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Identifying Responders to a Driving Refresher Course using Neuropsychological Tests: An Examination of Older Drivers

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Abstract

The older driving population is continuing to increase, and with age comes cognitive and physical changes that may negatively affect driving abilities. Despite the aging process, researchers have found that age is not the only predictor of on-road driving test outcomes. Recently researchers have suggested that overall cognitive functioning may be predictive of overall driving abilities in older drivers. The current study examines the associations between demographics, cognitive abilities, and driving abilities. In addition the current research addresses a novel inquiry into the ability of neuropsychological tests to predict responders to a driving refresher course. Participants consisted of 65 subjects, who held a valid driver's license, were currently driving, and were between 55 and 86 years of age (31 female, 34 male). Upon completion of a series of neuropsychological tests participants were block randomized into either a driving refresher course group or a waitlist control group. Prior to and following the refresher course or waiting period participants completed a standardized on-road test. Results indicated that age was negatively associated with baseline driving ability but was not associated with overall change in driving scores. Neuropsychological tests were associated with specific baseline driving abilities and change scores. A multiple regression model for overall change in driving ability included baseline ability, age, education, the Motor-Free Visual Perception Test, and the Stroop test and accounted for 35% of the variability in overall change scores.

Identifying Responders to a Driving Refresher Course using Neuropsychological Tests: An Examination of Older Drivers

The elderly population represents one of the fastest growing segments of the Canadian population. According to Statistics Canada, in 2002 persons aged 55 and older represented 22.1% of the population, and between 1999 and 2001 the number of persons aged 65 and older increased by 1.8 % (Statistics Canada, 2002). As the elderly population increases the number of elderly drivers in turn increases. The increase in the number of older drivers and the natural process of aging raises concerns surrounding driving safety and ability. Yet, for many older people driving is their primary mode of transportation and allows them to maintain their independence and continue with their normal activities. Rosenbloom (1993; as cited in Marottoli et al., 2000) noted that more than 80% of trips occur in private vehicles even among the oldest people. People clearly rely on their own vehicle for the majority of their transportation needs and the decision to discontinue driving may influence their ability to remain active. Driving cessation has been associated with decreased out-of-home activity, even after accounting for sociodemographic and health related factors (Marottoli et al., 2000). A decrease in out-of-home activity may have additional negative consequences including effects on well-being, health status and survival in old age (Marottoli et al., 2000). A growing body of evidence has indicated that driving cessation and even driving reduction is associated with increased depressive symptoms among older adults (Fonda, Wallace, & Herzog, 2001; Marottoli et al., 1997). Thus, for many older people driving cessation is a decision in which not only must they consider their competency but also their independence, autonomy and general health. When evaluating older drivers it is important to consider the effect on their quality of life as well as the safety considerations both for themselves and for other motorists.

With aging come natural changes, both physically and mentally, that may affect driving skills. Deterioration in vision is common to the aging process and includes difficulty in peripheral vision, seeing, focusing, rapidly changing focus and loss of depth perception (Irwin, 1989; Retchin & Anapolle, 1993; Stamatiadis & Deacon, 1995). Visual deteriorations could lead to slower responses to signals, signs, and traffic events, as well as misjudgment of distance between vehicle and other objects. Changes related to psychomotor slowing could decrease abilities related to reaction time, especially when choices are involved, and could affect manipulation of the steering wheel and pedals (Retchin & Anapolle, 1993). Cognitive changes, including short term memory deficits, could potentially impact driving skills by interfering with the processing of incoming information and decision making (Irwin, 1989). Age has been shown to be related to a slowing of processing speed and cognitive flexibility (Irwin, 1989). These changes may affect the time it takes older people to process incoming information and organize the information to make a decision, which could negatively affect their driving abilities as driving often requires rapid decision making based on environmental circumstances. Age may affect some peoples driving abilities however age does not affect all drivers and is not an efficient reason to discontinue driving.

The older driving population is a heterogeneous group, in which there are some at-risk drivers as well as many drivers who have a good driving record. Therefore it is important to look at all the ways in which researchers have evaluated driving ability in order to understand the heterogeneity of older drivers. Researchers have investigated many aspects of driving including the crash risk of this population, the relationship between cognition and crash, and the relationship between cognition and on-road driving ability. It is also important to evaluate the older drivers' ability to improve their driving status.

The risk of older drivers to be in a motor vehicle crash has been extensively researched. While older drivers account for a lower proportion of crashes as a group compared to the whole driving population (De Raedt & Ponjaert-Kristofferson, 2001a; Retchin & Anapolle, 1993), when distance driven is taken into account, older drivers and younger drivers are disproportionately involved in crashes compared to middle-aged drivers (Irwin, 1989; McKnight & McKnight, 1999; Mori & Mizohata, 1995; Retchin & Anapolle, 1993; Ryan, Legge, & Rosman, 1998; Stamatiadis & Deacon, 1995; Stutts & Martell, 1992). These crash statistics occur despite the precautions in which older drivers tend to voluntarily engage, including reduced driving speeds, driving fewer miles, and avoiding driving at night. When older drivers are involved in crashes certain crash types tend to characterize older drivers. Older drivers tend to be involved in crashes during clear weather and occurring at intersections (Daigneault, Joly, & Frigon, 2002b; McGwin & Brown, 1999; Mori & Mizohata, 1995; Zhang, Fraser, Lindsay, Clarke, & Mao, 1998; Zhang, Lindsay, Clarke, Robbins, & Mao, 2000). Daigneault, Joly, and Frigon (2002b) examined the driving records of elderly persons living in Quebec holding a valid driver's license. Their study found that within the selected population 81.9% of the crashes occurred while there was sunshine and 92.8% of the crashes occurred when there was good visibility. Additionally, 29.4% of the crashes occurred at intersections with 13.8% of the intersection crashes occurring when turning left. With the frequency of crashes at intersections, crashes that occur with older drivers often involve more than one vehicle. In the study by Daigneault and colleagues (2002b), 90.2% of the crashes involved more than one vehicle. Older drivers also tend to be involved in crashes involving errors such as, failure to yield the right of way, improper turns, violation of traffic signs or signals, improper lane changes, and improper passing (Clarke, Ward, & Jones, 1998; Daigneault et al., 2002b; Goggin & Keller, 1996;

McGwin & Brown, 1999; Zhang et al., 1998; Zhang et al., 2000). In addition to being disproportionately involved in crashes, older drivers are often responsible for the crashes.

Investigators have shown that when crashes involving older drivers occur, the older drivers are more likely than middle-age drivers to be at fault (Cooper, 1990; McGwin & Brown, 1999; Stutts & Martell, 1992). Cooper (1990) reported that while 51.8% of middle-aged drivers were probably 50% responsible for the crashes in which they were involved, 68.2% of those aged 65 – 74 and 80.1% of those aged 75 years and older were assessed as probably being responsible. When older drivers are at fault the crashes often involve improper turning, lane changes or merging into traffic and the right front of the vehicle is the most frequent impact point (McGwin & Brown, 1999). Parker, McDonald, Rabbitt, and Sutcliffe (2000) reported that with increasing age comes a decrease in passive crashes (crashes in which "I was hit"), while there is no age effect for active crashes (crashes in which "I hit them"). They also reported that drivers over the age of 75 were 44% more likely to hit someone (be at fault) than to be hit by someone (Parker, McDonald, Rabbitt, & Sutcliffe, 2000). Active accidents by older drivers were associated with errors (errors were defined as the failure of a planned action to achieve the desired consequence) or lapses (lapses were defined as attentional failures which are unlikely to impact directly on safety) versus violations (defined as deliberate risky driving behaviours). Although older drivers are more frequently at fault the crashes they are involved in often do more physical harm to the older driver than to the other drivers involved.

Dulisse (1997) reported that while older drivers do not impose an excess risk to other drivers with respect to physical injury or death, older drivers themselves are more susceptible to serious injuries or fatalities due to crashes (Bedard, Guyatt, Stones, & Hirdes, 2001; Brorsson, 1989; Lam, 2002; Lilley, Arie, & Chilvers, 1995; McKnight & McKnight, 1999; Mortimer &

Fell, 1989; Ryan et al., 1998). Zhang and colleagues (2000) reported that drivers aged 75 – 79 involved in an accident with a medical/physical condition were five times more likely to be fatally injured than drivers of the same age without a medical/physical condition. In 1998 older adults represented 18% of all those fatally injured in vehicle crashes and, given the current trends, this figure is projected to reach 27% by 2015 (Bedard, Stones, Guyatt, & Hirdes, 2001). Given the susceptibility of serious injuries or fatalities, the increased risk of being involved in a crash, the affects of the aging process on driving abilities, and the effects of driving cessation, maintaining driving abilities and safe driving practices is a concern for the older adult population.

