Running title: TESTING VISUAL ATTENTION FOR DRIVING ABILITY

The Predictive Value of Visual Attention Mechanisms for Driving Ability

M.Sc. Thesis

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Abstract

The increasing population of older adults and their greater risk of involvement in collisions has prompted research into various aspects of driving behaviour. Tests of visual attention have shown promise for predicting safe driving and collision involvement. The present study examined visual attention tests including UFOV, IOR, and the newer Attention Network Test (ANT) to predict driving ability in younger and older adults. Driving ability was evaluated with a road test on a driving simulator. Using a variety of statistical techniques it is shown that performance on a driving simulator can be predicted by visual attention tests however the influence of age is an important factor in performance. The most consistent predictor of driving performance was the ANT and was had high sensitivity and specificity for classifying drivers as pass or fail. Driving simulator adaptation syndrome showed to be a problem in the older adults and potential solutions are discussed. One clinical implication of this study is the potential use of visual attention tests as valuable screening tool to distinguish drivers that are experiencing driving difficulties. In addition, previous research on UFOV indicates that training could influence driving ability and future research should evaluate if ANT training can have similar benefits to driving performance.

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Mechanisms for Driving Ability

Older drivers comprise a substantial proportion of the driving population, one which is increasing over time. Presently, there is an increase in collisions involving older drivers (Transportation Canada, 2001; Hakamies-Blomqvist, Raitanen, & O'Neill, 2002), in addition to an increased risk of injury and fatality in older drivers (Evans, 2000; Bédard, Guyatt, Stones, & Hirdes, 2002; Dellinger, Kresnow, White, & Sehgal, 2004). Researchers report the increased risk of fatality and injury in collisions is largely due to fragility (Li, Braver, & Chen, 2003). The increase in collisions in older adults is a trend that is projected to continue (Bédard, Stones, Guyatt, & Hirdes; 2001; Lyman, Ferguson, Braver, & Williams, 2002). In light of these statistics, researchers are attempting to identify predictors of crash risk to reduce risk in this population.

Visual Function and Driving in Older Adults

When compared to younger drivers, older drivers report trouble with visual stimuli that were dimly lit, near to them, moving quickly, or in a complex visual scene (Kline, Kline, Fozard, Kosnik, Schieber, & Sekuler, 1992). The older adults also report difficulty in assessing their own speed, other vehicle speed, and in peripheral objects (McGwin, Chapman, & Owsley, 2000). Examination of crash data indicate that older adults are frequently involved in crashes while performing left turns against oncoming traffic, gap acceptance, and changing lanes (Chandraratna & Stamatiadis, 2003). Executing a left hand turn requires the driver to be able to accurately judge the speed of oncoming vehicles. Gap acceptance occurs when a driver attempts to cross a road with oncoming traffic which also requires the ability to judge the speed of other vehicles.

Finally, problems with peripheral vision and judging one's and others speed are involved in changing lanes. Driver inattention is thought to result in a good proportion of collisions because drivers fail to observe appropriate stimuli or fail to respond correctly to stimuli (Trick, Enns, Mills, & Vavrik, 2004). Research indicates that attention failures, or lapses, result in collisions in older adults more than any other bad habit (Parker, McDonald, Rabbitt, & Sutcliffe, 2000). Attention failures play an important factor in collisions involving older adults, and consequently attention tests could be useful in discriminating between good and poor drivers. Individuals with Alzheimer's disease are an important population that has been examined for the ability of visual attention tests to be associated with driving ability.

Alzheimer's Disease and Driving

Health professionals suggest that older individuals diagnosed with dementia of the Alzheimer's disease type should be prohibited from driving due to the deficits in attention associated with the disorder. Duchek Hunt, Ball, Buckles, and Morris (1998) examined visual attention tests and the relationship with severity of Alzheimer's disease. Poorer performance in visual search and the Useful Field of View (UFOV) tests were associated to greater severity of Alzheimer's disease. Alzheimer's patients were more likely to make errors in detecting targets and reacting to irrelevant information in the visual monitoring task. The latter results are consistent with the hypothesis that Alzheimer's patients have deficits in the inhibitory mechanisms. However, Duchek and associates found that although diagnosis of Alzheimer's disease may identify higher risk individuals, it does not differentiate between safe and unsafe drivers. The experiment also found that visual attention performance predicted driving ability better than other cognitive tests. The recommendation made by the researchers is to use selective attention tests as a screening tool for discerning unsafe drivers with dementia that require further assessment.

