions during the trip as best as you can.

Listened to the radio or music during trip: Please check yes or no.

Please note **all the places you went** (e.g., grocery store), approximate **time of arrival** to each place, and general **locations** (e.g. streets, intersection). **An example is provided.**

If you have any questions or problems, please call the number below. If I am not there, leave a message and someone from the MDRC will return your call as soon as possible.

Alex Crizzle

MDRC: 519-884-0710, extension 3924

FREQUENTLY ASKED QUESTIONS ABOUT THE DEVICES

At our first appointment, I will explain the two devices that are being installed in your vehicle for the two week monitoring period. This sheet also explains how the devices work, what you can expect and what you should do in certain circumstances.

1. How do the devices work?

The CarChip is the small device that plugs into your diagnostic port (usually located under the steering wheel). The second device is a Global Positioning System (GPS) unit (called the Otto) which is mounted on your dashboard via a sticky pad and plugged into your lighter/cigarette adapter. Together, these devices store data from your car's computer, including: distance traveled, duration and general location (using the GPS system and local maps). The data is recorded each time the car is turned on.

In most cases **you do not have to do anything** with these devices nor will they affect your vehicle in any way. However there are some important things you should know.

2. What if I need to take my car in for servicing?

As we discussed, try your best not go in for regular servicing over this two week period. However, if you need to please remind the mechanic to put the CarChip back in if they remove it (for diagnostic purposes). I will also show you how to do this. The Otto on the dashboard should be okay, however, the cables (connections) may get bumped (disconnected). I will show you how to reconnect these.

3. Why is it important that the Otto stay on the dashboard?

The Otto will not affect your view, but it is important that it stays on the dashboard to pick up satellite signals through your windshield. If moved (example to the cup holder), it will not pick up these signals. So please leave it on the dashboard.

4. How do I know the Otto is on and working?

When the vehicle is turned on, **a green (LED) light** should appear on the Otto. Don't worry if this takes a few minutes. If the device has been off for several hours it takes time to find the satellite signals. The signal can also temporarily be lost if you go under a bridge or past tall buildings.

5. What if I hear a message ("Outside Coverage Area") or the light flickers?

The Otto has been mapped for the K-W municipal area. If you drive outside this area, you will hear a voice say **"Outside Coverage Area"**. Unfortunately, this cannot be turned off. While it may be annoying, just ignore the message as the device is still working.
When the vehicle goes outside the coverage area, you will also notice that the solid green light starts flashing. Again please ignore, this should stop in two seconds.

6. What if the Otto light stays on after my car is turned off?
In most cars, the Otto lights turn off once your car is turned off. If your light stays on, it means that your socket is "live" and the Otto is being constantly supplied with power. This is a problem for the study as the Otto will keep recording whether the car is on or off and will run out of memory.
If this occurs, we need you to **manually remove** the Otto's power adapter from the socket. Each time you turn off your car, please remember to **unplug** the adapter from the socket and **plug it back in** the next time you turn on your car. I will show you how to do this in case it is necessary. **Please leave a message at the MDRC (519-884-0710, ext 3924) if this occurs. And call if you have any difficulty with this.**

7. What should I do if the Otto light keeps going off and on?
This means that the connection is loose. This can happen if you drive over a big bump.
When you stop driving please check if the **power adapter is pressed securely into the socket.** You can feel this when you can no longer turn/twist your adapter. I will also show you how to do this if case this happens.

8. What if I have two power sockets? Which one should I use?
Some vehicles may have more than one power outlet or socket: the main one (located on or near the front panel) and another for an accessory device, which may be on the arm rest or in the glove compartment. The main power source (front panel) is usually best for electronic devices such as the Otto. Do not worry, I will choose the best socket to connect the Otto when I install the device. But it is important you don't change this.

If you have any problems with the devices or questions about the trip logs or anything else over this two week period, please call the MDRC (519-884-0710, ext 3924). Leave a voice message if I am not there and someone will return your call as soon as possible.

Vehicle Recording Sheet

Driver Name: ________________________________ ID#: ______________________

	Make	Model	Year	Purchase Date (Mo/Year)
Vehicle 1				
Vehicle 2				

Primary vehicle driven: ______ (1 or 2?) and one used for study period? _____ (1 or 2 ?)

Purchased (primary) vehicle: ____ new or ____ used?

If used, odometer (kms) reading at time of purchase: _____________

Does someone else in household also drive? ____ no ____ yes

If yes, do they have their own vehicle? ____ no ____ yes

Odometer Reading	First Visit	Second Visit
Date:		
Vehicle 1		

Appendix E: Second Visit Materials and Tools

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Checklist for Assessment 2

Name: ________________________________ Date: _________________________

ID: _________________________ Group: ________________________

Time In: _______________________ Time Out: _____________________

Check box once completed: Researcher Notes:

Remove Devices	□	
Odometer Reading	□	
Collect trip logs/clipboard	□	Note: collect at beginning & go through (when doing scales)
DHQ	□	
DCS (both)	□	
PDA (both)	□	
Brake Test	□	Note time:______
SDF	□	
SDA	□	
ABC	□	
Interview	□	Note time:______
Permission to Contact (Control group only)	□	
Letter of Participation	□	

Driving Habits Questionnaire

Note: 13 pt font used for actual form

Please tell us about your general driving habits.

1. Approximately how **old were you** when you got your driver's license? _____

2. Did you **commute to work as a driver** more than one hour each way? __ No ___ Yes

3. How many **days a week** do you **normally** drive? _____

4. **How long** are most of your driving trips (each way)?

   ___ less than 15 minutes ___ about 15 to 30 minutes

   ___ about 30 to 60 minutes ___ over 60 minutes

5. What **types of roads** do you typically drive on? (check all that apply)

   ___ residential streets ___ main city streets ___ rural roads

   ___ freeways (e.g., 400 series) ___ highways (e.g., Hwys 6,7, and 8)

6. What **times of the day** do you usually drive? (check all that apply)

   ___ morning ___ afternoon ___early evening (before dark) ___at night (after dark)

7. Overall, **compared to 10 years ago**, do you drive:

   ___ much less often ___ a little less ___ the same ___ more often

8. Compared to the summer, in the **winter** do you drive:

   ___ much less often ___ a little less ___ the same ___ more often

9. How do you **prefer** to get around?

   ___ drive yourself ___ have someone drive you
   ___ special transit services ___ taxis ___ buses ___ walk

10. Do you prefer to drive alone or with a passenger? ___No ___Yes

11. Does anyone else **rely on you** to drive them? ___ No ___ Yes
    Note: this person may or may not live with you

12. To what extent **do you worry about car related expenses**?
(gas, maintenance or repair costs, license and insurance costs)

____ Often ____ Sometimes ____ Rarely ____ Never

13. Who takes your household vehicle in for **regular servicing**?

____ Me ____ My partner ____ Other (specify:__________________)

14. Do you change your tires for winter driving? ____No ____Yes

If you did not feel like driving, are you **close enough to walk** to:

a) do your weekly shopping & errands? ___ No ___ Yes

b) get to church, social or recreation clubs? ___ No ___ Yes

15. Has your physician ever **asked you whether you drive**? ___ No ___ Yes

16. Have you **talked about your driving** with any of the following**?**

An eye care professional ___ No ___ Yes

Family members ___ No ___ Yes

Friends ___ No ___ Yes

17. Has anyone **suggested** that you **limit or stop driving**? ___ No ___ Yes
If yes, who? (check all that apply)

___ Family ___ Friends ___Your physician ___ An eye care professional

18. Are you seriously thinking about **giving up driving** in the next few years?

____ No ____ Yes If so, why? ____________________________

19. Have you seriously thought about **reducing the amount you drive**?

____ Yes ____ No

20. Do you ever feel tired when driving?

____Yes _____No

21. Do you have difficulties staying awake or remaining alert when driving?

____Yes ____No

22. Do Parkinsonian medications affect your driving? **(note: Q 22-27 for PD group)**

____Yes ____No

23. Do your symptoms worsen when driving?

____Yes ____No

If yes, which ones? ____

If yes, how long can you drive without your symptoms worsening? ____

24. If you are taking Levodopa, do you find symptoms return before your next dose?

____Yes ____No _____NA (not taking Levodopa)

25. Do you adjust when you take your medication (or take your meds at a certain time) because of when you expect to drive on a particular day?

____Yes ____No

26. Do you have problems with dyskinesia (involuntary shaking) when you first take your medication?

____Yes ____No

27. Do you have unexpected return of symptoms when taking medications?

____Yes ____No

28. Have you taken **any driving courses**? ___ No ___ Yes

If yes, what type of course?_____________________

29. In the past five years, have you been asked by the Ministry of Transportation **to take:**

a vision test? ___ No ___ Yes

a rules test? ___ No ___ Yes

a road test? ___ No ___ Yes

a vision or medical examination? ___ No ___ Yes

a comprehensive or rehabilitation driving assessment? ___ No ___ Yes

30. In the past year, have you had any of these **problems when driving**?

Accidents involving another vehicle? ___ No___ Yes

If yes, how many accidents? ________

If yes, how many were you at fault? ________

Near misses (almost an accident)? ___ No___ Yes

Backing into things besides other cars? ___ No___ Yes

Getting lost? ___ No___ Yes

Traffic violations with loss of demerit points? ___ No ___Yes

31. What are the **main reasons** you drive? (Check all that apply)

___ shopping, banking and other errands

___ getting to appointments (such as the doctor or dentist)

___ visiting family or friends

___ getting to religious services

___ getting to recreational activities or social events

___ other (volunteer, employment), specify: ____________________

32. How **important** is it for you, personally, to **continue** to drive? (circle one)

1	2	3	4	5
Extremely Important	Very	Moderately Important	Somewhat	Not that Important

33. Using the scale above, please rate **how important** (from 1 to 5) it is for you to **keep driving** for each of the following reasons:

To maintain your present lifestyle (places you want to go) _____

To meet commitments such as volunteer work or helping others _____

To get to shops and services from where you live _____

Due to poor public transportation _____

Due to other people counting on you to drive them _____

Due to family or friends not available to drive you _____

Due to not wanting to bother others for rides _____

Due to physical difficulty walking or using public transport _____

Thank-you for completing the questionnaire.

Driving Comfort Scales

Please rate your level of comfort by choosing one option from the scale (0, 25, 50, 75 or 100 %) and checking the box beside each situation.

If you do not normally drive in the situation, imagine how comfortable you would be if you absolutely had to go somewhere and found yourself in the situation.

In your ratings, consider confidence in your own abilities and driving skills, as well as the situation itself (including other drivers).

Assume **normal traffic flow** unless otherwise specified.

'How **comfortable** are you driving in the **daytime**…?'