However, the elderly population is heterogeneous and despite the studies indicating that older drivers have higher incidents of at fault crashes, age is not the only predictor of driving ability. A retrospective case-control study by Carr, Jackson, and Alquire (1990) investigated the characteristics of the older driving population that was referred to a geriatric assessment center. Carr, Jackson, and Alquire (1990) found that compared to older non-drivers, older drivers were significantly younger, more likely to be male, were more independent in activities of daily living, and scored higher on the Folstein Mini-Mental Status Examination (MMSE) (Folstein, Folstein, & McHugh, 1975). However the mean MMSE score for drivers was below normal, 40% of the older drivers were diagnosed with dementia, and 26% of the older drivers needed help with some type of activity of daily living at the time of the cognitive evaluation. While this study did not look at driving abilities it did indicate that not all older drivers have the same level of cognitive or functional status. Various researchers have suggested that general cognitive status is better at detecting unsafe older drivers (as determined by driving test scores and crash involvement or crash risk) than age and have suggested that a cognitive screening test may be useful in determining driving performance and crash risks in the older driving population (Duchek, Hunt, Ball, Buckles, & Morris, 1998; Fitten et al., 1995; Hunt, Morris, Edwards, & Wilson, 1993; Mitchell, Castleden, & Fanthome, 1995; Stutts, Steward, & Martell, 1998). Recent research has focused on the relation between cognitive functioning and driving abilities of older drivers.

Studies using self-reports or family reports have found cognitive status to be related to driving events. Marottoli and colleagues (1998) found that a battery of tests including visual, cognitive and physical abilities were negatively associated with the number of self-reported adverse driving events (crashes, being pulled over by the police and moving violations) among a cohort of older drivers. Other researchers found that deficiencies in attention, perceptual abilities, cognition and psychomotor abilities were associated with unsafe driving incidents (McKnight & McKnight, 1999). Additionally, McKnight and McKnight (1999) found that a total composite abilities score could correctly identify 80% of drivers who had unsafe driving incidents.

Studies examining the association between cognition and crash involvement have found a similar relationship. A study by Tuokko, Tallman, Beattie, Cooper, and Weir (1995) looked at the crash rates of older drivers with dementia and their matched controls. The researchers found that the dementia sample had approximately 2.5 times the number of traffic crashes than did the matched control group (Tuokko, Tallman et al., 1995). This finding was similar to previous findings which have found individuals with dementia to be involved in more crashes than control subjects (Friedland, et al., as cited in Bedard, Molloy, Guyatt, Stones, & Strang, 1997). More recent research has examined crash involvement and healthy older drivers. A study by Stutts et al. (1998) reported that cognitive functioning was associated with crash risk in an older driver population even after controlling for the effects of age, race, and driving exposure. Furthermore, individuals falling in the lowest 10% of the obtained cognitive test scores had approximately an annual crash rate 1.5 times greater than those scoring in the highest 10% on the cognitive tests. Similarly, researchers found that older drivers who had a history of crashes, compared to older accident-free drivers, had significantly more cognitive deficits regarding executive functioning. Older drivers with a history of crashes tended to make more errors, which reflected mental rigidity and poorer ability to plan and solve problems (Daigneault, Joly, & Frigon, 2002a). De Raedt and Ponjaert-Kristoffersen (2000) found that a battery of neuropsychological tests was able to account for only 19% of the variability in self-reported at fault crashes in an older driver population. However, in a later study they found that the battery of neuropsychological tests and an on-road test were able to predict at fault crashes within the previous three years (De Raedt & Ponjaert-Kristofferson, 2001b). The group of neuropsychological tests was a better predictor of all classifications of crashes compared to the on-road test. As the classification of the type of crash became more defined there was an associated increase in predictability (De Raedt & Ponjaert-Kristofferson, 2001b). When using a global classification of crash versus no crash the neuropsychological tests correctly classified 62.9% of the cases. The most specific classifications included four types of crashes; crashes involving traffic coming from the right with right of way while driving straight, crashes involving traffic coming from the left with right of way and left turns, crashes involving rear-end collisions and side-swipes, and parking crashes. For each of the four classifications listed above the neuropsychological tests were able to correctly classify 73.5%, 73.8%, 72.5% and 71.4% of cases respectively. While the majority of the research into crash rates is retrospective a recent prospective study has shown neuropsychological measures to be possible indicators of crash risk for older drivers. Lesikar, Gallo, Rebok, and Keyl (2002) examined the relationship between the performance of participants on a battery of neuropsychological tests at baseline and self-reported traffic crashes at the two year follow-up interview. The researchers found three neuropsychological measures to be associated with an increased risk of reporting a traffic crash at the two year follow-up. Older drivers who scored in the lowest third on the Motor-Free Visual Perception Test and the Standardized Road Map Test of Directional Senses were respectively 2.83 and 2.33 times more likely to report a crash at follow-up than older drivers who scored in the upper two thirds on the respective tests. Older drivers who scored in the lower third on the Trial Making Test Part A were 3.15 times more likely to report a crash at follow-up than older drivers who scored in the upper two thirds on the same test. Research into the association between cognitive abilities and crash involvement or risk has continued to show that as cognition declines risk increases. Other research has continued to examine the relationship between cognitive ability and driving by examining older drivers using on-road tests instead of past driving history.

Fitten and colleagues (1995) found the degree of cognitive impairment to be a more reliable predictor of driving skills than age or a medical diagnosis of either mild Alzheimer dementia or vascular dementia. Hunt et al. (1993) found healthy older drivers and older drivers with very mild senile dementia of the Alzheimer type (SDAT) were able to pass the on-road test and that 40% of older drivers with mild SDAT failed the on-road test. Thus indicating that while cognitive impairment is associated with poorer driving skills a diagnosis of dementia is not sufficient to restrict driving privileges. With regards to cognition, attentional tasks were found to correlate well with the driving performance results. The researchers also found that neither the persons' self-assessment nor the caregivers assessment of the individual's driving abilities were consistent with their actual driving performance (Hunt et al., 1993). This indicates the importance of having a performance-based evaluation. Other investigators have also established that a diagnosis of dementia or Alzheimer disease is insufficient to determine driving ability

(Duchek et al., 1998; Fox, Bowden, Bashford, & Smith, 1997; Hunt et al., 1993; Mitchell et al., 1995).

While research using older drivers with various stages of dementia assists in determining the relationship between cognitive decline and driving ability, recent research has also focused on the general older driving population. De Raedt and Ponjaert-Krestoffersen (2000) used a top-down approach to identify cognitive factors associated with driving problems in older adults. The investigators found that tests of movement, perception, useful field of view, cognitive flexibility and selective attention could together account for 64% of the variance in the total score of the on-road test. However, the researchers did not examine if these tests accounted for the variance in any specific parts of the road test (i.e., obeying of the rules, vehicle operation etc.) better than the overall score. In addition to drawing conclusions based on overall cognitive function, researchers have focused on particular cognitive tests or particular models using a series of cognitive tests to predict driving ability.

Recently, De Raedt and Ponjaert-Krestoffersen (2001a) evaluated the ability of a short neuropsychological test battery, including the Trail Making Test, Part A, a visual acuity test, the clock drawing test and the Mini-Mental State Examination (MMSE) and age, to predict fitness to drive of older adults. De Raedt and Ponjaert-Krestoffersen (2001a) found that the test battery, using a combined test score, yielded a specificity rate of 85% and a sensitivity rate of 80%. The investigators indicated that the Trail Making Test, Part A showed the strongest discriminatory power, Wilk's Lambda = .67, $p = .005$ and the MMSE displayed an absence of predictive power in that it did not add significant discriminatory power to the model (De Raedt & Ponjaert-Kristofferson, 2001a).

Other researchers have found associations between the Trail Making Tests and driving abilities similar to De Raedt & Ponjaert-Kristofferson (2001a) (Hunt et al., 1993; Odenheimer et al., 1994; Tarawneh et al., 1993 as cited by Stutts et al., 1998). Contrary to these findings, some researchers failed to find associations between the Trail Making Tests and driving performance (Duchek et al., 1998; Fitten et al., 1995). Similar discrepancies have been reported regarding the predictive ability of the MMSE. While some researchers have found the MMSE to be significantly related to driving ability (Fitten et al., 1995; Fox et al., 1997; Mitchell et al., 1995), other researchers have failed to replicate these findings (Bieliauskas et al., 1998 as cited in De Raedt & Ponjaert-Kristofferson, 2001a; Marottoli et al., 1998). However, it should be noted that contrary to the researchers that found the MMSE to be a significant predictor of driving ability, Marottoli et al., (1998) used a self-report history of adverse driving events and not an on-road driving evaluation.