Although diagnosis of dementia does not indicate whether an individual is a good or poor drivers, patients with Alzheimer's disease have been found to have an increased crash risk. Rizzo, Reinach, McGehee, and Dawson (1997) hypothesized that individuals with Alzheimer's disease were at greater risk for crashes than older drivers without dementia. Individuals with and without dementia were recruited to participate in a driving simulator test where their driving performance was evaluated for crash involvement and driving errors. The results revealed that 29% participants with dementia were involved in a crash but none of the control participants without dementia had a crash. Distraction, inattention, and errors were the reasons behind crashes in participants with dementia. The researchers also analyzed close calls, or near misses, and found 74% of drivers with dementia were involved with at least one near miss while 35% of drivers without dementia had one near miss or more. The authors conclude that driving simulators can be a useful and objective measure in assessing the performance of drivers with dementia while maintaining public safety.

Neuropsychological assessments may be a useful tool in recognizing some deficits that may not yet evident from on-road driving evaluation. Stutts, Stewart, and Martell (1998) examined the relationship between cognitive status and crash risk in older drivers. Participants aged 65 or older were recruited to perform a cognitive test battery that included Trail Making test (Parts A and B), American Association of Retired Persons reaction time test, the Short Blessed Orientation-Memory-

Concentration cognitive screen, and the North Carolina Traffic Sign Recognition test. In addition to the cognitive battery the researchers examined state records for crash involvement, traffic violations, and State medical reviews of the participants. Although Stutts, Steward, and Martell found that individuals with cognitive impairment were at greater risk for crashes there was no clear cutoff for identifying high risk drivers. The best predictors of crash risk were both Parts A and B of the Trail Making test. Since older drivers are more likely to be involved in crashes due to distraction and attention lapses the authors concluded that the association between cognitive status and crash risk and could be useful as a screening tool for older drivers.

More recently, the relationship between neuropsychological tests and on-road driving abilities was examined in patients with mild cognitive impairment by Whelihan, DiCardo, and Paul (2005). The study incorporated both traditional and computer-administered neuropsychological batteries including the Mini-Mental State Examination test of dementia, Dementia Rating Scale, Brief Symptom Inventory, as well as attention measures like Useful Field of View and both parts A and B of the Trail Making Test. The results indicate that the Maze Navigation Test and the UFOV visual attention tests were related to driving ability as measured by an on-road test. However, the later subtests of the UFOV may be too difficult for some patients with early mild-cognitive impairment.

In summary, visual attention is important for driving however the research indicates that for Alzheimer's patients the diagnosis of dementia is not sufficient to recommend complete cessation of driving but rather should indicate further evaluation of driving abilities and frequent reassessment. Studies that have used UFOV in

Alzheimer's patients have been shown to be associated with driving performance. Visual attention tests, including UFOV, may be useful for predicting driving performance in other populations.

Visual Attention

In terms of the visual system, the benefit of attention is to allow concentration on important stimuli from the plethora of stimuli in the visual field. Selective attention requires responding to a target while ignoring other stimuli and selective attention tests are most used in studies that examine driving ability. Another aspect of attention is divided attention which requires simultaneous attending to two or more stimuli.

Visual Search

One method of measuring visual attention is to use a visual search task (Tales, Haworth, Nelson, Snowden, & Wilcock, 2005). In this task, a target that appears in a group of distractors can elicit attention if the target is different from the group of distractors. However, if the target becomes similar to the distractors and the number of distractors is increased the task becomes more difficult, there is an increase in the reaction time.