Comfort Level	**Not confident** **0%**	**25%**	**Moderately Comfortable** **50%**	**75%**	**Completely Comfortable** **100%**
1. In light rain?	☐	☐	☐	☐	☐
2. In heavy rain?	☐	☐	☐	☐	☐
3. In winter conditions (snow,ice)?	☐	☐	☐	☐	☐
4. If caught in an unexpected or sudden storm?	☐	☐	☐	☐	☐
5. Making a left hand turn with no lights or stop signs?	☐	☐	☐	☐	☐

~ Please continue on next page ~

Comfort Level	**Not confident** **0%**	**25%**	**Moderately Comfortable** **50%**	**75%**	**Completely Comfortable** **100%**
6. Pulling in or backing up from tight spots in parking lots with large vehicles on either side?	☐	☐	☐	☐	☐
7. Seeing street or exit signs with little warning?	☐	☐	☐	☐	☐
8. On two lane highways?	☐	☐	☐	☐	☐
9. Keeping up with the flow of highway traffic when the flow is <u>over</u> the posted speed limit of 100 km/h (60 miles/h)?	☐	☐	☐	☐	☐
10. With multiple transport trucks around you?	☐	☐	☐	☐	☐
11. When other drivers tailgate or drive too close behind you?	☐	☐	☐	☐	☐
12. When other drivers pass on a non-passing lane?	☐	☐	☐	☐	☐
13. When other drivers do not signal or seem distracted?	☐	☐	☐	☐	☐

~ Please continue on next page ~

Now we would like you to rate your level of comfort when driving in the following situations **at night**.

Even if you **do not normally drive at night**, imagine that you were out in the afternoon, got delayed and it was dark on your way back.

In your ratings, consider confidence in your own abilities and driving skills, as well as the situation itself (including other drivers).

'How **comfortable** are you driving **at night** …?'

Comfort Level	**Not confident** **0%**	**25%**	**Moderately Comfortable** **50%**	**75%**	**Completely Comfortable** **100%**
1 In good weather and traffic conditions?	☐	☐	☐	☐	☐
2. In light rain?	☐	☐	☐	☐	☐
3. In heavy rain?	☐	☐	☐	☐	☐
4. In winter conditions (snow,ice)?	☐	☐	☐	☐	☐
5. When there is glare of reflection from lights?	☐	☐	☐	☐	☐
6. In unfamiliar routes (different areas), detours or sign changes?	☐	☐	☐	☐	☐
7. Making a left hand turn with no lights or stop signs?	☐	☐	☐	☐	☐

~ Please continue on next page ~

Comfort Level	**Not confident** **0%**	**25%**	**Moderately Comfortable** **50%**	**75%**	**Completely Comfortable** **100%**
8. Pulling in or backing up from tight spots in parking lots with large vehicles on either side?	☐	☐	☐	☐	☐
9. Seeing street or exit signs with little warning?	☐	☐	☐	☐	☐
10. On two lane highways?	☐	☐	☐	☐	☐
11. Keeping up with the flow of highway traffic when the flow is <u>over</u> the posted speed limit of 100 km/h (60 miles/h)?	☐	☐	☐	☐	☐
12. With multiple transport trucks around you?	☐	☐	☐	☐	☐
13. Merging with traffic and changing lanes on the highway?	☐	☐	☐	☐	☐
14. When other drivers tailgate or drive too close behind you?	☐	☐	☐	☐	☐
15. When other drivers pass on a non-passing lane?	☐	☐	☐	☐	☐
16. When other drivers do not signal or seem distracted?	☐	☐	☐	☐	☐

Perceived Driving Abilities Scales

How would you rate your **current ability** to…..?

Assume daytime driving unless specified otherwise (night).

	Poor	**Fair**	**Good**	**Very Good**
1. See road signs at a distance	☐	☐	☐	☐
2. See road signs at a distance (night)	☐	☐	☐	☐
3. See your speedometer and controls	☐	☐	☐	☐
4. See pavement lines (at night)	☐	☐	☐	☐
5. Avoid hitting curbs or medians	☐	☐	☐	☐
6. See vehicles coming up beside you	☐	☐	☐	☐
7. See objects on the road (at night) with glare from lights or wet roads	☐	☐	☐	☐
8. Quickly spot pedestrians stepping out from between parked cars	☐	☐	☐	☐
9. Move your foot quickly from the gas to the brake pedal	☐	☐	☐	☐
10. Make an over the shoulder check	☐	☐	☐	☐
11. Quickly find a street or exit in an unfamiliar area and heavy traffic	☐	☐	☐	☐
12. Get in and out of your car	☐	☐	☐	☐
13. Reverse or back up	☐	☐	☐	☐
14. Make quick driving decisions	☐	☐	☐	☐
15. Drive safely (avoid accidents)	☐	☐	☐	☐

Compared to 10 years ago, how would you rate your own ability to…?

	better	**same**	**a little worse**	**a lot worse**
1. See road signs at a distance	☐	☐	☐	☐
2. See road signs at a distance (night)	☐	☐	☐	☐
3. See your speedometer and controls	☐	☐	☐	☐
4. See pavement lines (at night)	☐	☐	☐	☐
5. Avoid hitting curbs or medians	☐	☐	☐	☐
6. See vehicles coming up beside you	☐	☐	☐	☐
7. See objects on the road (at night) with glare from lights or wet roads	☐	☐	☐	☐
8. Quickly spot pedestrians stepping out from between parked cars	☐	☐	☐	☐
9. Move your foot quickly from the gas to the brake pedal	☐	☐	☐	☐
10. Make an over the shoulder check	☐	☐	☐	☐
11. Quickly find a street or exit in an unfamiliar area and heavy traffic	☐	☐	☐	☐
12. Get in and out of your car	☐	☐	☐	☐
13. Reverse or back up	☐	☐	☐	☐
14. Make quick driving decisions	☐	☐	☐	☐
15. Drive safely (avoid accidents)	☐	☐	☐	☐

Situational Driving Frequency Rating Scale

Based on your present lifestyle, on average **<u>how often</u>** do you drive….?
Check one box for each situation.

	Never	**Rarely** Less than once a month	**Occasionally** More than once a month, but not weekly	**Often** 1 - 3 days a week	**Very Often** 4 - 7 days a week
1. In the winter?	☐	☐	☐	☐	☐
2. At night?	☐	☐	☐	☐	☐
3. On two-lane highways?	☐	☐	☐	☐	☐
4. In rural areas?	☐	☐	☐	☐	☐
5. On highways with 3 or more lanes?	☐	☐	☐	☐	☐
6. Over the posted highway speed limit?	☐	☐	☐	☐	☐
7. On one-way trips lasting over 2 hours?	☐	☐	☐	☐	☐
8. In heavy traffic or rush hour in town?	☐	☐	☐	☐	☐
9. In heavy traffic or rush hour on the highway?	☐	☐	☐	☐	☐
10. With passengers?	☐	☐	☐	☐	☐
11. Outside your village, town or city?	☐	☐	☐	☐	☐
12. In new or unfamiliar areas?	☐	☐	☐	☐	☐
13. Making left hand turns at intersections?	☐	☐	☐	☐	☐
14. Parking in tight spaces?	☐	☐	☐	☐	☐

Situational Driving Avoidance Rating Scale

If possible, do you **try to avoid** any of these driving situations?

(*Check all that apply.)*

1. Night	☐
2. Dawn or dusk	☐
3. Bad weather conditions (in general)	☐
4. Heavy rain	☐
5. Fog	☐
6. Nighttime driving in bad weather (e.g., heavy rain)	☐
7. Winter	☐
8. First snow storm of the season	☐
9. Trips lasting more than 2 hours (one way)	☐
10. Unfamiliar routes (different areas) or detours	☐
11. Heavy traffic or rush hour in town	☐
12. Heavy traffic or rush hour on the highway (or expressway)	☐
13. Making left hand turns with traffic lights	☐
14. Making left hand turns with no lights or stop signs	☐
15. Parking in tight spaces	☐
16. Highways with 3 or more lanes and speed limits of 100 km/h or more	☐
17. Changing lanes on a highway with 3 or more lanes	☐
18. Two-lane highways	☐
19. Rural areas at night	☐
20. Driving with passengers who may distract you	☐
21. No: I don't try and avoid any of these situations	☐

The Activities-specific Balance Confidence (ABC) Scale

Note: Additional items added to Original ABC-16 (Q# 17-21)

For each of the following activities, please indicate your level of self-confidence by choosing a corresponding number from the following rating scale:

0% No Confidence	25%	50%	75%	100% Completely Confident

"How confident are you that you can maintain your balance and remain steady when you....

Balance Confidence	**No confidence 0%**	**25%**	**50%**	**75%**	**Completely Confident 100%**
1 walk around the house?	☐	☐	☐	☐	☐
2. walk up or down stairs?	☐	☐	☐	☐	☐
3. bend over and pick up a slipper from the front of a closet floor?	☐	☐	☐	☐	☐
4. reach for a small can off a shelf at eye level?	☐	☐	☐	☐	☐
5. stand on your tip toes and reach for something above your head?	☐	☐	☐	☐	☐
6. stand on a chair and reach for something?	☐	☐	☐	☐	☐
7. sweep the floor?	☐	☐	☐	☐	☐
8. walk outside the house to a car parked in the driveway?	☐	☐	☐	☐	☐
9. get into or out of a car?	☐	☐	☐	☐	☐
10. walk across a parking lot to the mall?	☐	☐	☐	☐	☐
11. walk up or down a ramp?	☐	☐	☐	☐	☐
12. walk in a crowded mall where people rapidly walk past you?	☐	☐	☐	☐	☐
13. are bumped into by people as you walk through the mall?	☐	☐	☐	☐	☐
14. step onto or off of an escalator while holding onto a railing?	☐	☐	☐	☐	☐

15. step onto or off an escalator while holding onto parcels such that you cannot hold onto the railing?	☐	☐	☐	☐	☐
16. walk outside on icy sidewalks?	☐	☐	☐	☐	☐
17. stepping up and down from sidewalk curves?	☐	☐	☐	☐	☐
18. standing on a moving bus/train/subway?	☐	☐	☐	☐	☐
19. crossing crosswalks at intersections?	☐	☐	☐	☐	☐
20. crossing intersections where there is a median?	☐	☐	☐	☐	☐
21. crossing intersections when there is no median?	☐	☐	☐	☐	☐

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The Activities-specific Balance Confidence (ABC) Scale

Administration

The ABC can be self-administered, via personal or telephone interview. Larger typeset should be used for self-administration, while an enlarged version of the rating scale on an index card will facilitate interviews. Each respondent should be queried concerning their understanding of the instructions, and probed regarding difficulty answering any specific items.