Despite the varying results reported on the association between cognitive tests and driving ability, cognitive tests are widely used to assess driving ability. Korner-Bitensky, Sofer, Gelinas and Mazer (1998) reported that the Trail Making Test, Part B was the second most commonly reported tool for assessing driving ability prior to the on-road test used by professionals attending the 1997 Association of Driver Educators for the Disabled annual conference. The Motor-Free Visual Perception Test (MVPT) was the most frequently used tool and those who scored poorly on both the MVPT and the Trail Making Test, Part B were 22 times more likely to fail the on-road driving evaluation (Korner-Bitensky et al., 1998).

The majority of the research has indicated that cognitive functioning is related to driving ability in older drivers and that a cognitive screening test may help to predict driving ability. However, given the inconsistent conclusions regarding various cognitive and neuropsychological testing it is clear that more research is needed to establish the link between cognitive abilities and driving abilities in older adults. A majority of the research also involves primarily or exclusively older adults with some form of dementia (Duchek et al., 1998; Fitten et al., 1995; Fox et al., 1997; Hunt et al., 1993; Mitchell et al., 1995) and therefore more research focusing on the general older adult population is needed.

While the previous research has focused on cognitive abilities in relation to driver abilities and safety there is a gap in the research regarding the predictive nature of cognitive/neuropsychological tests in that previous research has failed to analyze the association between cognitive tests and specific driving abilities (i.e., following rules of the road, ability to perform turns and lane changes). Additionally, previous research has not attempted to predict which drivers may improve if given training. The author of this study addresses the predictive ability of a series of neuropsychological tests in predicting initial driving performance on a standardized road test. Where previous research has focused on total cognitive scores and total driving scores this research analyzes specific (e.g., scores on items related to attention) and total test scores (e.g., the total score for the MMSE) in relation to specific (e.g., ability to execute turning maneuvers) and total driving scores. This in depth analysis may assist in gaining a clearer picture of the relationship between cognitive abilities and driving abilities.

In addition, this research examines which older adults, based on the neuropsychological testing, will respond to a driver refresher course. By adding this component not only is predicting initial driving abilities addressed, but a novel examination into which older drivers would benefit the most from a refresher course is conducted. By looking at the change scores between the first and second driving examinations the author hypothesizes that the research will be able to identify responders to the refresher course. Change scores for specific aspects of the driving evaluation (i.e., obeying road signs) are hypothesized to reflect which areas older drivers are able to improve on and in which areas of driving older drivers do not improve. Predicting driving abilities is important for formulating preventative measures and to enable driving retraining programs to focus on the specific concerns related to older drivers.

Method

Participants.

Participants were actively recruited on a volunteer basis through the Thunder Bay Council on Positive Aging (TBCPA), and through public advertising such as newspaper articles, radio announcements, television announcements and posters. The inclusion criteria comprised being 55 years of age or older, having a valid drivers license, being currently driving, and achieving a score of 24 or above on the cognitive screening tool (MMSE). The cutoff score of 24 was used because a score of 24 or greater indicates no cognitive impairment, whereas a score of 23 or less has been accepted as indicating the presence of cognitive impairment (Tombaugh & McIntyre, 1992). All participants tested met the cutoff score of 24 and therefore were eligible to complete the driving portion of the study.

Seventy-two participants were recruited, of which seven people withdrew prior to completion of the study. Two people withdrew without completing any component of the study, three withdrew prior the first on-road test, and two withdrew after the first on-road test, prior to completing the second on-road test. Reasons for withdrawing included, discomfort with driving the driving instructors car, death of a spouse, discomfort with the in-class setting and lack of free time to complete the components of the study. In total 67 participants completed the first on-road test and 65 participants completed the entire study (31 females and 34 males).

Design.

Prior to participation in the study all participants received an information sheet and signed a consent form (See Appendix B). All participants then completed a series of cognitive/neuropsychological tests. The neuropsychological testing was conducted by a trained researcher in the home of the participant. Upon completion of the cognitive tests participants completed a standardized on-road driving test. A trained driving instructor, who was blind to the outcome of the neuropsychological evaluation, conducted and scored the driving evaluations. The participants were given no feedback on their performance during the first driving evaluation. Following the first on-road test participants were randomized into one of two groups, a refresher course group or a waiting group. Those in the refresher course group then completed the training sessions. Participants then completed a second on-road driving test and following the second test those who were in the waiting group received the training sessions.

Cognitive Tests.

The cognitive tests included the Standardized Mini-Mental State Examination (MMSE) (Folstein et al., 1975), the Modified Mini-Mental State Examination (3MS) (Teng & Chang Chui, 1987), the Stroop test (Regard, 1981), the Digit Span and Block Design Subtests of the Wechsler Adult Intelligence Scale – Third Edition (Wechsler, 1997), the Motor-Free Visual Perception Test – Vertical Format (MVPT-V) (Mercier, Hebert, Colarusso, & Hammill, 1997), the Trail Making Tests A and B (Reitan, 1986), and the clock drawing test (Shulman, Gold, Zucchero, & Cohen, 1993). The tests were selected on the basis of measuring cognitive skills associated with driving, psychometric properties, ease of administration, and test length. Some of these tests measure specific cognitive abilities such as attention, cognitive flexibility, mental and motor processing speeds, and visual perceptual skills (i.e., Trail Making Test, Block Design and

Digit Span Subtests, the Stroop test, and the MVPT-V), while other tests are brief cognitive screening instruments used to identify possible general cognitive impairment (i.e., the 3MS, SMMSE, and the clock drawing test). Many of these tests have been well-studied and some of these tests have been utilized by the Canadian Study of Health and Aging (i.e., 3MS and clock design) (Canadian Study of Health and Aging, 1994) and thus can claim up to date Canadian norms (Tuokko, Kristjansson, & Miller, 1995; Tuokko & Woodward, 1996).

The 3MS (Teng & Chang Chui, 1987) is an expanded version of the MMSE (Folstein et al., 1975). Both the 3MS and the MMSE have been well-studied and have satisfactory reliability and validity (Tombaugh, McDowell, Kristjansson, & Hubley, 1996; Tombaugh & McIntyre, 1992). Tombaugh and colleagues (1996) reported the internal consistency Cronbach alpha coefficients for a non-clinical group to be .82 for the 3MS and .62 for the MMSE. The higher alpha for the 3MS in part reflects the test's larger number of questions. The researchers compared the sensitivity of the two tests using receiver operating characteristics and found, when collapsed across gender and education level, the 3MS and the MMSE to be equally sensitive (.926 and .905 respectively) (Tombaugh et al., 1996). The MMSE has frequently been utilized in studies on the elderly and driving (De Raedt & Ponjaert-Kristofferson, 2000, 2001a; Fitten et al., 1995; Fox et al., 1997; Irwin, 1989; Marottoli et al., 1998; Mitchell et al., 1995). The 3MS has been widely administered in the Thunder Bay community and allows for the calculation of both the 3MS score out of one hundred and the MMSE score out of thirty.

The clock drawing test is another screening tool used to detect the presence of cognitive impairment in older adults and has been used in previous studies on driving and the elderly (Fitten et al., 1995). The clock-drawing test assesses higher-order cognitive functioning such as visuospatial organization. The 5 level scoring system by Shulman, Gold, Zucchero, and Cohen

(1993), in which a score of 5 indicates a perfect clock, was used to score all the clock drawing tests. Researchers have found interrater reliability for scoring the clock drawing test, using a Spearman rank order correlation, to range from .94 to .97 (Shulman et al., 1993). The Stroop test (Regard, 1981) is a measure of cognitive flexibility, selective attention, and requires speed of processing. The Stroop has been found to have test-retest reliabilities with reliability estimates ranging from .83 - .91 (Regard, 1981) and also claims up to date Canadian norms (Spreen & Strauss, 1998).

The Block Design Subtest involves visual-motor organization, attention, concentration and visual organization. The Digit Span Subtest measures concentration, short-term sequential memory and attention. The Block Design and Digit Span Subtests have reliability coefficients, calculated using Fisher's z transformation, ranging from .76 - .88 and .84 - .93 respectively for ages 55 through 90 (WAIS-III WMS-III Technical Manual, 1997). The MVPT-V (Mercier et al., 1997) measures various aspects of visual perception skills including visual discrimination, visual analysis, and figure-ground discrimination. Using the Pearson product correlation, the test-retest reliability and internal consistency of the MVPT-V were found to be $\underline{r} = .93$ and $\underline{r} = .93$ respectively (Mercier et al., 1997). The Trail Making Tests measure both visuomotor tracking and divided attention. These tests (Block Design and Digit Span Subtests, MVPT-V and Trail Making Tests) all measure various aspects related to driving ability and have all been utilized in studies on driving and older adults (De Raedt & Ponjaert-Kristofferson, 2001a; Duchek et al., 1998; Fox et al., 1997; Korner-Bitensky et al., 1998; Marottoli et al., 1998; Stutts, 1998).