Useful Field of View

The Useful Field of View is a test of attentional processing at preattentive level and depends on the subjects' ability to detect and locate targets in a group of distractors (Duchek, et al., 1998). It also measures the visual field in which an individual can extract useful information at any given time (Sekuler, Bennett, & Mamelak, 2000). The UFOV Visual Attention Analyzer has three subtests, one designed for each of three areas: visual processing, divided attention, and selective attention (Myers, Ball, Kalina, Roth, & Goode, 2000).

Clinical Use of UFOV

A specific population studied for driving and UFOV scores are individuals with brain injury. Patients with brain injury often have cognitive and visual deficiencies that could influence driving ability. Fisk, Novack, Mennemeier, & Roenker (2002) examined the differences between patients with traumatic brain injury and individuals without. UFOV scores were capable of differentiating patients from non-patients especially in the selective attention subtest of the UFOV and may be a useful tool in identifying patients that are ready to resume driving.

A recent study found that the UFOV test was useful in measuring of attention in individuals with acquired brain injury (Calvanio, Williams, Burke, Mello, Lepak, Ad-Adawi, & Shah, 2004). The patients with brain injury had attentional problems indicated by greater UFOV scores. In addition, the sample used showed that UFOV scores were correlated with the length of stay in a facility for the patients as well as level of cognitive impairment. The authors' identify the utility of UFOV tests for tracking long-term cognitive change and suggest it is comparable to better cognitive tests.

UFOV and Driving

McGwin, Chapman, & Owsley (2000) found that participants with decreased visual acuity had more difficulty driving in visually demanding environments (driving in the rain, during rush hour, on the interstate, etc). Participants' self-reported the driving situations in which they encounter difficulty. These visual scenes were more complex with a greater number of distractors. Individuals with impaired UFOV reported greater difficulty in driving in visually demanding environments.

Another study examining self-perceived driving ability and UFOV scores (van Rijn, Wilhelm, Emesz, Kaper, Heine, Nitsch, Grabner, & Völker-Dieben, 2002) found that individuals who reported visual impairments were correct in identifying their driving limitations. Regression analysis showed that both visual acuity and UFOV were predictive of level of driving difficulties. As the UFOV score also accounts for higher cognitive processing of visual stimuli the researchers hypothesized that UFOV could be used as a model of difficult driving situations, such as driving in an unfamiliar area.

Preliminary studies have also found an association between UFOV index and evaluated driving ability. Goode, Ball, Sloane, Roenker, Roth, Myers, and Owsley (1998) examined drivers over the age of 55 and tested them with the Mattis Organic Mental Syndrome Screening Examination (MOMSSE), Trail Making Test, Parts A and B, Wechsler Memory Scale-Visual Recognition Subtest, Rey-Osterrieth Complex Figure Test, and the Useful Field of View Attention Analyzer. The crash data were obtained from the Alabama Department of Public Safety. The researchers found UFOV reduction score alone was a better predictor of crashes when compared to other neurocognitive tests, and the addition of the UFOV test to the neurocognitive battery significantly improved ability to predict past car crashes.

Another study examining UFOV as a predictor of driving performance found that the UFOV was better at classifying drivers than a battery of cognitive tests (Myers, et al., 2000). Participants completed cognitive tests, reaction time, sign recognition, and examination of visual processing in addition to the UFOV attention analyzer. These tests were then compared to the participants' ratings as pass, fail, or questionable, from on-road driving evaluation. The UFOV test was useful in identifying individuals who failed the road test. The authors noted that cognitive and visual impairments could affect the UFOV scores.

A more recent study (Hoffman, McDowd, Atchley, & Dubinsky, 2006) investigated the predictability of driving performance from UFOV scores. The total sample size consisted of 155 older drivers between ages 63 and 87. Participants were recruited to complete a UFOV test, Driverscan, and an evaluation on a driving simulator. Driverscan is an attention test that varies in level of visual clutter and contrast. Information on past collision history was also obtained. The UFOV Subtest 2 for divided attention and Subtest 3 for selective attention could be predicted by structural equation modeling. Also, the researchers found ROC curves obtained cut points with sensitivity at 85% and specificity at 56%.