Instructions to Respondents

"For each of the following, please indicate your level of confidence in doing the activity without losing your balance or becoming unsteady by choosing one of the percentage points on the scale from 0% to 100%. If you **do not currently do** the activity in question, try and imagine how confident you would be if you had to do the activity. If you **normally** use a walking aid to do the activity or hold onto someone, rate your confidence as if you were using these supports. If you have any questions about answering any of the items, please ask the administrator."

Instructions for Scoring

Total the ratings (possible range = 0 to 1600) and divide by 16 (or the number of items completed) to get each person's ABC score. If a person qualifies his/her response to items #2, #9, #11, #14, or #15 (different ratings for "up" vs "down" or "onto" vs "off"), solicit separate ratings and use the **lowest** confidence rating of the two (as this will limit the entire activity, e.g, likelihood of using stairs). Total scores can be computed if at least 12 of the items are answered. Note: internal confidence (alpha) does not decrease appreciably with the deletion of item # 16--icy sidewalks--for administration in warmer climates (Myers et al.'98).

Powell LE & Myers AM. The Activities-specific Balance Confidence (ABC) Scale. *J Gerontol Med Sci* 1995; 50 (1):M28-34.

Myers AM, Powell LE, Maki BE et al. Psychological indicators of balance confidence: Relationship to actual and perceived abilities. *J Gerontol Med Sci* 1996; 51A: M37-43.

Myers AM, Fletcher PC, Myers AH & Sherk W. Discriminative and evaluative properties of the Activities-specific Balance Confidence (ABC) Scale. *J Gerontol Med Sci* 1998; 53A: M287-M294.

Myers AM. *Program Evaluation for Exercise Leaders.* Champaign, IL: Human Kinetics.

Final Visit Interview Script

Name: ___________________________________ Date: ____________________

Part A: Driving Over the Past Two Weeks

1. Did having the **devices** in your car **affect your driving** behavior in any way?
   ___No ___Yes If so, how? ____

2. Can you **estimate the number of km** you drove over the last two weeks? __ No __ Yes
   If yes, ________ (# kms) If unsure, do you want to try and guess? _________ (# **km**)

   or ___Can't estimate

3. Over the past 2 weeks, did you have **any car or driving problems**? ___ No ___ Yes
   If so, **what were they**? ____

   ____

   ____

   (Probe: Accidents involving another vehicle, near misses, backing into things besides other cars, getting lost, traffic violations with loss of demerit points, car troubles)

4. Were the last two weeks **typical** **of your usual driving** with respect to **how much** you drove, **when, where, passengers**? ___Yes ___No If not, **what was different?**

   ____

   ____

   ____

5. Any **special circumstances** (e.g., illness, visitors) OR **events** (e.g., birthdays, appointments) that affected your usual driving patterns (e.g., longer trips than usual)?

   ____

   ____

   ____

6. Did you have any **regularly scheduled activities** (e.g., curling, bridge club) or appointments over the past two weeks? ___ Yes ___ No

If yes, what were these?____

7. Over the past two weeks, were there **any trips you were going to take but decided not to**?
___No ___Yes *If yes, elaborate. Probe:* ***why*** *canceled or postponed, typicality*

____

____

____

Part B: Activity Trip Logs

I looked over your activity trip logs and want to clarify a few things with you.

List activities (apart from routine chores like shopping) from the logs *and probe for typical frequency of things like exercise classes, volunteering, babysitting, playing bridge.*

I see you went to….. Do you do this on a regular basis? How often? (e.g., weekly)

Activities from Logs:	**Regularity:**

Part C: General Questions

1. Generally speaking, what are the kinds of things you **might cancel or postpone** if you did not feel like driving (e.g., tired) or the weather was bad?

____

____

2. Are there any activities you **feel compelled to do,** even if you did not feel like driving?

____

____

____

3. If you did **not feel like driving yourself**, could you get there **another way**?

____

____

4. **If you were no longer able to drive** for some reason, what would be affected the most?

____

____

Comments:____

____

____

Thank them for completing the interview.

Permission to Contact for Future Studies
Control Group Only

In the future, we will likely be conducting further studies with older drivers at the University of Waterloo. If you would like to receive information about such studies, we require your permission to contact you by mail, phone or e-mail.

I give my permission for Dr. Anita Myers from the University of Waterloo or her graduate students to contact me in the next five years to let me know about further studies with older drivers. I understand that I am under no obligation to participate in future studies should I be contacted. Contact information will be kept secure (in a locked file cabinet) and not be given to anyone or used for any other purpose. This information will be destroyed once contact has been made, if any, or within five years from this date.

Name (please print):____

Address: ____

Phone number: ___________________Email: ________________________

Signature:_____________________________________ Date: ___________

Researcher's Signature: ___________________________Date: ___________

Appendix F: UPDRS and Hoehn & Yahr Scales

UNIFIED PARKINSON'S DISEASE RATING SCALE

III. MOTOR EXAMINATION

18. Speech
0 = Normal.
1 = Slight loss of expression, diction and/or volume.
2 = Monotone, slurred but understandable; moderately impaired.
3 = Marked impairment, difficult to understand.
4 = Unintelligible.

19. Facial Expression
0 = Normal.
1 = Minimal hypomimia, could be normal "Poker Face".
2 = Slight but definitely abnormal diminution of facial expression
3 = Moderate hypomimia; lips parted some of the time.
4 = Masked or fixed facies with severe or complete loss of facial expression; lips parted 1/4 inch or more.

20. Tremor at Rest (head, upper and lower extremities)
0 = Absent.
1 = Slight and infrequently present.
2 = Mild in amplitude and persistent. Or moderate in amplitude, but only intermittently present.
3 = Moderate in amplitude and present most of the time.
4 = Marked in amplitude and present most of the time.

21. Action or Postural Tremor of hands
0 = Absent.
1 = Slight; present with action.
2 = Moderate in amplitude, present with action.
3 = Moderate in amplitude with posture holding as well as action.
4 = Marked in amplitude; interferes with feeding.

22. Rigidity (Judged on passive movement of major joints with patient relaxed in sitting position. Cogwheeling to be ignored.)
0 = Absent.
1 = Slight or detectable only when activated by mirror or other movements.
2 = Mild to moderate.
3 = Marked, but full range of motion easily achieved.
4 = Severe, range of motion achieved with difficulty.

23. Finger Taps (Patient taps thumb with index finger in rapid succession.)
0 = Normal.
1 = Mild slowing and/or reduction in amplitude.
2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.
3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement.
4 = Can barely perform the task.

24. Hand Movements (Patient opens and closes hands in rapid succession.)
0 = Normal.
1 = Mild slowing and/or reduction in amplitude.
2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.
3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement.
4 = Can barely perform the task.

25. Rapid Alternating Movements of Hands (Pronation-supination movements of hands, vertically and horizontally, with as large an amplitude as possible, both hands simultaneously.)
0 = Normal.
1 = Mild slowing and/or reduction in amplitude.
2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.
3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement.
4 = Can barely perform the task.

26. Leg Agility (Patient taps heel on the ground in rapid succession picking up entire leg. Amplitude should be at least
3 inches.)
0 = Normal.
1 = Mild slowing and/or reduction in amplitude.
2 = Moderately impaired. Definite and early fatiguing. May have occasional arrests in movement.
3 = Severely impaired. Frequent hesitation in initiating movements or arrests in ongoing movement.
4 = Can barely perform the task.

27. Arising from Chair (Patient attempts to rise from a straightbacked chair, with arms folded across chest.)
0 = Normal.
1 = Slow; or may need more than one attempt.
2 = Pushes self up from arms of seat.
3 = Tends to fall back and may have to try more than one time, but can get up without help.
4 = Unable to arise without help.

28. Posture
0 = Normal erect.
1 = Not quite erect, slightly stooped posture; could be normal for older person.
2 = Moderately stooped posture, definitely abnormal; can be slightly leaning to one side.
3 = Severely stooped posture with kyphosis; can be moderately leaning to one side.
4 = Marked flexion with extreme abnormality of posture.

29. Gait
0 = Normal.
1 = Walks slowly, may shuffle with short steps, but no festination (hastening steps) or propulsion.
2 = Walks with difficulty, but requires little or no assistance; may have some festination, short steps, or propulsion.
3 = Severe disturbance of gait, requiring assistance.
4 = Cannot walk at all, even with assistance.

30. Postural Stability (Response to sudden, strong posterior displacement produced by pull on shoulders while patient erect with eyes open and feet slightly apart. Patient is prepared.)
0 = Normal.
1 = Retropulsion, but recovers unaided.
2 = Absence of postural response; would fall if not caught by examiner.
3 = Very unstable, tends to lose balance spontaneously.
4 = Unable to stand without assistance.

31. Body, Bradykinesia and Hypokinesia (Combining slowness, hesitancy, decreased armswing, small amplitude, and poverty of movement in general.)
0 = None.
1 = Minimal slowness, giving movement a deliberate character; could be normal for some persons. Possibly reduced amplitude.
2 = Mild degree of slowness and poverty of movement which is definitely abnormal. Alternatively, some reduced amplitude.
3 = Moderate slowness, poverty or small amplitude of movement.
4 = Marked slowness, poverty or small amplitude of movement.

UPDRS Scoring

UPDRS Sub-Scale	Assessment	Score Range	Total Range
Bradykinesia	Score includes: #23 – Finger taps #24 – Hands #25 – Alternating Hands #26 – Heel Taps #31 – Body Bradykinesia	 0 to 8 0 to 8 0 to 8 0 to 8 0 to 4	0 to 36
Tremor	Score includes: #20 – Action Tremor (both hands) #21 – Resting Tremor -both hands -both feet -face, lips, and chin	 0 to 8 0 to 8 0 to 8 0 to 8	0 to 32
Rigidity	Score includes: #22 -in neck -both hands -both feet	 0 to 4 0 to 8 0 to 8	0 to 20
Postural Instability	Score includes: #27 – Arising from Chair #28 - Posture #29 - Gait #30 – Postural Instability	 0 to 8 0 to 4 0 to 4 0 to 4	0 to 20
TOTAL UPDRS	#18 to 31	-	0 to 108

References:

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2. Fahn,S., & Elton, R.L. (1987). *UPDRS Development Committee. Unified Parkinson's Disease Rating Scale*. In: Fahn S, Marsden CD, Calne DB, Goldstein M, eds. Recent Developments in Parkinson's Disease. Florham Park, NJ: Macmillan; 153-163.

3. Rascol, O., Goetz, C., Koller, W, Poewe, W., & Sampaio, C. (2002). Treatment interventions for Parkinson's disease: an evidence based assessment. *Lancet*, 359, 1589-1598.