Driving Evaluations.

The driving test consisted of a standardized 35 minutes driving circuit within Thunder Bay. There were six standardized circuits available for the driving test, of which the participant was tested on the circuit closest to his/her residence. The same circuit was used for the pre- and post-tests. To maximize rater reliability, one certified driving instructor, blind to both the neuropsychological test outcomes and to the group the participant was allocated to, conducted and scored all driving tests. Potential practice effects were handled with the utilization of the control group. The on-road test provided a final total score ranging from zero to one hundred as well as scores on seven subscales. The subscales provided on the test included, vehicle handling errors, compliance/dangerous errors, and total corrected collision-free errors (CCFE), which is a summation of the four collision-free scores corrected for external conditions. The four collision-free error factors were look well ahead, move your eyes, keep space, and spot the problem. The first factor (factor 1), "look well ahead", contains errors regarding planning the route, following the flow of traffic and safety precautions prior to moving the vehicle. The second factor (factor 2), "move your eyes", consists of errors regarding checking mirrors, scanning the surroundings while driving, and scanning intersections. The third factor (factor 3), "keep space", indicates errors made regarding the space between your vehicle and other vehicles, blind spots, and avoiding rear crashes. The fourth factor (factor 4), "spot the problem", consists of errors regarding seeing and solving problems when turning, point of no return when approaching a set of lights, and reactions to potential road hazards or problems.

Results

Participants.

Of the seventy-two participants who were recruited, sixty-five participants completed the study. The ages ranged between 55 and 86 years old (M = 71.07 years, SD = 8.37) (see Table 1). Of the 65 participants, 33 were in the control/wait list group (15 females and 18 males) and 32 participants were in the refresher course group (16 females, 16 males).

Table 2 displays the means and standard deviations for the neuropsychological tests. The average scores for the MMSE, 3MS, Stroop test, MVPT-V, Trial Making Tests (A and B), and the Block Design and Digit Span subtests of the WAIS-III of this sample were comparable to that of published age norms (less than one SD from published means) (Bravo & Hebert, 1997; Mercier et al., 1997; Spreen & Strauss, 1998; WAIS-III WMS-III Technical Manual, 1997; Wechsler, 1997). This suggests that this sample was a relatively healthy sample. There was no normative data available for the clock drawing test.

Driving scores and change scores.

Table 1 displays the descriptive statistics for all of the driving scores and driving change scores. The mean scores on the first driving evaluation (N = 67) and second driving evaluation (N = 65) for the entire sample were 62.99 (SD = 7.65) and 66.92 (SD = 7.49), respectively. The mean scores on the first driving evaluation for the four corrected collision free errors for the sample were respectively, 4.18 (SD = 1.74), 11.64 (SD = 3.16), 5.06 (SD = 1.75), and 5.37 (SD = 1.28). The mean improvement between the first and second driving evaluation was 3.73 (SD = 6.87), which was significantly different from zero, $t(64) = 4.38$, $p < .001$. The mean improvement between the first and second driving evaluations on the four corrected collision free errors were as follows; factor 1 had a mean improvement of 0.39 (SD = 1.79) and was not significantly different from zero, $p = .08$, factor 2 had a mean improvement of 1.86 (SD = 3.11) and was significantly different from zero, $t(64) = 4.82$, $p < .001$, factor 3 had a mean improvement of 0.66 (SD = 2.27) and was significantly different from zero, $t(64) = 2.32$, $p = .024$, and factor four had a mean of 0.47 (SD = 1.51) and was significantly different from zero, $t(64) = 2.49$, $p = .015$. The mean improvement on vehicle handling errors was not significantly different from zero, $p = .12$.

We examined the potentially clinically significant difference by comparing the difference in the number of participants who would pass the first driving evaluation to the number of participants who would pass the second driving evaluation using a criteria cutoff of 70. At baseline 15 (22.4%) of the participants met the cutoff score of 70. Using a McNemar nonparametric test, the number of people meeting the 70 cutoff score was found to have increased significantly (p = .035) to 23 (34.3%) on the second driving evaluation. Using a less stringent criteria of 60% cutoff score yielded similar results. With a cutoff score of 60, at baseline 43 (64.2%) of participants met the cutoff. Using the McNemar nonparametric test, the number increased significantly (p = .017) to 54 (80.6%) of people meeting the cutoff on the second driving evaluation.

Differences between intervention and control groups.

Despite the improvement between the first and second driving evaluation for the entire sample, there was no significant difference in the amount of improvement between the refresher course group (M = 4.02, SD = 7.11) and the control group (M = 3.46, SD = 6.72), F (1, 63) = 0.10, p = .75. A series of ANOVAs indicated that there were no significant differences between the refresher course group and the waitlist group on the driving scores for the two driving evaluations and the driving change scores (See Table 3). The only exception was that the treatment group made significantly more errors on factor 1, look well ahead, (M = 4.68, SD = .29) during the first driving evaluation than the control group (M = 3.74, SD = .29), F (1, 63) = 5.22, p = .03. However when all the first driving evaluation scores where accounted for in a MANOVA there was no significant differences between the treatment and control groups, F (1, 63) = 1.20, p = .32. The MANOVAs for group differences and the second driving evaluation scores and the driving change scores were also non-significant (See Table 4). In addition to the driving scores the two groups did not differ significantly on the neuropsychological tests. The ANOVAs for this are displayed in Table 5. As a result of the refresher course group and the control group not differing significantly on the driving evaluation scores, the entire sample of scores was used in all remaining analyses.

Predictors of driving ability and change scores.

We examined if participants' demographic characteristics (age, gender, education) and results on neuropsychological tests would be predictive of their scores on the driving evaluations and their change scores between the first and second evaluations. Change scores for the difference between the overall driving scores was calculated as; the second driving evaluation overall score minus the first driving evaluation overall score. Change scores for each of the error scores were calculated as; error score during the first driving evaluation minus error score during the second driving evaluation. It should be noted that for all change scores in driving ability a higher change score is reflective of an improvement (i.e., higher overall score compared to baseline or fewer errors compared to baseline). As a first approach we used bivariate correlations (Pearson r). We found age to be statistically significantly correlated with the first driving evaluation ($r = -.48$), with factor 1, 2 and 4 ($r = .24$, $r = .46$, $r = .35$, respectively), with the total CCFE ($r = .45$) and with vehicle handling errors ($r = .32$) from the first driving evaluation. Age was not correlated with any of the change scores. Thus lower age was associated with a higher driving score and fewer errors. Education level was only significantly associated with factor 3 from the first driving evaluation ($r = .27$) indicating that those with a higher education were associated with more errors regarding keeping safe space around a vehicle. Gender was not significantly correlated with baseline or change scores.

When examining the association between driving scores and neuropsychological tests, the first driving evaluation was significantly associated with the dots and words sections of the Stroop test (r = -.33, r = -.25, respectively), and with the clock test (r = .30). Whereas the driving change score was significantly associated with the Stroop difference (colours – dots) score (r = -.27) and the Stroop ratio (colours/dots) score (r = -.31). Table 6 and 7 respectively display the correlations of the demographic characteristics and neuropsychological test for the first driving evaluation and for the change scores between the first and second evaluations.

The second approach relied on multivariate regression models. Table 8 displays the regression models for the first driving evaluation and for the change scores between the first and second driving evaluations. The hierarchical models for the first driving evaluation scores had variables entered in two groups. The first group of variables, age and education, were forced into the model. The second group of variables consisted of neuropsychological tests and were entered in a stepwise procedure to create the most parsimonious model. The hierarchical models for the driving change scores also had variables entered in two groups. The first group of variables, baseline driving score, age, and education were forced into the model and the second group of variables, various neuropsychological tests, were entered in a stepwise procedure.

Some of the models to predict the first driving evaluation scores, including the overall driving score, factor 1, factor 2 and total CCFE, had only age and education as variables and only age was predictive of the driving score (See Table 8). Adding the neuropsychological tests did not improve the predictability of these models. The model to predict factor 3 for the first driving evaluation included age, education and digit span (forward only). Digit span (forward) increased the adjusted R^2 by 4% (F-change = 4.34, p = .04). Education and digit span were significant predictors, however age was not. The model to predict factor 4 for the first driving evaluation included age, education and the Stroop ratio. Adding the Stroop ratio increased the adjusted R^2 by 6% (F-change = 5.60, p = .02). Overall this model accounted for 15% of the variance in factor 4. Age and the Stroop ratio were significant predictors, however education was not. The model to predict vehicle handling errors included age, education and Stroop test (dots) and accounted for 12% of the variance (F (3, 63) = 4.31, p = .01). Again, education was not a significant predictor.