Age differences in UFOV

Sekuler, Bennett, and Mamelak (2000) explored age differences in UFOV by using a large sample of participants ranging in age from 15 to 84 years old. The UFOV test consisted of both focused and divided attention conditions. The focused attention had two parts one each for central and peripheral tasks. In the divided attention task, the participant attended to both central and peripheral stimuli simultaneously. The focused attention central and peripheral tasks showed decreased accuracy with age. The error rate for the central task remained stable until about age 40 and then increased in older ages while the error rate for the peripheral task increased after the age of 20.

The authors suggested this may be a result of presbyopia, or age-related reduced lens accommodation. The divided attention task also examined eccentricity and the researchers found no interaction between age and eccentricity. The authors concluded that the size of the UFOV is comparable in younger and older adults however older adults have difficulty extracting information from the UFOV and thus have less efficient visual processing in divided attention tasks.

UFOV and Training

There is evidence to suggest that UFOV scores can be increased through training. In Mazer, Sofer, Korner-Bitensky, and Gelinas' (2001) study examining UFOV in older adults who experienced a stroke. Participants were assessed on the UFOV Attention Analyzer and the training intervention had participants work with different levels of difficulty, eccentricity, colour, and level of light. The stroke patients were found to have greater reduction scores on all subtests of the UFOV but following the training participants had significantly better UFOV scores, indicated by less UFOV reduction. However, of the 52 participants only 6 completed the UFOV training. In addition, the lack of a proper control group was a major limitation to the study. Yet, all six participants showed significant improvement in their UFOV scores. The results imply that attentional declines in stroke patients might be partially reversed by training.

An extension of Mazer, Sofer, Korner-Bitensky, and Gelinas' (2001) study indicated that UFOV training may improve driving scores. Mazer, Sofer, Korner-Bitensky, Gelinas, Hanley, & Wood-Dauphinee (2003) performed a study in another group of stroke patients. The UFOV training was compared to traditional perceptual training and the primary outcome measured driving ability. The researchers found the experimental group receiving the UFOV retraining showed improvements in driving ability however similar results were found in the control group receiving the traditional perceptual training. They concluded that the UFOV training for stroke victims was just as effective as traditional perceptual training and new methods of intervention should be examined in this population.

The effect of UFOV training was also investigated by Roenker, Cissell, Ball, Wadley, and Edwards (2003) however the study population was older adults averaging 69 years old. Screening measures were used to identify potential individuals that would benefit from training including visual acuity, contrast sensitivity, and the UFOV Attention Analyzer. Participants were initially tested on the simple and choice reaction time on a driving simulator and completed an on-road driving evaluation. Participants that had a minimum of 30% UFOV reduction, indicating a loss in peripheral vision, were included into the speed-of-processing training or the driving simulator training groups. The driving simulator training had experts reviewing rules, explaining and practicing various techniques for safe driving and crash avoidance. The individuals in the speed-of-processing training group were age-matched to 'low risk' participants who did not have UFOV impairment. Initially, the low risk reference group had less UFOV reduction however after the posttest the speed-of-processing group had UFOV scores equal to the reference group. The simulator group had decreased the UFOV reduction but was not as effective as speed-of-processing training. No groups showed any training effects on the simple reaction time on the driving simulator however the speed-of-processing group showed faster choice reaction time at the posttest and the 18 month follow-up while the driving simulator group did not show as great an increase in reaction time. The on-road driving evaluation showed that the reference group had the best overall global rating on the pretest. At the time of the posttest all the groups had similar global driving ratings. At the pretest the reference groups showed the lowest score on the dangerous maneuvers composite. At the time of the posttest, all groups showed similar scores on the dangerous maneuvers composite scores, however, at the 18-month follow-up only the reference group and simulator training group maintained the lower number of dangerous maneuvers. Overall, the results show that both speed-of-processing and driving simulator training can increase driving ability in older adults although the speed-of-processing training showed longer lasting effects.