Conversion of UPDRS to Hoehn & Yahr Scale

UPDRS	Hoehn & Yahr
# 20 to 26 – all unilateral	Stage 1
# 20 to 26 – all unilateral and axial rigidity (#22 - neck and head)	Stage 1.5
# 20 to 26 – bilateral and No gait/balance impairment (#30)	Stage 2
# 20 to 26 – bilateral (if sum is < 12) and Recovery on Pull test (#30)	Stage 2.5
# 20 to 26 – bilateral (if sum is ≥ 12) and More than 3 items of # 20 to 26 and Score of ≥ 2 on #30 (balance) and Sum of # 29 & 30 (< 4)	Stage 3
# 20 to 26 – bilateral (if sum is ≥ 12) and Gait # 29 (≥3) and Sum of # 29 & 30 (≥4)	Stage 4
Wheelchair bound/bedridden	Stage 5

Original and Modified Hoehn and Yahr Scale

Hoehn and Yahr scale	**Modified Hoehn and Yahr scale**
1: Unilateral involvement only usually with minimal or no functional disability	1.0: Unilateral involvement only
	1.5: Unilateral and axial involvement
2: Bilateral or midline involvement without impairment of balance	2.0: Bilateral involvement without impairment of balance
	2.5: Mild bilateral disease with recovery on pull test
3: Bilateral disease: mild to moderate disability with impaired postural reflexes; physically independent	3.0: Mild to moderate bilateral disease; some postural instability; physically independent
4: Severely disabling disease; still able to walk or stand unassisted	4.0: Severe disability; still able to walk or stand unassisted
5: Confinement to bed or wheelchair unless aided	5.0: Wheelchair bound or bedridden unless aided

Appendix G: Definition of Time Periods and Roadways

Term	**Definition**
Morning	Sunrise to 11:59am
Afternoon	12:00pm to 5:00pm
Evening	5:01pm to sunset
Night	Sunset to sunrise
City road	Main arterial roads, speed limits of 50-60 km/hour with several stop lights
Freeway	Multi-lane, divided highways, usually with speed limits 90+ km/hour
Highway	Roadways with speed limits generally greater than 70 km/hour; denoted by highway sign on maps
Residential road	Minor arterial roads with speed limits of < 50 km/hr, usually no stop lights; intersections are uncontrolled or controlled by stop signs.
Rural road	Roads in rural areas, usually denoted by regional road on maps

Note: time of sunrise and sunset for K-W region obtained from http://www.sunsetsunrise.com.

Appendix H: Additional Sample and Health Characteristics

	Total Sample N=47	Group	
		PD n=27	Control n=20
Place of Residence			
Private Home	31 (66.0)	17 (63.0)	14 (70)
Apartment/Condo	13 (27.6)	8 (29.6)	5 (25)
Retirement Complex	3 (6.4)	2 (7.4)	1 (5)
Income			
For Most Things	32 (68.1)	17 (63.0)	15 (75)
For Many Things	10 (21.3)	7 (25.9)	3 (15)
Little for Extras	3 (6.4)	2 (7.4)	1 (5)
Barely meet Needs	1 (2.1)	0 (0)	1 (5)
Missing	1 (2.1)	1 (3.7)	0 (0)
Diagnosed with			
Arthritis, rheumatism or osteoporosis	19 (40.4)	12 (44.4)	7 (35)
Multiple Sclerosis	0	0	0
High blood pressure, cholesterol, heart problems	25 (54.2)	15 (55.6)	10 (50)
Diabetes	3 (6.4)	2 (7.4)	1 (5)
Asthma, other breathing problems	4 (8.5)	3 (11.1)	1 (5)
Back problems	9 (19.1)	7 (25.9)	2 (10)
Foot problems	2 (4.3)	1 (3.7)	1 (5)
Hearing problems	12 (25.5)	5 (18.5)	7 (35)
Cataracts	6 (12.8)	2 (7.4)	4 (20)
Sleep disorders	6 (12.8)	3 (11.1)	3 (15)
Others(prostate cancer)	1 (2.1)	1 (3.7)	0
Problems			
Staying awake/alert [a]	6 (12.8)	6 (22.2)	0
Maintaining balance [a]	12 (25.5)	10 (37.0)	2 (10)
Initiating Movement [b]	10 (21.3)	9 (33.3)	1 (5)
Persistent Pain	11 (23.4)	9 (33.3)	2 (10)
Limited Strength/movement [b]	18 (38.3)	16 (59.3)	2 (10)
Torso/hips	7 (14.9)	6 (22.2)	1 (5)
Legs/feet	10 (21.3)	9 (33.3)	1 (5)
both	1 (2.1)	1 (3.7)	0
Lack of feeling/sensation	3 (6.4)	3 (11.1)	0
Upper body	1 (2.1)	1 (3.7)	0
Lower body	2 (4.3)	2 (7.4)	0

	Total Sample N=47	PD Group n=27	Control Group n=20
Years Driven	52.6±7.91 37 to 68	53.9±6.52 41 to 66	50.8±9.35 37 to 68
Commuted 1 hr to work No Yes	32 (68.1) 15 (31.9)	19 (70.4) 8 (29.6)	13 (65) 7 (35)
Compared to 10 years			
Drive much less	12 (25.5)	9 (33.3)	3 (15)
Drive little less	15 (31.9)	9 (33.3)	6 (30)
Drive the same	15 (31.9)	8 (29.6)	7 (35)
Drive more	5 (10.6)	1 (3.7)	4 (20)
Compared to Summer, in Winter			
Drive much less often	6 (12.8)	5 (18.5)	1 (5)
Drive a little less	20 (42.6)	12 (44.4)	8 (40)
Drive the same	21 (44.7)	10 (37.0)	11 (55)
Worry about expenses?			
Often	1 (2.1)	0	1 (5)
Sometimes	10 (21.3)	6 (22.2)	4 (20)
Rarely	28 (59.8)	15 (55.6)	13 (65)
Never	8 (17.0)	6 (22.2)	2 (10)
Servicing of Vehicle			
Self	45 (95.7)	26 (96.3)	19 (95)
Partner	1 (2.1)	0	1 (5)
Other	1 (2.1)	1 (3.7)	0
Winter tires			
No	26 (55.3)	12 (44.4)	14 (70)
Yes	21 (44.7)	15 (55.6)	6 (30)
Close enough to Walk			
Shopping/errands [c]			
No	37 (78.7)	25 (92.6)	12 (60)
Yes	10 (21.3)	2 (7.4)	8 (40)
Church/Clubs [b]			
No	41 (87.2)	21 (77.8)	20 (100)
Yes	6 (12.8)	6 (22.2)	0
Physician asked about driving?			
No	44 (93.6)	25 (92.6)	19 (95)
Yes	3 (6.4)	2 (7.4)	1 (5)

	Total Sample N=47	Group	
		PD n=27	Control n=20
Problems			
Stiffness	16 (34.0)	12 (44.4)	4 (20)
In back	8 (17.0)	6 (22.2)	2 (10
In neck/spine	5 (10.6)	3 (11.1)	2 (10)
both	3 (6.4)	3 (11.1)	0
Involuntary movement [c]	14 (29.8)	14 (51.9)	0
Upper body	9 (19.1)	9 (33.3)	0
Lower body	1 (2.1)	1 (3.7)	0
both	4 (8.5)	4 (14.8)	0
Cataract Surgery			
No	41 (87.2)	23 (85.2)	18 (90)
Yes	6 (12.8)	4 (14.8)	2 (10)
Drive with Glasses/Contacts			
All the time	32 (68.1)	18 (66.7)	14 (70)
Sometimes	3 (6.4)	2 (7.4)	1 (5)
Never	12 (25.5)	7 (25.9)	5 (25)
Use Hearing Aid			
Most of the time	5 (10.6)	1 (3.7)	4 (20)
Sometimes	3 (6.4)	3 (11.1)	0
No	39 (83.0)	23 (85.2)	16 (80)
Visit Physician			
Within 6 months	39 (83.0)	25 (92.6)	14 (70)
Past year	2 (4.3)	1 (3.7)	1 (5)
More than a year ago	6 (12.8)	1 (3.7)	5 (25)

Note: Above questions are from the Background Questionnaire;
Values are frequencies (%); Comparisons were chi-square $\chi^2(p)$ and Independent t-test $t(p)$;
[a] group difference, $p < .05$
[b] group difference, $p < .02$
[c] group difference, $p < .01$

	Total Sample N=47	PD Group n=27	Control Group n=20
Years Driven	52.6±7.91 37 to 68	53.9±6.52 41 to 66	50.8±9.35 37 to 68
Commuted 1 hr to work			
No	32 (68.1)	19 (70.4)	13 (65)
Yes	15 (31.9)	8 (29.6)	7 (35)
Compared to 10 years			
Drive much less	12 (25.5)	9 (33.3)	3 (15)
Drive little less	15 (31.9)	9 (33.3)	6 (30)
Drive the same	15 (31.9)	8 (29.6)	7 (35)
Drive more	5 (10.6)	1 (3.7)	4 (20)
Compared to Summer, in Winter			
Drive much less often	6 (12.8)	5 (18.5)	1 (5)
Drive a little less	20 (42.6)	12 (44.4)	8 (40)
Drive the same	21 (44.7)	10 (37.0)	11 (55)
Worry about expenses?			
Often	1 (2.1)	0	1 (5)
Sometimes	10 (21.3)	6 (22.2)	4 (20)
Rarely	28 (59.8)	15 (55.6)	13 (65)
Never	8 (17.0)	6 (22.2)	2 (10)
Servicing of Vehicle			
Self	45 (95.7)	26 (96.3)	19 (95)
Partner	1 (2.1)	0	1 (5)
Other	1 (2.1)	1 (3.7)	0
Winter tires			
No	26 (55.3)	12 (44.4)	14 (70)
Yes	21 (44.7)	15 (55.6)	6 (30)
Close enough to Walk Shopping/errands [c]			
No	37 (78.7)	25 (92.6)	12 (60)
Yes	10 (21.3)	2 (7.4)	8 (40)
Church/Clubs [b]			
No	41 (87.2)	21 (77.8)	20 (100)
Yes	6 (12.8)	6 (22.2)	0
Physician asked about driving?			
No	44 (93.6)	25 (92.6)	19 (95)
Yes	3 (6.4)	2 (7.4)	1 (5)
Discussed driving with:			
Eye care professional	13 (27.7)	9 (33.3)	4 (20)
Family member	19 (40.4)	13 (48.1)	6 (30)
Friends	10 (21.3)	8 (29.6)	2 (10)