Two of the models to predict change score between the first and second driving evaluation (factor 1 and vehicle handling errors) did not increase predictability by the addition of neuropsychological tests (See table 8). The model to predict overall driving change score included baseline driving score, age, education, MVPT-V and the Stroop ratio. The addition of the MVPT-V increased the adjusted R^2 by 6% (F-change = 6.24, p = .01) and the addition of the Stroop ratio increased the adjusted R^2 by an additional 7% (F-change = 8.36, p = .005). Age and education were not significant predictors. The model accounted for 35% of the variance in overall change scores (F (5, 59) = 7.95, p < .001). Indicating that individuals with lower baseline scores, higher MVPT-V scores and better Stroop ratios showed the most amount of improvement in overall scores. Neuropsychological tests also improved the predictive ability of models looking at change in specific factors of driving ability.

By adding the MVPT-V to the model to predict change in factor 2 the adjusted R^2 increased 6% (F-change = 7.82, p = .007). The entire model accounted for 52% of the variance in change scores on factor 2. The model for change score on factor 3 was improved by adding the Stroop ratio. The model accounted for 63% of the variance in the change scores on factor 3. Both age and education did not significantly contribute to the model. The model to predict change scores on factor 4 was improved by 5% by adding MVPT-V (F-change = 6.37, p = .01) and by an additional 8% by adding the Stroop test (words) (F-change = 10.25, p = .002). The model accounted for 49% of the variance in change scores on factor 4. Again age did not significantly contribute to the model. When looking at all four factors combined using the change score on the total CCFE, the MFVP-V increased the adjusted R^2 by 6% (F-change = 6.79, $p = .01$) and the Stroop ratio increased the adjusted R^2 by an additional 4% (F-change = 5.28, $p = .02$). Overall the model for change on the total CCFE accounted for 47% of the variance in the change scores.

Sensitivity and Specificity

To further investigate the demographic and neuropsychological tests in predicting driving ability, we investigated the extent to which each test was capable of discriminating between individuals who failed and individuals who passed the driving evaluation. The cutoff of 70 was used to differentiate individuals as having passed (score of 70 or above) or having failed (score below 70). A score of 70 is the pass point on road tests given to older drivers by the Ministry of Transportation in Ontario. The groups were also defined and analyzed using a less stringent cutoff criterion of 60.

We examined the properties of the demographics and the neuropsychological tests using Receiver Operating Characteristic (ROC) curves. The differences between the curves were calculated, where possible, using the method by Hanley and McNeil (1983) for comparing ROC curves with the same sample. Only ROC curves with an average area under the curve of .70 are comparable using the Hanley and McNeil methodology.

For the first driving evaluation (baseline) a cutoff of 70 resulted in 15 participants passing and 52 participants failing the on-road test. Age, Stroop test (dots), and Trail B all had significant ROC curves ($p = .001$, $p = .035$, $p = .041$, respectively). Age was the most powerful (area under the curve (AUC) = .78), followed by Stroop test (dots) (AUC = .68), followed by Trail B (AUC = .675). Using a two-tailed test at the .05 level, the Age curve did not differ significantly from the Stroop test, z = 1.17 or Trail B curves, z = 0.89. The Stroop test and Trail B curves were not compared as the average area under the curve was insufficient to use the method by Hanley and McNeil (1983). Similar findings occurred with a less stringent cutoff of 60, however Trial B was no longer significant and the clock drawing test was significant, p = .04, AUC = .65.

Additional ROC curves were analyzed for the second driving evaluation using the cutoff of 70. Using this criteria 23 participants passed and 42 failed the second on-road test. The significant ROC curves included age, 3MS, Stroop dots, Stroop words, MVPT-V, and Block Design (p = .001, .016, .048, .04, .015 and .017 respectively). Again age was the most powerful curve (AUC = .74), followed by the 3MS, MVPT-V and Block design, AUC = .68 for all three curves. The Stroop tests were equivalent, AUC = .65. Using a two-tailed test at the .05 level, the age curve did not significantly differ from the 3MS, z = 0.62, the MVPT-V, z = 0.60, the Block design, z = 0.57, the Stroop dots, z = 1.16, or the Stroop words, z = 1.14, curves. The 3MS, MVPT-V, Block design and Stroop curves were not compared as the average area under the curve was insufficient to use the method by Hanley and McNeil (1983). Using a less stringent cutoff of 60 resulted in age, Stroop test (words), MVPT-V and Block Design remaining significant with a trend towards slightly larger areas under the curve than found with the 70 cutoff (AUC = .81, .75, .78, and .70 respectively). The clock drawing test was also significant with the less stringent cutoff, p = .021, AUC = .72.

Discussion

One purpose of this study was to examine the predictive nature of neuropsychological testing and demographic information with regards to baseline driving abilities as measured with the first on-road evaluation. We found that age was negatively correlated with overall driving ability and positively correlated with all specific driving ability errors except for the errors captured by factor 3 (keep space). This suggests that, within the age range of this study, older drivers may have lower driving abilities than their younger counterparts.

An examination of the neuropsychological tests abilities to predict baseline driving scores indicated that, the clock test, which is a screening test for cognitive impairment, was predictive of overall driving ability, factor 1 (look well ahead) and factor 2 (move your eyes). However, these correlations were weak and did not hold up in multiple regressions. Trail A, a test of visual motor tracking, was found to be positively correlated with vehicle handling errors and factor 4 (spot the problems), however these also did not hold up in multivariate analyses. Our findings identified the Stroop test and the Digit Span subtest as predictive of baseline driving scores in multiple regressions. Specifically, the Stroop test, a measure of cognitive flexibility and selective attention requiring processing speed, was predictive of factor 4 (spot the problems) and vehicle handling errors. This finding suggests that older drivers with an increase in the Stroop interference effect (the cost of performing one task while in the presence of another task as measured by the Stroop ratio) were associated with fewer errors on skills such as point of no return and solving problems when turning, and that those with a lower baseline processing speed (higher Stroop dot score) were associated with more errors regarding skills such as braking, acceleration and signaling. These multivariate models explained 15% and 12% of the variability in factor 4 and in vehicle handling errors at baseline. Higher scores on the forward section of the Digit span subtest, a measure of working memory, was predictive of fewer errors regarding blind spots and space between vehicles. The multivariate model accounted for only 9% of the variability in baseline scores on factor three. While the relationships between baseline driving abilities and neuropsychological tests may be minimal, it does support the findings that age is not the only factor to consider when examining driving abilities.

While our findings follow a similar trend to previous research, other researchers have found stronger relationships between neuropsychological tests and on-road driving abilities (De Raedt & Ponjaert-Kristofferson, 2000, 2001a). However, De Raedt & Ponjaert-Kristofferson (2000, 2001b) recruited participants from a fitness-to-drive evaluation center and participants had been referred for a fitness-to-drive evaluation by their physician or by their insurance company. It is possible that the participants in these studies may differ from other healthy older drivers because there are already questions surrounding these participants ability to drive. In our study we focused on drivers in the community with valid driver's licenses who were currently driving and who fell in the normal range on a cognitive screening measure.

The second purpose of this study was to examine the ability of demographics and neuropsychological test to predict change in driving scores. The examination of the ability of older drivers to improve on a driving evaluation is a novel inquiry. Our analyses revealed that older adults are able to significantly improve their score on a driving evaluation regardless of their involvement in the driving refresher course. Specifically, using a 70% cut-off, the number of drivers who met this criteria increased by 53.3% on the second driving evaluation. These results suggest that many older drivers are able to improve sufficiently and those who failed an initial on-road driving test may pass the test on a subsequent attempt. Additionally, while we found age to be negatively correlated with some baseline scores it was not correlated with any change scores, suggesting that older drivers are able to improve just as well as their younger counterparts. This may also reflect a cohort effect as our drivers ranged in age from 55 to 86 years. It is plausible that younger drivers had better initial training when obtaining their licenses than did the older drivers.