In summary, the UFOV visual attention test has been shown to positively identify safe older drivers from self-reported driving difficulty, crash statistics, and on-road driving evaluations. In addition training on the UFOV Attention Analyzer can increase scores on driving ability which may require booster training sessions over time. However in terms of age differences, the UFOV field size remains the same and the effects influence older adults' ability to efficiently process visual stimuli. This suggests that an attentional measure designed to assess the efficiency of the attentional networks could be used on both younger and older adults to predict driving ability.

Inhibition of Return

A visual cue that captures attention facilitates the detection of targets in the visual scene. However, when attention is moved to a different location there is inhibitory effect to the previous location. Posner and Cohen (1984) coined the term inhibition of return (IOR) for the phenomenon in which there is a slower response to detect a stimulus at a previously attended location. Facilitation occurs when the interval between the cue and the target, known as the stimulus onset asynchrony (SOA), is less than 150 ms, where as IOR occurs when the SOA interval is between 300 ms and 1500 ms (Posner & Cohen, 1984). The IOR effect can last as long as 1.5 seconds (Posner & Cohen, 1984). Posner and Cohen suggested that IOR is an important aspect in making visual search an efficient process by reducing the likelihood that a previously viewed location would recapture attention. Accordingly, IOR could be referred to as a 'fundamental search mechanism' (Weaver, Lupiáñez, & Watson, 1998) and would require the visual operator of orienting, or shifting attention (Trick, Enns, Mills, & Vavrik, 2004).

When considering eye movement, Posner and Cohen (1984) theorized that individuals can orient their eyes to control facilitation and the IOR effect remains at the previous viewed location. This idea was investigated by Tipper, Driver, and Weaver (1991) by observing the IOR phenomenon in a dynamic visual scene. The first experiment employed a static display to demonstrate the IOR phenomenon in order to replicate findings from previous IOR studies. The subsequent two experiments used a dynamic paradigm in which three outer squares orbit the central cue in apparent motion to show object-based IOR. The moving condition had a smaller IOR effect than in the static display in the initial experiment which indicates that in a static display some additional inhibitory effects influence the IOR phenomenon. In the last two experiments the participants showed the presence of object-centered IOR, leading Tipper, Driver, and Weaver to conclude that inhibition will follow a moving object, creating an abstract environmental map, which is a 'highly adaptive' behaviour.

To show that IOR plays a role in visual search Dodd, Castel, and Pratt (2003) attempted to show that even when attention is rapidly switching an IOR effect occurs, indicating that IOR has a memory component. The researchers utilized a multiple cue paradigm and varied the cues from short (50 ms) to long (500 ms). In each of the experiments performed by Dodd, Castel, and Pratt the IOR was present for both short and long cues with the largest IOR effect found for more recently viewed locations and that IOR declines over time. In conclusion, the results imply that visual search has both memory and IOR components.

In addition to the IOR effects on attention and visual search the electrophysiological responses in the brain was explored by Prime and Ward (2004). The areas of interest were the event-related brain potential (ERP) in the sensory cortex and the lateralized readiness potential (LRP) in the motor cortex. The results indicate that IOR also disrupts the motor cortex. This disruption in the motor response is likely due to interruption of perceptual processing or selecting a motor response rather than an inhibition of motor response.

Age Differences in IOR

The IOR phenomenon and importance in visual search lead Hartley and Kieley (1995) to examine if age-related differences in IOR contribute to age-related declines in attention. They theorized that if IOR was impaired in older adults previously viewed locations would be revisited and thus have a less efficient visual search. The initial four experiments of the study showed that younger and older adults showed IOR in static displays. In spite of this similarity more time was necessary before the onset of IOR and the effect lasted longer in older adults. The younger and older adults did not differ in detection and discrimination tasks for IOR. In addition, the time course and the spread in the visual field were similar between the age groups although the tests lacked power. The final two experiments incorporated the Stroop effect, demonstrated in both younger and older adults, and showed that the Stroop effect and IOR are not related phenomena. Importantly, the older adults showed increased error rates. Taken as a whole, these results suggest that stimuli capture attention in older adults but shifting attention away is a more difficult process which has implications for observing and responding to novel stimuli in the environment.