	Total Sample N=47	PD Group n=27	Control Group n=20
Told to stop driving?			
No	46 (97.9)	26 (96.3)	20 (100)
Yes	1 (2.1)	1 (3.7)	0
Thought about Quitting?			
No	43 (91.5)	23 (85.2)	20 (100)
Yes	4 (8.5)	4 (14.8)	0
Thought about Reducing? [b]			
No	40 (85.1)	20 (74.1)	20 (100)
Yes	7 (14.9)	7 (25.9)	0
Feel Tired when driving?			
No	32 (68.1)	20 (74.1)	12 (60)
Yes	15 (31.9)	7 (25.9)	8 (40)
Remain Awake/Alert			
No	44 (93.6)	25 (92.6)	19 (95)
Yes	3 (6.4)	2 (7.4)	1 (5)
PD meds affect driving?			
No		21 (77.8)	
Yes		6 (22.2)	
Symptoms worsen when driving?			
No		27 (100)	
Yes		0	
Symptoms return before next dose?			
No		13 (48.1)	
Yes		10 (37.0)	
N/A		4 (14.8)	
Adjust medications?			
No		23 (85.2)	
Yes		4 (14.8)	
Dyskinesia			
No		22 (81.5)	
Yes		5 (18.5)	
Unpredictable Effects			
No		24 (88.9)	
Yes		3 (11.1)	
Taken driving course			
No	33 (70.2)	21 (77.8)	12 (60)
Yes	14 (29.8)	6 (22.2)	8 (40)

	Total Sample N=47	PD Group n=27	Control Group n=20
MTO asked to			
Vision test	5 (10.6)	2 (7.4)	3 (15)
Rules test	7 (14.9)	3 (11.1)	4 (20)
Road test	2 (4.3)	1 (3.7)	1 (5)
Vision/medical	2 (4.3)	1 (3.7)	1 (5)
CDE/Rehab	2 (4.3)	2 (7.4)	0
Problems Score	.53±.72 0 to 3	.52±.75 0 to 3	.55±.69 0 to 2
No	27 (57.4)	16 (59.3)	11 (55)
Yes	20 (44.7)	11 (30.7)	9 (45)
Accidents	3 (6.4)	3 (11.1)	0
Near misses	11 (23.4)	5 (18.5)	6 (30)
Backing into things	7 (14.9)	4 (14.8)	3 (15)
Getting lost	3 (6.4)	1 (3.7)	2 (10)
Traffic violation	1 (2.1)	1 (3.7)	0
Main reasons to drive			
Shopping/errands	46 (97.9)	26 (96.3)	20 (100)
Going to appointments	47 (100)	27 (100)	20 (100)
Visit family/friends	43 (91.5)	24 (88.9)	19 (95)
To religious services	27 (57.4)	16 (59.3)	11 (55)
Recreational/Social	41 (87.2)	22 (81.5)	19 (95)
Employment/Volunteer	13 (27.7)	4 (14.8)	9 (45)
Driving Importance Score [a]	3.40±.87 0 to 4	3.19±1.00 0 to 4	3.70±.57 2 to 4
Extremely important	27 (57.4)	12 (44.4)	15 (75)
Very important	15 (31.9)	11 (40.7)	4 (20)
Moderately important	3 (6.4)	2 (7.4)	1 (5)
Somewhat important	1 (2.1)	1 (3.7)	0
Not that important	1 (2.1)	1 (3.7)	0
Reasons to Drive Score	17.46±6.05 6 to 32	18.03±6.47 6 to 32	16.63±5.46 6 to 30
Maintain lifestyle [a]	3.33±.1.12 0 to 4	3.07±1.27 0 to 4	3.68±.75 0 to 4
Meet commitments	2.48±1.59 0 to 4	2.41±1.53 0 to 4	2.58±1.71 0 to 4
Get to shops/services	3.20±1.15 0 to 4	3.00±1.30 0 to 4	3.47±.84 0 to 4
Poor public transport	1.57±1.56 0 to 4	1.85±1.66 0 to 4	1.16±1.34 0 to 4
To drive others	1.63±1.55 0 to 4	1.67±1.71 0 to 4	1.58±1.35 0 to 4
No one to drive you	1.89±1.61 0 to 4	2.22±1.55 0 to 4	1.42±1.61 0 to 4

Not bothering others	1.96±1.62 0 to 4	2.04±1.63 0 to 4	1.84±1.64 0 to 4
Physical difficulty	1.41±1.67 0 to 4	1.78±1.74 0 to 4	.89±1.45 0 to 4

Note: Above questions are from the Driving Habits Questionnaire; Values are frequencies (%); Comparisons were chi-square $\chi^2(p)$ and Independent t-test $t(p)$;
Significant group differences:
[a] $p < .05$
[b] $p < .02$
[c] $p < .01$

Appendix I: Additional Scale Results

Epworth Sleepiness Scale 207

Geriatric Depression Scale... 209

Parkinson’s disease Questionnaire.. 210

Montreal Cognitive Assessment 212

Activities-specific Balance Confidence Scale 215

Epworth Sleepiness Scale

ESS items	**Total sample N=47**	**PD Group N=27**	**Control Group N=20**
Sitting and Reading	1.15±.86	1.22±.89	1.05±.83
	0 to 3	0 to 3	0 to 3
Never doze	11 (23.4)	6 (22.2)	5 (25)
Slight chance	21 (44.7)	11 (40.70	10 (50)
Moderate chance	12 (25.5)	8 (29.6)	4 (20)
High chance	3 (6.4)	2 (7.4)	1 (5)
Watching TV [a]	1.34±.84	1.56±.70	1.05±.94
	0 to 3	0 to 3	0 to 3
Never doze	7 (14.9)	1 (3.7)	6 (30)
Slight chance	21 (44.7)	12 (44.4)	9 (45)
Moderate chance	15 (31.9)	12 (44.4)	3 (15)
High chance	4 (8.5)	2 (7.4)	2 (10)
Sitting/Inactive in Public	.49±.75	.56±.89	.40±.50
	0 to 3	0 to 3	0 to 1
Never doze	29 (61.7)	17 (63.0)	12 (60)
Slight chance	15 (31.9)	7 (25.9)	8 (40)
Moderate chance	1 (2.1)	1 (3.7)	0
High chance	2 (4.3)	2 (7.4)	0
Passenger in car < 1hr	.60±.71	.67±.83	.50±.51
	0 to 3	0 to 3	0 to 1
Never doze	24 (51.1)	14 (51.9)	10 (50)
Slight chance	19 (40.4)	9 (33.3)	10 (50)
Moderate chance	3 (6.4)	3 (11.1)	0
High chance	1 (2.1)	1 (3.7)	0
Lying down in afternoon	1.85±1.06	1.89±1.09	1.80±1.06
	0 to 3	0 to 3	0 to 3
Never doze	7 (14.9)	4 (14.8)	3 (15)
Slight chance	9 (19.1)	5 (18.5)	4 (20)
Moderate chance	15 (31.9)	8 (29.6)	7 (35)
High chance	16 (34.0)	10 (37.0)	6 (30)
Sitting and talking	.02±.15	.04±.19	0±0
	0 to 1	0 to 1	0 to 0
Never doze	46 (97.9)	26 (96.3)	20 (100)
Slight chance	1 (2.1)	1 (3.7)	0
Moderate chance	0	0	0
High chance	0	0	0
Lunch with alcohol [a]	.64±.82	.85±.91	.35±.59
	0 to 3	0 to 3	0 to 2
Never doze	26 (55.3)	12 (44.4)	14 (70)
Slight chance	13 (27.7)	8 (29.6)	5 (25)
Moderate chance	7 (14.9)	6 (22.2)	1 (5)
High chance	1 (2.1)	1 (3.7)	0

In car, stuck in traffic	.04±.20 0 to 1	.07±.27 0 to 1	0±0 0 to 0
Never doze	45 (95.7)	25 (92.6)	20 (100)
Slight chance	2 (4.3)	2 (7.4)	0
Moderate chance	0	0	0
High chance	0	0	0
Total Scores	6.13±3.43 0 to 15	6.85±3.62 1 to 15	5.15±2.96 0 to 12
Normal (≤ 10)	41 (87.2) 5.22±2.54 0 to 9	22 (81.5) 5.59±2.54 1 to 9	19 (95) 4.79±2.55 0 to 9
Borderline (10-12)	4 (8.5) 11.25±.96 10 to 12	3 (11.1) 11.0±1.0 10 to 12	1 (5) 12.0±0 0 to 12
Abnormal (>12)	2 (4.3) 14.5±.71 14 to 15	2 (3.7) 14.5±.71 14 to 15	0

Note: Mean±SD, and range
Comparisons were independent t-tests $t(p)$
[a] $p > .05$

Geriatric Depression Scale

GDS items	Total sample N=47	PD Group N=27	Control Group N=20
Satisfied with life	No = 5 (10.6) Yes = 42 (89.4)	No = 2 (7.4) Yes = 25 (92.6)	No = 3 (15) Yes = 17 (85)
Dropped activities	No = 37 (78.7) Yes = 10 (21.3)	No = 19 (70.4) Yes = 8 (29.6)	No = 18 (90) Yes = 2 (10)
Life is empty	No = 45 (95.7) Yes = 2 (4.3)	No = 27 (100) Yes = 0	No = 18 (90) Yes = 2 (10)
Bored	No = 45 (95.7) Yes = 2 (4.3)	No = 25 (92.6) Yes = 2 (7.4)	No = 20 (100) Yes = 0
Good spirits	No = 1 ((2.1) Yes = 46 (97.9)	No = 1 (96.3) Yes = 26 (3.7)	No = 0 Yes = 20 (100)
Afraid something bad will happen	No = 46 (97.9) Yes = 1 (2.1)	No = 26 (96.3) Yes = 1 (3.7)	No = 20 (100) Yes = 0
Feel Happy	No = 2 (4.3) Yes = 45 (95.7)	No = 1 (3.7) Yes = 26 (96.3)	No = 1 (5) Yes = 19 (95)
Feel Helpless	No = 42 (89.4) Yes = 5 (10.6)	No = 23 (85.2) Yes = 4 (14.8)	No = 19 (95) Yes = 1 (5)
Prefer to stay at home	No = 33 (70.2) Yes = 14 (29.8)	No = 18 (66.7) Yes = 9 (33.3)	No = 15 (75) Yes = 5 (25)
Problems with memory [a]	No = 35 (74.5) Yes = 12 (25.5)	No = 16 (59.3) Yes = 11 (40.7)	No = 19 (95) Yes = 1 (5)
Wonderful to be alive	No = 2 (4.3) Yes = 45 (95.7)	No = 1 (3.7) Yes = 26 (96.3)	No = 1 (5) Yes = 19 (95)
Are worthless	No = 45 (95.7) Yes = 2 (4.3)	No = 26 (96.3) Yes = 1 (3.7)	No = 19 (95) Yes = 1 (5)
Full of energy	No = 16 (34.0) Yes = 31 (66.0)	No = 12 (44.4) Yes = 15 (55.6)	No = 4 (20) Yes = 16 (80)
Situation is hopeless	No = 47 (100) Yes = 0	No = 27 (100) Yes = 0	No = 20 (100) Yes = 0
Most people better than me	No = 46 (97.9) Yes = 1 (2.1)	No = 26 (96.3) Yes = 1 (3.7)	No = 20 (100) Yes = 0
Total score	1.60±1.75 0 to 7	2.00±1.84 0 to 7	1.05±1.50 0 to 6
Normal (0-5)	44	25	19
Depression suspected (5-10)	3	2	1