We found the clock test to be positively correlated with change scores on factor 4, however this correlation was weak and did not hold up in multiple regressions. Our findings identified the MVPT-V test, a measure of various aspects of visual perception skills including visual discrimination, visual analysis, and figure-ground discrimination, and the Stroop test to be predictive in multivariate analyses. Specifically, the MVPT-V and the Stroop test were predictive of overall change scores. The model suggests that older drivers with better visual perception skills and with better cognitive flexibility requiring processing speed are associated with greater improvements in overall driving abilities on a subsequent driving test. Thus, while age was not predictive of overall change, the inclusion of two neuropsychological tests accounted for 13% of the variance in the overall improvement on the driving test. Our multivariate model accounted for 35% of the variability in overall change scores.

Further examination of change scores found the MVPT-V to be predictive of change on factor 2. This suggests that older drivers who have better visual perceptual skills are better able to improve on driving skills that involve eye movements such as checking mirrors, scanning the surroundings while driving and scanning intersections. The Stroop test was predictive of change on factor 3, suggesting that older drivers who have better cognitive flexibility and processing speed are better able to improve on driving skills including keeping space between your vehicle and other vehicles, avoiding blind spots and avoiding rear crashes. Both the MVPT-V and the Stroop test were predictive of change scores on factor 4 and on total CCFE. Our multivariate models accounted for respectively, 52%, 63%, 49%, and 47% of the variability in change scores on factor 2, factor 3, factor 4, and total corrected collision free errors. The results regarding improvement on the on-road driving evaluation indicate that older adults are able to improve the overall scores and improve on several specific elements of driving. Interestingly, the only two change scores for which the neuropsychological factors did not increase the predictive ability of the model were for factor 1 and vehicle handling errors. However, in this sample neither of these change scores were significantly different from zero. Thus, there may have been a range restriction that underestimated the association between these scores and neuropsychological tests.

It is clear that some older adults are able to improve their driving abilities from the first driving test to a subsequent driving test. The results indicate that older drivers who improved were associated with attributes such as higher scores on tests of visual perceptual abilities, cognitive flexibility and processing speed that appear to facilitate and predict improvement. Those who improved were also associated with lower baseline driving scores and more errors at baseline. Therefore, those who made the improvements had greater room for improvement. Thus it is possible that the improvement is a result of a regression towards the mean. It is also possible that some older adults who did not improve were unable to improve as the result of a ceiling effect.

While these results involving neuropsychological tests are encouraging the increase in predictive power associated with improvement in driving skills by the addition of neuropsychological tests was minimal. There are possible reasons as to why this occurred. Firstly, the participants in the study were all older drivers who were currently driving and the majority of the participants were recruited through the 55-plus center and posters in the community and were therefore fairly active. Additionally, all participants met the cutoff criteria of 24 on the MMSE, which indicates that all participants were in the normal range of cognitive functioning. Furthermore, the average MMSE score for the sample was 28.1, which put participants in the higher end of cognitive functioning. These inclusion criteria may have restricted the range of scores on both the neuropsychological tests and the on-road driving evaluations. The restricted range may underestimate the associations between driving ability and neuropsychological tests. The restricted range may have also lead to an underestimation in change scores and in the association between neuropsychological tests and change in driving ability. Secondly, the baseline score for each variable was a significant predictor and added the most predictive power. The results indicate that those with lower overall baseline scores and with more errors in on the various factors were associated with the greatest amount of improvement. Therefore we may have had a ceiling effect in which some older drivers were unable to improve on a second driving test because of their high scores on the first evaluation. If they were unable to improve due to a ceiling effect the ability of the neuropsychological test to predict improvement would have been adversely effected. Thirdly, it is possible that the predictive strength of the neuropsychological tests was underestimated due to the heterogeneity of the sample. For example, while the results indicated that lower Stroop ratios (better performance on the Stroop test) were associated with greater improvement on overall driving change and high Stroop ratios (poorer performance) were associated with lower improvement on overall driving change scores, it is possible that a third variable further categorized individuals who achieved low and high scores on the Stroop ratio. This third variable could be one of the other variables that we were trying to measure, such as perceptual abilities, or it could be a third unknown variable. If this occurred the variety of subgroups that may exist within the sample may have decreased the correlations between the predictive variables and the change scores.

We also examined ROC curves to determine the ability of the neuropsychological tests to correctly discriminate between older drivers who passed versus older drivers who failed the first and second driving evaluations. For both driving tests age was the most accurate at discriminating between individuals who passed and failed. However, age alone still led to 22% and 20% of individuals being incorrectly classified for the first and second on-road tests. Thus age alone may not be the best predictor of which older drivers will pass or fail an on-road driving test.

This study does have other limitations including the relatively small sample size. Once the sample was split into groups based on passing or failing the driving evaluation the sample sizes of these groups diminished further. Additionally, no base rate information was available on the percentage of older adults in the general population who pass or fail an on-road test. Future studies may benefit from the use of driving stimulators in order to evaluate a broader range of driving abilities without causing safety issues. Future studies looking at change in driving scores may benefit from larger sample sizes when comparing differences between the two groups. Future studies may benefit from a sample with a larger range of cognitive abilities and driving abilities. Driving simulators may be one way in which older drivers with lower cognitive abilities can be safely tested with a practical driving component. Driving simulators would also allow for constructing incidents that may not occur during routine on-road testing. This may allow for a larger range of driving abilities and skills to be tested. It should be noted that there may be some issues surrounding the validity of simulating a driving experience that would require further examination prior to using the driving simulator.

Despite these limitations, the results support previous research indicating that age is not the only predictor of baseline on-road driving abilities. Furthermore, some neuropsychological tests were shown to be predictive of specific driving skills. Regarding improvement in driving skills, the study was unable to determine which older driver's would benefit from the driving refresher course as the intervention did not significantly effect driving improvement. However, the results indicated that older drivers are able to improve and that age is not the best predictor of improvement. Rather, baseline driving abilities and tests of visual perceptual skills, cognitive flexibility and processing speed were the best predictors of improvement on driving abilities.

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Appendix A

Table 1
Descriptive statistics of demographics and driving scores

	Minimum	Maximum	Mean/N	Std. Deviation/ %
Age	55.00	86.00	71.07	8.37
Gender				
Female			31	47.7
Male			34	52.3
Education				
Elementary			7	10.8
High school			31	47.7
University/Collage			23	35.4
Graduate School			4	6.1
Driving Evaluation #1	39.3	79.6	62.99	7.65
Driving Evaluation #2	45.5	83.0	66.92	7.49
*Factor #1- look well ahead	.90	9.00	4.18	1.74
*Factor #2 - move your eyes	5.00	18.00	11.64	3.16
*Factor #3 – keep space	.90	9.90	5.06	1.75
*Factor #4 – spot the problems	2.60	9.00	5.37	1.28
*Total corrected collision free errors	13.40	38.70	26.26	5.08
*Total vehicle handling errors	9.00	32.00	17.09	3.68
Driving Change score (drive 2 - drive1)	-15	20	3.73	6.87
Factor #1 - look well ahead - change (drive 1 - drive 2)	-3.60	4.50	.39	1.79
Factor #2 - move your eyes – change (drive 1 - drive 2)	-6.00	8.00	1.86	3.11
Factor #3 - keep space - change (drive 1 - drive 2)	-3.60	7.20	.66	2.27
Factor #4 - spot the problems – change (drive 1 - drive 2)	-2.70	4.20	.47	1.51
Corrected collision-free errors - change (drive 1 – drive 2)	-9.10	13.70	3.39	5.24
Vehicle handling errors - change (drive 1 – drive 2)	-5	16	1.12	3.82
*Compliance Errors	0	5	2.00	1.48
*Dangerous Actions	0	4	.15	.58

*variables are from the first driving evaluation (baseline scores)

Table 2
Descriptive statistics of scores on the neuropsychological tests

	Minimum	Maximum	Mean	Std. Deviation
Mini-Mental State Examination (max = 100)	68	100	93.37	5.83
Modified Mini-Mental State Examination (max = 30)	24	30	28.10	1.70
Stroop – dots (seconds)	7	60	17.39	8.64
Stroop – words (seconds)	11	51	21.74	7.60
Stroop – colours (seconds)	17	89	38.92	15.24
Stroop – Difference (colours – dots)	-17	69	21.54	14.09
Stroop – Ratio (colours/dots)	.50	4.83	2.48	.96
Motor Free Visual Perception Test – V (max = 36)	19	36	33.50	3.01
Block Design (max = 68)	12	56	30.71	9.53
Digit Span – forward (max = 16)	5	15	9.51	2.17
Digit Span – backwards (max = 14)	2	12	6.40	2.47
Digit Span – total (max = 30)	8	26	15.91	3.93
Trail Making Test – A (seconds)	11	191	53.07	29.39
Trail Making Test – B (seconds)	22	382	108.31	57.96
Clock Drawing Test (max = 5)	3	5	4.66	.71