McCrae and Abrams (2001) also investigated the age differences in object-based IOR in both static and moving paradigms. The first experiment of the study employed a static IOR paradigm and results showed that both younger and older adults showed IOR, or slower responding to the targets, and older adults showed a larger amount of IOR. The second experiment attempted to demonstrate object-based IOR. McCrae and Abrams found that younger adults showed an IOR effect while older adults showed a facilitation effect. In order to explore the reason behind the facilitation effect, the third experiment lengthened the stimulus-onset asynchrony from 467 ms to a maximum of 3,967 ms. In spite of the lengthened time, an inhibition effect was not shown for objects in older adults. The lack of an object-based IOR effect in older adults was suggested to cause difficulties in visual search of moving objects. The fourth and final experiment of the study used a moving paradigm to study location-based IOR. Both younger and older adults showed significant location-based IOR and the effect was larger in older adults. In static scenes, McCrae and Abrams found no age differences in location-based IOR however when examining object-based IOR there were significant age differences. The dynamic paradigm for examining location-based IOR found similar effects in both younger and older adults. The fact that older adults showed no object-based IOR leads to the conclusion that older adults have difficulties in inhibiting the return of attention to moving objects and as a consequence may have difficulty in performing efficient visual searches.

In a follow-study, Castel, Chasteen, Scialfa, and Pratt (2003) examined the age differences in the time course of location IOR with a more powerful test and larger range of stimulus-onset asynchrony time intervals. The researchers used an IOR test in a static display with SOA ranging from 50 ms to 3,000 ms. In younger adults the IOR effect occurred earlier (222 ms after cue onset) than older adults (592 ms after cue onset). The time when IOR ended was similar in younger adults (2,800 ms after cue onset) and older adults (2,700 ms after cue onset). Castel, Chasteen, Scialfa, and Pratt found that IOR requires more time to develop in older adults and suggested that this age-related difference is the result of early facilitation effects.

IOR and Driving

Since driving requires effective scanning of the environment and IOR has been labeled as a fundamental search mechanism Bédard, Leonard, McAuliffe, Gibbons, Dubois, and Weaver (2006) investigated whether IOR is predictive of on-road driving performance in older adults. The participants ranged in age from 55 to 84, and the results confirmed that age alone is not an accurate predictor of driving ability. The inclusion of IOR scores enhanced the predictive model. Bédard and others also showed that influence of IOR was attributed to the location-IOR frame of referenc.

In summary, IOR is an aspect of visual search and there are age differences in the time course and length of IOR. The age differences and preliminary research that indicates IOR may predict driving ability and with confirming evidence could be used clinically as an assessment method for predicting safe driving.

Attention Network Test

The Attention Network Test (ANT) was developed and first used by Fan and colleagues (2002) to evaluate the efficiency of three anatomically separate attention networks in the brain: alerting, orienting, and conflict resolution (Posner & Peterson, 1990). The alerting system functions to maintain alertness and sensory processing. Through fMRI studies the alerting system has been found to activate frontal and parietal regions in the right hemisphere (Fan et al, 2002), as well as the thalamus (Fan,et al, 2005). The orienting system is crucial to switching foveal attention and is associated with activity in the pariental and frontal lobes. The conflict resolution system, or conflict resolution, and otherwise known as executive function, involves conflicting cues and requires cognitive effort. The conflict resolution system activates the anterior cingulate and lateral prefrontal cortex. Responses to the ANT are based on response time to indicate the direction of a central arrow. The central arrow points to the left or the right and difficulty is increased by including cues and flankers. The ANT has the ability of testing the independence of the attentional networks and the functionality of those networks. Although the networks are anatomically separate there is constant interaction between the networks to create an efficient attention system (Callejas, Lupiáñez, & Pio Tudela, 2004). To date no published studies have examined the use of the ANT to predict driving performance.