Note: values were frequencies (%), Mean±SD, and range
Comparisons were chi-square $\chi^2(p)$ and independent t-test $t(p)$
[a] $p > .05$

Parkinson's disease Questionnaire

PDQ items **Have you ever.........**	**Total sample** **N=47**	**PD Group** **N=27**	**Control Group** **N=20**
Had difficulty getting around[a]	.47±.85 0 to 3	.70±.27 0 to 3	.10±.45 0 to 2
Never	35 (74.5)	16 (59.3)	19 (95)
Occasionally	5 (10.6)	5 (18.5)	0
Sometimes	5 (10.6)	4 (14.8)	1 (5)
Often	2 (4.3)	2 (7.4)	0
Always	0	0	0
Had difficulty dressing[b]	.43±.85 0 to 4	.74±1.02 0 to 4	0 0 to 0
Never	34 (72.3)	14 (51.9)	20 (100)
Occasionally	9 (19.1)	9 (33.3)	0
Sometimes	2 (4.3)	2 (7.4)	0
Often	1 (2.1)	1 (3.7)	0
Always	1 (2.1)	1 (3.7)	0
Felt depressed	.49±.78 0 to 3	.41±.75 0 to 3	.60±.82 0 to3
Never	30 (63.8)	19 (70.4)	11 (55)
Occasionally	13 (27.7)	6 (22.2)	7 (35)
Sometimes	2 (4.3)	1 (3.7)	1 (5)
Often	2 (4.3)	1 (3.7)	1 (5)
Always	0	0	0
Problems with relationships	.23±.56 0 to 3	.22±.42 0 to 1	.25±.72 0 to 3
Never	38 (80.9)	21 (77.8)	17 (85)
Occasionally	8 (17.0)	6 (22.2)	2 (10)
Sometimes	1 (2.1)	0	1 (5)
Often	0	0	0
Always	0	0	0
Problems with concentration[a]	.47±.69 0 to 3	.70±.78 0 to 3	.15±.37 0 to 1
Never	29 (61.7)	12 (44.4)	17 (85)
Occasionally	15 (31.9)	12 (44.4)	3 (15)
Sometimes	2 (4.3)	2 (7.4)	0
Often	1 (2.1)	1 (3.7)	0
Always	0	0	0
Unable to communicate[b]	.62±.87 0 to 4	.89±.97 0 to 4	.25±.55 0 to 2
Never	26 (55.3)	10 (37.0)	16 (80)
Occasionally	16 (34.0)	13 (48.1)	3 (15)
Sometimes	3 (6.4)	2 (7.4)	1 (5)
Often	1 (2.1)	1 (3.7)	0
Always	1 (2.1)	1 (3.7)	0

Had painful muscle cramps[a]	.83±1.05 0 to 4	1.15±1.20 0 to 4	.40±.60
Never	23 (48.9)	10 (37.0)	13 (65)
Occasionally	15 (31.9)	9 (33.3)	6 (30)
Sometimes	4 (8.5)	3 (11.1)	1 (5)
Often	4 (8.5)	4 (14.8)	0
Always	1 (2.1)	1 (3.7)	0
Embarrassed in public	.32±.73 0 to 4	.41±.84 0 to 4	.20±.52 0 to 2
Never	36 (76.6)	19 (70.4)	17 (85)
Occasionally	9 (19.1)	7 (25.9)	2 (10)
Sometimes	1 (2.1)	0	1 (5)
Often	0	0	0
Always	1 (2.1)	1 (3.7)	0
Total Scores[a]	3.81±4.45 0 to 20	5.19±4.99 0 to 20	1.95±2.72 0 to 9
Total Percent[a]	11.90±13.89 0 to 62.5	16.20±15.60 0 to 62.50	6.09±8.51 0 to 28.13

Note: values are frequencies (%), Mean±SD, and range
Comparisons were independent t-test $t(p)$
[a] $p > .01$
[b] $p > .001$

Montreal Cognitive Assessment

MOCA Scores	Total Sample N=47	PD Group n=27	Control Group n=20
Trails B			
No	7 (14.9)	5 (18.5)	2 (10)
Yes	40 (85.1)	22 (81.5)	18 (90)
Draw Cube			
No	13 (27.7)	8 (29.6)	5 (25)
Yes	34 (72.3)	19 (70.4)	15 (75)
Clock Contour			
No	0	0	0
Yes	47 (100)	27 (100)	20 (100)
Clock Numbers			
No	29 (61.7)	14 (51.9)	15 (75)
Yes	18 (38.3)	13 (48.1)	5 (25)
Clock Hands			
No	15 (31.9)	11 (40.7)	4 (20)
Yes	32 (68.1)	16 (59.3)	16 (80)
Visual Spatial score	3.66±.89 1 to 5	3.59±.97 1 to 5	3.75±.79 2 to 5
Lion			
No	0	0	0
Yes	47 (100)	20 (100)	20 (100)
Hippo			
No	9 (19.1)	4 (14.8)	5 (25)
Yes	38 (80.9)	23 (85.2)	15 (75)
Camel			
No	2 (4.3)	2 (7.4)	0
Yes	45 (95.7)	25 (92.6)	20 (100)
Naming score	2.77±.48 1 to 3	2.78±.51 1 to 3	2.75±.44 2 to 3
Forward			
No	3 (6.4)	2 (7.4)	1 (5)
Yes	44 (93.6)	25 (92.6)	19 (95)
Backward			
No	7 (14.9)	5 (18.5)	2 (10)
Yes	40 (85.1)	22 (81.5)	18 (90)
Letters			
No	9 (19.1)	8 (29.6)	1 (5)
Yes	38 (80.9)	19 (70.4)	19 (95)
Subtraction			
0 correct	1 (2.1)	1 (3.7)	0
1 correct	2 (4.3)	1 (3.7)	1 (5)
2/3 correct	3 (6.4)	2 (7.4)	1 (5)
4/correct	41 (87.2)	23 (85.2)	18 (90)

Attention score	5.38±.92 2 to 6	5.19±1.00 2 to 6	5.65±.75 3 to 6
Sentence 1 No Yes	 9 (19.1) 38 (80.9)	 7 (25.9) 20 (74.1)	 2 (10) 18 (90)
Sentence 2 No Yes	 10 (21.3) 37 (78.7)	 7 (25.9) 20 (74.1)	 3 (15) 17 (85)
Fluency No Yes	 22 (46.8) 25 (53.2)	 15 (55.6) 12 (44.4)	 7 (35) 13 (65)
Language Score	2.13±.99 0 to 3	1.93±1.07 0 to 3	2.40±.82 0 to 3
Train-bicycle No Yes	 21 (80.8) 26 (55.3)	 16 (59.3) 11 (40.7)	 5 (25) 15 (75)
Watch-ruler No Yes	 10 (21.3) 37 (78.7)	 6 (22.2) 21 (77.8)	 4 (20) 16 (80)
Abstraction score	1.34±.67 0 to 2	1.19±.68 0 to 2	1.55±.60 0 to 2
Face No Yes Recall MC DNC	 24 (51.1) 23 (48.9) 7 (14.9) 10 (21.3) 7 (14.9)	 16 (59.3) 11 (40.7) 3 (11.1) 8 (29.6) 5 (18.5)	 8 (40) 12 (60) 4 (20) 2 (10) 2 (10)
Velvet No Yes Recall MC DCC	 17 (36.2) 30 (63.8) 5 (10.6) 8 (17.0) 4 (8.5)	 12 (44.4) 15 (55.6) 3 (11.1) 7 (40.7) 2 (7.4)	 5 (25) 15 (75) 2 (10) 1 (5) 2 (10)
Church No Yes Recall MC DCC	 16 (34.0) 31 (66.0) 1 (2.1) 7 (14.9) 8 (17.0)	 12 (44.4) 15 (55.6) 1 (3.7) 5 (18.5) 6 (22.2)	 4 (20) 16 (80) 0 2 (10) 2 (10)
Daisy No Yes Recall MC DCC	 30 (63.8) 17 (36.2) 18 (38.3) 8 (17.0) 4 (8.5)	 21 (77.8) 6 (22.2) 13 (48.1) 6 (22.2) 2 (7.4)	 9 (45) 11 (55) 5 (25) 2 (10) 2 (10)

Red			
No	22 (46.8)	13 (48.1)	9 (45)
Yes	25 (53.2)	14 (51.9)	11 (55)
Recall	13 (27.7)	10 (37.0)	3 (15)
MC	4 (8.5)	1 (3.7)	3 (15)
DCC	5 (10.6)	2 (7.4)	3 (15)
Memory score [a]	2.66±1.55 0 to 5	2.26±1.56 0 to 5	3.20±1.40 0 to 5
Date			
No	3 (6.4)	2 (7.4)	1 (5)
Yes	44 (93.6)	25 (92.6)	19 (95)
Month			
No	0	0	0
Yes	47 (100)	27 (100)	20 (100)
Year			
No	0	0	0
Yes	47 (100)	27 (100)	20 (100)
Day			
No	1 (2.1)	1 (3.7)	0
Yes	46 (97.9)	26 (96.3)	20 (100)
Place			
No	2 (4.3)	2 (7.4)	0
Yes	45 (95.7)	25 (92.6)	20 (100)
City			
No	1 (2.1)	1 (3.7)	0
Yes	46 (97.9)	26 (92.6)	20 (100)
Orientation score	5.85±.42 4 to 6	5.78±.51 4 to 6	5.95±.22 5 to 6
Point added <grade 12	5 (10.6)	4 (14.8)	1 (5)
Yes	42 (89.4)	23 (85.2)	19 (95)
No			
Total Scores [b]	23.83±3.14 16 to 29	22.78±3.12 16 to 28	25.25±2.61 18 to 29
Impaired [a]			
No	18 (38.3)	7 (40.7)	11 (55)
Yes	29 (61.7)	20 (59.3)	9 (45)

Note: values are frequencies (%), Mean±SD, and range
Comparisons are chi-square $\chi^2(p)$ and independent t-tests $t(p)$,
[a] p >.05;
[b] p >.01