Table 3
ANOVAs between group (Control vs. Treatment) and demographic, and driving measures

Predictors	Group (Control vs. Treatment)			
	M_1 (SD) / N (%)	M_2 (SD) / N (%)	F	p
	Demographics			
Age	70.12 (1.74)	72.09 (1.50)	.88	.35
Gender				
Female	19 (57.6)	15 (46.9)	.73	.40
Male	14 (42.4)	17 (53.1)		
Education				
Elementary	4 (12.1)	3 (9.4)		
High school	17 (51.5)	14 (43.8)	.50	.48
University/Collage	10 (30.3)	13 (40.6)		
Graduate School	2 (6.1)	2 (6.3)		
	Driving Scores: Evaluation #1			
Driving Evaluation #1	63.44 (1.23)	62.92 (1.25)	.09	.77
Factor #1 (look well ahead)	3.74 (.29)	4.68 (.29)	5.22	.03
Factor #2 (move your eyes)	11.43 (.54)	11.71 (.55)	.13	.72
Factor #3 (keep space)	5.00 (.31)	5.10 (.32)	.05	.82
Factor #4 (spot the problems)	5.43 (.22)	5.19 (.22)	.63	.43
Total Corrected Collision Free Errors	25.61 (.85)	26.68 (.86)	.78	.38
Compliance Errors	2.18 (.25)	1.81 (.26)	1.04	.31
Dangerous Actions	.09 (.06)	.09 (.06)	.001	.97
Vehicle Handling Errors	8.72 (.49)	8.41 (.50)	.20	.65
	Driving Scores: Evaluation #2			
Driving Evaluation #2	66.91 (1.31)	66.94 (1.34)	.000	.99
Factor #1 (look well ahead)	3.63 (.25)	3.98 (.26)	.97	.32
Factor #2 (move your eyes)	9.43 (.50)	9.99 (.50)	.62	.43
Factor #3 (keep space)	4.49 (.25)	4.30 (.25)	.27	.60
Factor #4 (spot the problems)	4.84 (.23)	4.85 (.23)	.000	.99
Compliance Errors	2.30 (.27)	2.09 (.27)	.30	.59
Dangerous Actions	.06 (.04)	.03 (.04)	.31	.58
Total Corrected Collision Free Errors	22.39 (.86)	23.12 (.87)	.35	.56
Vehicle Handling Errors	8.30 (.42)	7.81 (.43)	.67	.42
	Driving Scores: Change (Evaluation #2 - #1)			
Driving Change Score	3.46 (1.20)	4.02 (1.22)	.10	.75
Factor #1 (look well ahead)	.11 (.31)	.69 (.31)	1.72	.19
Factor #2 (move your eyes)	2.00 (.55)	1.72 (.55)	.13	.72
Factor #3 (keep space)	.51(.40)	.80 (.41)	.25	.62
Factor #4 (spot the problems)	.59 (.26)	.34 (.27)	.43	.51
Total Corrected Collision Free Errors	3.22 (.92)	3.56 (.93)	.07	.79
Vehicle Handling Errors	.42 (.46)	.59 (.48)	.07	.80

M_1 (SD) represents the mean and standard deviation for the control group
M_2 (SD) represents the mean and standard deviation for the treatment group

Table 4
MANOVAs for driving scores as a function of group (control vs. driving course treatment)

Source	DV	F	p
Group		1.20`	.32
(control/treatment)	Driving Evaluation #1		
	Factor #1 evaluation 1 (look well ahead)		
	Factor #2 evaluation 1 (move your eyes)		
	Factor #3 evaluation 1 (keep space)		
	Factor #4 evaluation 1 (spot the problems)		
	Total Corrected Collision Free Errors (evaluation 1)		
	Total Vehicle handling (errors evaluation 1)		
Group		.74	.62
(control/treatment)	Driving Evaluation #2		
	Factor #1 evaluation 2 (look well ahead)		
	Factor #2 evaluation 2 (move your eyes)		
	Factor #3 evaluation 2 (keep space)		
	Factor #4 evaluation 2 (spot the problems)		
	Total Corrected Collision Free Errors (evaluation 2)		
	Total Vehicle Handling Errors (evaluation 2)		
Group		.39	.88
(control/treatment)	Driving Evaluation Change		
	Factor #1 Change (look well ahead)		
	Factor #2 Change (move your eyes)		
	Factor #3 Change (keep space)		
	Factor #4 Change (spot the problems)		
	Total Corrected Collision Free Errors Change		
	Total Vehicle Handling Errors Change		

Table 5
ANOVAs between group (Control vs. Treatment) and neuropsychological tests

Predictors	Group (Control vs. Treatment)			
	M_1 (SD)	M_2 (SD)	F	p
MMSE	93.09 (1.01)	94.10 (1.02)	.49	.49
3MS	27.91 (.29)	28.40 (.29)	1.84	.23
MVPT-V	33.24 (.50)	34.03 (.51)	1.20	.28
Block Design	31.36 (1.69)	30.28 (1.71)	.20	.65
Digit Forwards	10.12 (2.46)	9.00 (1.68)	4.57	.04
Digit Backwards	6.09 (2.58)	6.78 (2.34)	1.28	.26
Digit Span	16.21 (.69)	15.78 (.70)	.19	.66
Trail A	51.24 (5.22)	54.34 (5.30)	.17	.68
Trail B	113.94 (10.26)	102.20 (10.76)	.62	.43
Clock Test	4.64 (.11)	4.78 (.11)	.79	.38
Stroop (dots)	16.18 (8.19)	18.53 (9.31)	1.17	.28
Stroop (words)	22.30 (9.28)	21.12 (5.75)	.37	.54
Stroop (colours)	38.39 (15.15)	38.97 (15.91)	.02	.88
Stroop difference	22.21 (14.66)	20.44 (14.01)	.25	.62
Stroop ratio	2.64 (.17)	2.31 (.17)	1.82	.18

M_1 (SD) represents the mean and standard deviation for the control group
M_2 (SD) represents the mean and standard deviation for the treatment group

Table 6
Correlations between demographic characteristics, neuropsychological tests, and driving abilities for the first driving evaluation.

	Driving Evaluation #1		Total CCFE		Vehicle Handling Errors		Factor #1 (look well ahead)		Factor #2 (move your eyes)		Factor #3 (keep space)		Factor #4 (spot the problems)	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Age	-.482	<.001	.447	<.001	.321	.008	.244	.046	.465	<.001	-.046	.710	.353	.003
Gender	-.044	.722	.030	.811	-.025	.843	.090	.469	.030	.808	-.002	.990	-.078	.532
Education	.056	.654	.009	.942	-.159	.198	.118	.341	-.160	.196	.274	.025	-.106	.392
MMSE (100)	.174	.160	-.156	.207	-.114	.385	-.094	.449	-.184	.137	.116	.348	-.196	.112
3MS (30)	.117	.346	-.116	.351	-.075	.546	.013	.916	-.124	.318	-.017	.891	-.148	.233
Stroop (dots)	-.334	.006	.257	.036	.350	.004	.177	.152	.240	.050	-.024	.846	.219	.075
Stroop (words)	-.252	.040	.294	.016	.108	.382	.034	.788	.322	.008	.072	.561	.223	.070
Stroop (colour)	-.232	.058	.236	.054	.124	.319	.230	.061	.244	.047	-.084	.498	.134	.278
MVPT-V	.197	.110	-.133	.283	-.222	.071	-.069	.579	-.088	.480	.007	.958	-.226	.066
Block design	.218	.077	-.161	.194	-.211	.086	-.152	.220	-.252	.040	.199	.107	-.081	.517
Digit forward	.188	.127	-.192	.119	-.122	.325	-.220	.074	-.073	.559	-.168	.173	-.052	.676
Digit backward	.083	.503	-.057	.649	-.130	.294	-.031	.802	-.111	.372	.150	.227	-.113	.362
Digit Span	.156	.207	-.142	.253	-.149	.228	-.141	.255	-.110	.376	.001	.992	-.100	.421
Trial A	-.196	.111	.098	.430	.308	.011	.031	.803	.204	.098	-.291	.017	.242	.048
Trail B	-.145	.249	.081	.523	.234	.060	-.016	.898	.187	.136	-.238	.056	.214	.088
Clock test	.297	.015	-.260	.034	-.226	.066	-.215	.036	-.257	.036	-.019	.897	-.077	.534
Stroop difference	-.046	.709	.097	.433	-.081	.514	.117	.347	.117	.347	-.076	.539	.011	.926
Stroop ratio	.102	.410	-.061	.624	-.139	.262	-.022	.858	-.022	.858	-.102	.412	-.173	.162

*CCFE stands for corrected collision free errors

Table 7
Correlations between demographic characteristics, neuropsychological tests, and driving ability change scores.