Activities-specific Balance Confidence Scale

ABC items	Total sample N=47	PD Group N=27	Control Group N=20
1. Walk around house	95.2±11.2 50 to 100	95.4±9.9 75 to 100	95.0±13.1 50 to 100
2. Walk up/down stairs	92.0±13.9 50 to 100	91.7±13.9 50 to 100	92.5±14.3 50 to 100
3. Bend over – pick up	91.5±16.7 25 t0 100	89.8±18.7 25 to 100	93.8±13.8 50 to 100
4. Reach for item at eye level	97.9±8.8 50 to 100	99.1±4.8 75 to 100	96.3±12.2 50 to 100
5. Stand on tip toes and reach[a]	85.6±22.6 0 to 100	82.4±20.6 50 to 100	90.0±24.9 0 to 100
6. Stand on chair and reach	72.9±30.8 0 to 100	65.7±32.6 0 to 100	82.5±25.8 25 to 100
7. Sweep floor	94.1±18.2 0 to 100	91.7±23.0 0 to 100	97.5±7.7 75 to 100
8. Walk outside to car	96.3±9.0 75 to 100	95.4±9.9 75 to 100	97.5±7.7 75 to 100
9. Get in/out of car	92.6±15.6 50 to 100	89.8±17.3 50 to 100	96.3±12.2 50 to 100
10. Walk across mall parking lot	92.0±15.7 25 to 100	88.9±18.8 25 to 100	96.3±9.2 75 to 100
11. Walk up/down ramp	92.0±13.9 50 to 100	90.7±14.1 50 to 100	93.8±13.8 50 to 100
12. Walk in crowded mall [a]	90.4±16.1 25 to 100	86.1±18.8 25 to 100	96.3±9.2 75 to 100
13. Bumped by people in mall [a]	84.0±18.4 25 to 100	78.7±19.2 25 to 100	91.3±14.7 50 to 100
14. Step on/off escalator holding to railing	91.5±15.0 50 to 100	90.7±14.1 50 to 100	92.5±16.4 50 to 100
15. Step on/off escalator carrying items [a]	77.1±23.8 25 to 100	71.3±22.7 25 to 100	85.0±23.5 25 to 100
16. Walk on icy sidewalks	67.6±22.7 25 to 100	63.0±22.3 25 to 100	73.8±22.2 25 to 100
17. Step on/off sidewalk curb	88.3±19.4 25 to 100	85.2±19.9 50 to 100	92.5±18.3 25 to 100
18. Stand on moving bus/train/subway	82.4±21.4 25 to 100	78.7±22.7 25 to 100	87.5±19.0 25 to 100
19. cross street at pedestrian crosswalk [a]	89.9±17.0 50 to 100	85.2±18.7 50 to 100	96.3±12.2 50 to 100
20. cross street at timed pedestrian intersection [a]	89.4±18.6 25 to 100	84.3±21.0 25 to 100	96.3±12.2 50 to 100
21. cross street with no timer [a]	86.7±21.4 0 to 100	81.5±24.6 0 to 100	93.8±13.8 50 to 100

Total ABC-16[b]	88.3±12.1 51.6 to 100	85.6±11.6 62.5 to 100	91.9±12.0 51.6 to 100
Total ABC-21[b]	88.1±12.9 48.8 to 100	85.0±12.8 59.5 to 100	92.2±12.3 48.8 to 100

Note: Mean±SD, and range; Comparisons are independent t-test $t(p)$

[a] $p > .05$,

[b] $p > .02$

Appendix J: Brake Test Protocol

Description of Brake Reaction Time Apparatus:

The Brake Test (BRT) apparatus includes a foot switch mounted on a board to simulate the position of a gas and brake pedal, a timing device and light stimulus consisting of a red and green light. The brake test can measure reaction time (onset of stimulus to initiation of movement), movement time (initiation to completion of movement) and response time (time from stimulus to completion of movement).

The BRT was standardized by following the same sequence of light stimuli that are presented to all participants (see BRT measurement sheet below) and keeping the same distance between the light stimulus and pedals (tape marked 3 m away from light display) for all participants. Participants could shift the chair and pedals left or right as needed. However, they could not move the chair past the taped line (3 meter mark).

BRT protocol:

- Explanation: *"This test measures your brake reaction time, which is the time it takes for you to move your foot from the gas to the brake pedal."*
- Instructions: (Demonstrate while providing the instructions)
    - "*When I say "GO" push down the gas pedal (on the right)"*
    - *"On top of the box you will see a Red light" (show red light)*
    - *"When you see the Red Light push down the brake as fast as you can"*
- Demonstrate sequence.
- Instruct the participant to sit in the chair and adjust so that can comfortably reach the pedals.
- Do 3 Practice Trials
- Practice Trial Sequence
    - 1 = 5 seconds
    - 2 = 2 seconds
    - 3 = 10 seconds
- After 3 practice trials, testing will begin and scores recorded.

Brake Test Measurements			
Random Trials	**Response Time**	**Movement Time**	**Reaction Time**
1. 5 sec			
2. 2 sec			
3. 10 sec			
4. 2 sec			
5. 5 sec			
6. 2 sec			
7. 10 sec			
8. 5 sec			
9. 10 sec			
10. 2 sec			
11. 5 sec			
12. 2 sec			
13. 10 sec			
14. 5 sec			
15. 5 sec			
16. 2 sec			
17. 10 sec			
18. 10 sec			
19. 2 sec			
20. 5 sec			
21. 10 sec			
22. 2 sec			
23. 10 sec			
24. 5 sec			
25. 10 sec			
26. 5 sec			
27. 2 sec			
28. 10 sec			
29. 2 sec			
30. 5 sec			

Appendix K: Additional Driving Patterns

	Group N=46		PD Age Group n=26		Control Age Group n =20	
	PD n=26	**Control n=20**	**Under 70 n=10**	**Over 70 n=16**	**Under 70 n=9**	**Over 70 n=11**
Trips per Day						
Monday	.85±.70	1.51±.71	1.06±.86	.75±.60	1.56±.68	1.48±.77
	0 to 3	0 to 2.5	0 to 3	0 to 2	.5 to 2.5	.5 to 2.5
Tuesday	1.15±.62	1.54±.86	1.13±.76	1.15±.57	1.53±.78	1.55±.99
	0 to 2.5	0 to 3	0 to 2	.5 to 2.5	.5 to 3	0 to 3
Wednesday	.90±.56	1.36±.53	1.06±.64	.81±.51	1.22±.58	1.48±.48
	0 to 2	.5 to 2.5	0 to 2	0 to 2	.5 to 2	1 to 3
Thursday	.98±.65	1.68±.89	1.25±.89	.84±.48	1.56±.73	1.77±1.03
	0 to 2.5	.5 to 4.5	0 to 2.5	0 to 1.5	.5 to 2.5	1 to 3
Friday	1.07±.60	1.50±.85	1.09±.68	1.06±.57	1.75±.81	1.30±.86
	0 to 2	0 to 3.5	0 to 2	0 to 2	.5 to 3	0 to 3.5
Saturday	.75±.61	1.24±.79	.94±.77	.66±.51	1.10±.75	1.36±.84
	0 to 2	0 to 3	0 to 2	0 to 2	0 to 2.5	.5 to 3
Sunday	.81±.81	1.06±.57	.75±.76	.84±.85	.69±.43	1.36±.50
	0 to 2.5	0 to 2	0 to 2	0 to 2.5	0 to1.5	.5 to 2
Km per Day						
Monday	26.34±26.63	39.03±53.09	35.9±37.12	21.56±19.27	45.66±72.58	33.61±32.7
	0 to 111.85	6.15 to 235.15	0 to 111.85	0 to 69.65	6.15 to 235.15	6.9 to 99.9
Tuesday	32.92±32.11	42.41±41.93	28.71±19.61	35.03±37.25	36.52±26.18	47.22±52.3
	0 to 136.2	0 to 189.65	0 to 54.1	0 to 136.2	13.65 to 83.5	0 to 189.65
Wednesday	22.23±16.19	34.04±28.64	24.20±17.20	21.25±16.14	26.62±29.38	40.11±27.89
	0 to 65.85	6.15 to 103.55	0 to 47.75	0 to 65.85	9.05 to 103.55	6.15 to 80.8
Thursday	34.06±43.26	37.10±35.97	19.31±12.52	41.43±51.21	44.94±51.22	30.67±16.08
	0 to 162.75	7.75 to 160.95	0 to 35.10	0 to 162.75	7.75 to 160.95	8.25 to 56.3
Friday	25.11±19.16	45.02±41.2	27.12±23.86	24.11±17.14	59.10±53.0	33.50±25.58
	0 to 73.6	0 to 169.2	0 to 73.6	0 to 59.85	6 to 169.2	0 to 88.75
Saturday	20.10±35.02	54.23±68.42	14.06±9.98	23.12±42.49	82.41±91.54	31.18±29.9
	0 to 176.05	0 to 279.65	0 to 26.05	0 to 176.05	0 to 279.65	1.3 to 108.25
Sunday	18.56±19.99	33.82±38.19	18.51±23.45	18.58±18.87	34.12±37.10	33.58±40.87
	0 to 59.15	0 to 129.85	0 to 59.15	0 to 50.8	0 to 105.45	6.85 to 129.85

Appendix L: Associations between Perceptions and Driving Behaviour

Associations between Perception Scores and Driving Behaviour (PD group, n=26)

Driving Indicators	DCS-D	DCS-N	DCS-N Item 1	PDA	SDF	SDA
Days driven	-.04	-.08	-.30	.08	.10	-.01
# trips	-.12	-.13	-.27	.03	.26	-.12
# stops	-.06	-.07	-.28	.07	.29	-.01
Distance (km)	.17	.30	.08	.38	**.56****	**-.49***
Duration	.07	.14	-.08	.30	**.46****	-.32
Radius (max)	.24	.25	.19	.21	**.41***	**-.40***
Radius (avg)	.37	**.42***	.33	**.41***	.37	-.39
Nights driven	-.28	-.21	-.22	-.22	.20	-.16
Night trips	-.30	-.19	-.20	-.14	.16	-.23
Night (km)	-.08	-.02	-.05	.07	.14	-.39
Night duration	-.06	.01	-.06	.09	.16	-.38
Frequency Index	.01	-.04	-.29	-.03	.49*	-.13

Note: Pearson or Spearman rank (stops, radius (max and avg), night trips, days, duration), DCS-N, item-1,
* significant at p <.05,
** significant at p < .01

Associations between Perception Scores and Driving Behaviour (Controls, n=20)

Driving Indicators	DCS-D	DCS-N	DCS-N Item 1	PDA	SDF	SDA
Days driven	-.30	-.15	-.30	**-.61****	-.21	.07
# trips	-.23	-.10	-.42	**-.51***	-.10	.09
# stops	-.21	-.14	-.31	-.05	.11	-.05
Distance (km)	-.03	.09	-.18	.26	.18	-.37
Duration	-.07	.06	-.29	.12	.12	-.33
Radius (max)	-.25	-.03	-.07	.13	.14	.05
Radius (avg)	-.09	.08	-.02	.33	.39	-.18
Nights driven	.14	.18	-.11	-.12	-.01	-.05
Night trips	.15	.17	-.22	-.12	-.01	-.07
Night (km)	0	.14	-.01	.15	-.09	.04
Night duration	.03	.23	.09	.11	-.17	-.01
Frequency Index	-.13	.04	-.31	.02	.09	-.20

Note: Pearson or Spearman Rank (DCS-N item 1, days, trips, radius (max and avg), night distance and duration.
* significant at p <.05,
** significant at p < .01

Appendix M: Comparison with Prior Samples of Healthy Drivers

	Present Study		Blanchard (2008) N=61	Trang (2010) N=47
	PD Group N=27	Control Group N=20		
Demographics				
Age	71.6±6.6 57-82	70.6±7.9 57-84	80.4±5.5 67-92	77.2±6.6 65-91
% Male	21 (78%)	16 (80%)	25 (41%)	24 (51%)
% Sole Driver	8 (30%)	7 (35%)	39 (64%)	24 (51%)
Perception Scores				
DCS-D	71.1±19.2 28.9-100	79.8±13.3 50-100	68.9±15.2 30.8-100	70.6±17.1 36.5-100
DCS-N	58.6±26.1 1.6-100	73.8±15.5 40.6-100	54.3±24.8 6.3-100	58.1±23.0 18.8-100
PDA	33.4±8.7 13-44	37.7±5.4 27-44	32.5±6.3 15-45	32.5±6.5 21-42
PDA Change	25.3±5.7 10-34	26.9±3.3 19-30	19.1±5.9 2-44	26.0±4.2 14-37
Self-Reported Driving				
SDF	33.9±8.2 16-48	38.8±6.7 23-53	30.2±9.0 12-49	33.5±6.5 19-51
SDA	8.5±4.9 0-20	4.2±3.3 0-9	9.2±4.8 0-19	6.3±4.1 0-16
Objective Driving				
# Days Driven	4.8±1.4 2-7	6.1±.8 4.5-7	5.2±1.9 1-7	4.88±1.48 1.5-7
Distance (km)	188.8±102.3 60.95-407.9	285.7±174.3 96.1-686.9	164.1±158.4 4.2-633.3	156.6±108.8 22.7-466.1
Mileage Category				
Low	0	0	17 (29%)	9 (20%)
Middle	21 (81%)	12 (60%)	28 (53%)	31 (67%)
High	5 (19%)	8 (40%)	13 (22%)	6 (13%)
Average Radius	6.0±4.7 1.99-21.22	6.7±5.4 1.5-23.1	7.4±7.5 1.0-45.1	7.0±5.7 1.9-26.5
Maximum Radius	18.6±24.2 3.3-112.4	37.9±39.9 2.7-121.9	21.3±27.4 1.8-113.7	18.0±18.3 2.4-80.8
% Drove at Night	89% 23/26	90% 18/20	28% 16/58	89% 41/46
# Nights	1.2±.80 0-3	2.4±1.5 0-5.5	1.5±1.1 1-5	1.9±1.5 0-6
Night Distance (km)	16.2±16.7 0-73.45	40.4±38.5 0-142.7	25.4±34.1 2.7-129.4	31.2±39.7 0-215.9

Note: Values are Mean±SD, range or Frequencies (%) Exposure: PD Group (n=26), Blanchard (n=58) and Trang (n=46) with CarChip data; Radius: PD Group (n=26), Control Group (n=19), Blanchard (n=55) and Trang (n=40) with Otto data

Appendix N: Comparison with Prior Samples of PD Drivers

	Age	Disease Duration (years)	UPDRS (motor) or other	Hoehn & Yahr	ESS	GDS or other	PDQ or other	Cognitive Measure	Contrast Sensitivity (binocular)
Present Study (2010) 27 PD (21 ♂, 6 ♀)	71.6±6.6 57-82	-	30.13±8.56 18 to 50	2.57±.51 2 to 4	6.85±3.62 1 to 15	2.00±1.8 4 0 to 7	5.19±4.99 0 to 20	22.78±3.12 16 to 28 (MoCA)	Binocular 1.85±.15 Left 1.67±.25 Right 1.54±.40
Adler et al. (2000) 89 PD (56 ♂, 33 ♀) Survey given at driver improvement course	72.7 (Mean)	5.8 (Mean)	-	-	-	-	-	26.0 16 to 30 (MMSE)	-
Amick et al. (2007a) 25 PD (17 ♂, 8 ♀) Open road test + cognitive/visual predictors	Safe 62.9±8.9 Unsafe 66.1±6.5	Safe 4.1±2.0 Unsafe 5.6±5.5	Safe 15±8.7 Unsafe 25.5±11.5	-	-	Safe 2.2±2.1 Unsafe 2.2±2.5	-	Safe 97.4±1.9 Unsafe 92.6±5.7 3MS	Safe (range) 1.1 to 1.7 Unsafe (range) 1.4 to 1.7
Amick et al. (2007b) 21 PD (14 ♂, 7 ♀) Open road test + EDS	With EDS 63.4±12.7 No EDS 69.6±6.6	With EDS 3.2±.8 No EDS 7.0±8.1	With EDS 25.8±6.3 No EDS 29.2±8.0	With/No EDS 2 to 3 Range	With EDS 12.4±2.1 No EDS 5.3±2.7	-	-	With EDS 29.0±.07 No EDS 27.8±1.7 (MMSE)	-
Cordell et al. (2005) 53 PD (41 ♂, 12 ♀) Open road test	69.3±8.3	5.3±5.6	18±8	1.6±.5 1 to 3	10±5.6 2 to 24	-	-	29±1.2 (MMSE)	-
Cubo et al. (2010) Survey 98 PD Current (n=73) vs Former (n=25)	Current 60.5±11.4 Former 70.9±9.6	Current 5.6±4.2 Former 8.0±5.6	Current 14.2±7.7 Former 18.8±5.4 (SCOPA)		Current 3.5±2.9 Former 3.6±3.0 (SCOPA)	Current 5±4.2 Former 5.5±3.8 (HADS)	Current 66±19.4 Former 65.9± 20.7 (Eu-QoL)	Current 27.3±5.8 Former 22.8±6.9 (SCOPA)	

Appendix N Continued….

	Age	Disease Duration (years)	UPDRS (motor) or other	Hoehn & Yahr	ESS	GDS or other	PDQ or other	Cognitive Measure	Contrast Sensitivity (binocular)
Devos et al. (2007) 40 PD (31 ♂, 9 ♀) Simulator	61.6±9.4 44 to 75	6.7±4.0 5 to 20	Pass (n=29) 16.79±8.48 Fail (n=11) 29.82±11.56	Med = 2 1.5 to 3	Pass 5.86±4.16 Fail 7.55±4.87	-	-	CDR 0 0 to .5 (Very mild CI)	Pass (n=29) 1.95 1.8 to 1.95 Fail (n=11) 1.65 1.65 to 1.95
Dubinsky et al. (1991) 150 PD Survey	67.8±8.8	-	79.7±14.3 (Schwab & England)	-	-	-	-	27.2±3.1 (MMSE)	-
Grace et al. (2005) 21 PD (14 ♂, 7♀) Open road test	68.1±8.5 45 to 83	-	28.4±7.7	2 1 to 3	-	-	-	28.1±1.6 24 to 30 (MMSE)	-
Heikkila et al. (1998) 20 PD (20 ♂) Open road test	59±11 35 to 73	5.6±2.8 2 to 12	-	1.9±.6 1 to 3	-	-	-	28.6±1.5 25 to 30 (MMSE)	-
Singh et al. (2007) 154 PD (134 ♂, 20♀) Retrospective (previous open road test + assessment battery)	67.6 (Mean)	5.9 (Mean)	-	1.9 (Mean)	-	-	-	-	-
Stolwyk et al. (2006a, b) 18 PD (14 ♂, 4 ♀) Simulator	67.62±6.53 55 to 77	6.67±4.21 1.5 to 16	11.67±8.15 0 to 23	-	-	-	-	27.89±2.05 24 to 30 (MMSE)	-

Appendix N Continued….

	Age	Disease Duration (years)	UPDRS (motor) or other	Hoehn & Yahr	ESS	GDS or other	PDQ or other	Cognitive Measure	Contrast Sensitivity (binocular)
Uc et al. (2007) 77 PD (65 ♂, 12 ♀) Open road test	65.9±8.6	5.7±5.1	23.7±8.7	2.2±.6	9.6±4.2	-	-	28.4±1.8 (MMSE)	-
Uc et al. (2009a) 67 PD Simulator	66.2±9.0	6.5±5.4	25.6±10.6	2.3±.8	-	-	-	-	-
Uc et al. (2009b) 84 PD (69 ♂, 15 ♀) Open road test with IV	67.3±7.8		24.1±8.9	2.2±.06	10.1±4.1	5.9±5.6		28.2±1.8 (MMSE)	1.68±.02
Vaux et al. (2010) 8 PD (6 ♂, 2 ♀) Simulator	61.9 (Mean)	-	-	-	-	-	-	28.5±1.6 (MMSE)	1.67±.01
Wood et al. (2005) 25 PD (21 ♂, 4 ♀) Closed road test	63.7±6.8	6.2±4.6	27.4±11.3	2.3±.7	-	-	-	-	-
Zesiewicz et al. (2002) 39 PD (25 ♂, 14 ♀) Simulator	Collision 69.7±7.4 No Collision 60.4±11.1		Collision 20±8.9 No Collision 14.6±7.7	Collision 2.3±.8 No Collision 1.6±.6				Collision 27.2±3.5 No Collision 29.8±1.0 (MMSE)	

Note: Age breakdown are for total sample; Pass/fail = performance on driving simulator; CDR = Clinical Dementia Rating Scale; ESS = Epworth Sleepiness Scale; Eu-QoL = European Quality of Life Scale; GDS = Geriatric Depression Scale; HADS = Hospital Anxiety and Depression Scale; MoCA = Montreal Cognitive Assessment; MMSE = Mini Mental State Exam; 3MS = Modified Mini Mental State Exam; PDQ = Parkinson's Disease Questionnaire; SCOPA =Scale for Outcomes of Parkinson's disease; UPDRS = Unified Parkinson's Disease Rating Scale; Mean±SD and range (if provided)