	Driving Evaluation		Total CCFE		VH Errors Change		Factor #1 (look well ahead)		Factor #2 (move your eyes)		Factor #3 (keep space)		Factor #4 (spot the problems)	
	r	p	r	p	r	p	r	p	r	p	r	p	r	p
Age	-.007	.955	-.056	.660	.099	.435	.126	.317	-.061	.629	-.154	.221	.017	.896
Gender	-.145	.248	-.045	.724	-.240	.054	.075	.551	.039	.758	-.125	.320	-.135	.285
Education	.133	.289	.225	.071	-.072	.570	.200	.109	.083	.513	.156	.213	.137	.275
MMSE (100)	.081	.519	.154	.220	-.107	.398	-.041	.748	.185	.141	.100	.426	.050	.691
3MS (30)	.063	.617	.064	.614	-.018	.885	-.095	.452	.159	.207	.005	.968	-.001	.994
Stroop (dots)	.094	.457	-.006	.960	.239	.055	.107	.398	-.087	.490	-.026	.835	.071	.576
Stroop (words)	-.025	.843	-.013	.918	-.038	.765	-.076	.548	-.056	.655	-.050	.693	.237	.058
Stroop (colour)	-.192	.125	-.191	.127	-.074	.560	.028	.824	-.113	.371	-.273	.028	-.051	.686
MVPT-V	.225	.072	.291	.019	-.106	.399	-.027	.830	.344	.005	.082	.518	.208	.097
Block design	.150	.233	.167	.185	-.011	.928	-.154	.220	.181	.149	.177	.157	.120	.341
Digit forward	.038	.761	.012	.926	-.038	.765	-.165	.189	.136	.281	-.133	.289	.159	.206
Digit backward	.004	.972	.008	.950	-.083	.513	-.090	.477	.049	.697	.053	.677	-.047	.712
Digit Span	.024	.850	.011	.928	-.072	.566	-.147	.243	.106	.403	-.041	.748	.058	.645
Trial A	-.126	.317	-.198	.114	.138	.273	.058	.647	-.216	.084	-.251	.044	.070	.581
Trail B	-.177	.166	-.230	.069	.130	.311	-.025	.844	-.234	.064	-.210	.099	.030	.818
Clock test	.154	.221	.202	.107	-.076	.547	-.113	.369	.175	.164	.132	.293	.274	.027
Stroop difference	-.266	.033	-.203	.105	-.226	.070	-.035	.781	-.068	.589	-.279	.024	-.099	.435
Stroop ratio	-.312	.011	-.212	.090	-.277	.026	-.040	.752	-.068	.589	-.266	.032	-.144	.253

*CCFE stands for corrected collision free errors

Table 8
Regressions models for the first driving evaluation scores and for change scores

Dependent Variable	Predictors	B	p	R^2 change	Sig. F change	Adj. R^2	F	Sig.
Driving Evaluation #1								
	Age	-.45	<.001					
	Education	-.58	.61			.21	9.84	<.001
Factor #1 (look well ahead)								
	Age	.06	.01					
	Education	.44	.13			.08	3.77	.029
Factor #2 (move your eyes)								
	Age	.17	<.001					
	education	-.24	.62			.19	8.98	<.001
Factor #3 (keep space)								
	Age	-.02	.46					
	Education	.72	.01			.05	2.60	.08
	Digit forwards	-.22	.04	.06	.04	.09	3.27	.03
Factor #4 (spot the problems)								
	Age	.05	.002					
	Education	.15	.47			.09	4.07	.02
	Stroop ratio	-.39	.02	.07	.02	.15	4.78	.005
Total Corrected Collision Free Errors(CCFE)								
	Age	.29	<.001					
	Education	.93	.23			.19	8.46	.001
Vehicle Handling Errors								
	Age	.08	.08					
	Education	-.15	.74			.13	4.00	.02
	Stroop (dots)	.09	.04	.06	.038	.12	4.31	.01
Driving Evaluation Change								
	Driving Evaluation #1	-.50	<.001					
	Age	-.04	.73					
	Education	.85	.40			.21	6.67	.001
	MVPT-V	.83	.005	.07	.01	.27	6.99	<.001
	Stroop Ratio	-2.20	.005	.08	.005	.35	7.95	<.001
Factor #1 (look well ahead) Change								
	Factor #1 (baseline)	.69	<.001					
	Age	-.004	.98					
	Education	.29	.23			.42	16.16	<.001

Dependent Variable	Predictors	B	p	R^2 change	Sig. F change	Adj. R^2	F	Sig.
Factor #2 (move your eyes) Change								
	Factor #2 (baseline)	.74	<.001					
	Age	-.09	.03					
	Education	.13	.73			.46	19.32	<.001
	MVPT-V	.31	.007	.06	.007	.52	18.06	<.001
Factor #3 (keep space) Change								
	Factor #3 (baseline)	.99	<.001					
	Age	-.03	.17					
	Education	-.13	.61			.61	34.16	<.001
	Stroop ratio	-.40	.04	.02	.04	.63	28.09	<.001
Factor #4 (spot the problems) Change								
	Factor #4 (baseline)	.77	<.001					
	Age	-.03	.14					
	Education	.34	.09			.36	13.85	<.001
	MVPT-V	.16	.004	.06	.01	.41	12.35	<.001
	Stroop (words)	.07	.002	.08	.002	.49	13.45	<.001
Total CCFE Change								
	Total CCFE (baseline)	.68	<.001					
	Age	-.09	.24					
	Education	.80	.26			.37	13.70	<.001
	MVPT-V	.58	.005	.06	.01	.43	12.95	<.001
	Stroop ratio	-1.20	.02	.04	.02	.47	12.16	<.001
Vehicle Handling Errors Change								
	Vehicle handling errors (baseline)	.60	<.001					
	Age	-.03	.37					
	Education	.04	.91			.35	12.43	<.001

*B represents the unstandardized coefficients for the final regression model
*Stroop ratio = colours/dots

Appendix B

Consent Form – Driver Re-training Study

My signature below shows that I agree to take part in a study looking at the impact of driver re-training on driving skills. We hope to evaluate the effectiveness of a refresher program based on the 55 Alive retraining program and to determine who benefits the most from the program. I understand the following:

1. I can refuse to answer any questions which make me uncomfortable.

2. I can withdraw from the study at any time.

3. The data collected will be confidential and only used for the stated research purposes.

4. Before participation in the program, I agree to take part in an assessment used to examine skills people rely on when driving. This data collection will take place at the homes of participants.

5. Individuals who continue in the study will be given an on-road evaluation to assess driving skills. These evaluations will take place on a route near to the participants home, using the driving examiner's car.

6. Individuals will be randomly assigned to two groups. One will attend the driver training program and then complete a second on-road evaluation. Another group will undergo a waiting period, after which the second on-road evaluation will be completed. Then this group will receive the driver retraining.

7. When the study is completed, I will be able to receive a summary of the findings.

____________________________ __________________

Signature of Participant Date

____

Signature of Witness

Information Sheet - Driver Re-training Study

We would like to invite you to participate in a study to determine the effectiveness of a refresher program based on the 55 Alive driver re-training program.

This program is based on the 55 Alive program developed by the American Association for Retired Persons and modified by the Canada Safety Council for the Canadian setting. The program consists of two half-day sessions of three hours each. Class size is between 10 and 12 with course materials supplied at no cost (the regular fee is $25.00).

We hope to document the effectiveness of the program and to determine who benefits most from the program.

Before participation in the program, all individuals will take part in an assessment used to examine the skills people rely on when driving, such as attention span, memory and the ability to judge distances. This data collection will take place at the homes of participants and will require between 45 and 60 minutes.

Individuals who continue in the study will be given an on-road evaluation to assess driving skills. These evaluations will take place on a route near to the participants home, using the driving examiner's car. About 35 minutes is required for the on-road evaluation.

Individuals will then be randomly assigned to two groups. One group will attend the driver re-training program and then complete a second on-road evaluation. Another group will undergo a waiting period, after which the second on-road evaluation will be completed. This group will then receive the driver re-training.

Your participation is voluntary, and you may terminate your participation at any time.

The information you provide will be treated in a confidential manner. There will be no disclosure of the data to anyone other than the researchers conducting the study. In any scientific presentation or publication your name will not be used. The data will be stored in a secure filing cabinet in the research department at Lakehead Psychiatric Hospital.

When the study has been completed, you can receive a copy of the findings by contacting the principal investigator listed below.

Dr. Michel Bédard
Director of Research