Present Study

The primary research goal of this study was to examine the ability for visual attention tests to predict driving ability. The visual attention tests used are UFOV, IOR, ANT, and visual search. The ability to predict driving was evaluated by assessing the relationship between driving ability based on performance on a driving simulator and the visual attention tests. I hypothesize that the divided and selective attention subtests of the UFOV (Subtest 2 and 3, respectively) will predict driving ability, however the predictive value in younger adults will be limited. Location IOR and ANT are hypothesized to predict driving ability in both age groups.

The secondary research goal was to investigate if older and younger drivers differ in driving ability, visual attention, and predictive ability of visual attention test for safe driving ability. I hypothesized that the age groups will differ in performance for the visual attention measures with the exception of the location IOR. Older adults will have increased reaction time on the visual attention measures when compared to younger adults.

The final research goal was to provide evidence on the validity of the driving simulator in predicting driving ability by comparing the on-road test results with the driving simulator. I hypothesized that the driving simulator will be highly correlated with the on-road driving assessment and thus a valid instrument for evaluating driving ability.

Method

Participants

The target population was older adults, age 65 or older, with a wide range of driving abilities from poor/unlicensed drivers to excellent drivers. To obtain 80% power of detecting a 0.5 correlation, assuming a two-tailed situation at $p = .05$, our sample required 30 subjects. Older drivers were recruited through concurrent initiatives. The researchers also contacted seniors groups, physician practices, and a local Geriatrician to look for ex-drivers, with and without dementia, but were not successful in recruiting any participants. A group of younger drivers between ages 18 and 30 were used for comparison and were recruited by contacting students in the Introductory Psychology courses at Lakehead University. The comparison group of younger drivers also had 30 participants.

Procedure

Once telephone contact had been established with participants, a meeting at Lakehead University campus was scheduled in order for participants to learn about their role in the study and the time commitment required for completing each section (Appendix A). As well, researchers obtained informed consent from participants at this meeting (Appendix B). Participants completed questionnaires for health (Short Form Health Survey, SF-12), demographic information, driving history/patterns, medical conditions and prescriptions, the Trail Making Test, and a visual acuity test. The older adult drivers completed the Mini-Mental State Examination (MMSE) dementia test. The participants then completed visual attention tests (visual search, UFOV Attention

Analyzer, IOR, and ANT). Following the visual tests the participants completed a road test on the driving simulator.

Instruments

SF-12 Health Survey

All participants had their physical and mental health assessed with the SF-12 Standard US version 1.0, Copyright 1998 (Appendix C). The questionnaire covers physical functioning, role limitations due to physical health problems, bodily pain, general health, vitality, social functioning, role limitations due to emotional problems, and mental health. Completion of the questionnaire took approximately 2 minutes and was self-administered on the Lakehead University campus. A researcher was present to answer any questions by the participants. The participants' data from SF-12 was compared to the normative data for their age group.

Demographic Information

A demographic questionnaire was developed to gather some basic information from the participant including birthday, marital status, education, and income (Appendix D). Participants were reminded that the information collected would remain confidential. Approximately 5 minutes was required for completion.

Driving Pattern

The driving patterns questionnaire examined information including amount and frequency of driving, stressful/difficult situations, and perception of driving ability (Appendix E). Participant completed the questionnaire on campus at Lakehead University. Total time to complete was 5 minutes.

Medical History and Medication Use

Participants completed a short questionnaire at Lakehead University campus concerning present health (Appendix F). The first portion consisted of questions where the participant indicated the presence or absence of a number of medical conditions. The second portion had participants indicate any prescription medication they were using. Approximately 5 minutes was needed for the participant to complete the questionnaire.

Mini Mental State Examination

Older drivers were tested for severity of dementia by the Standarized Mini Mental State Examination (MMSE). The MMSE is a test concentrating on cognitive abilities of the individual and consists of questions divided into two parts. The first part focuses on orientation to time and place, memory, and attention. The second part tests the ability to name, follow verbal and written commands, write a sentence, and copy a complex geometric figure. A higher score indicates better cognitive functioning. The test administrator is instructed, prior to giving the test, to make the participant comfortable, develop a rapport, praise success, and to avoid pressuring for an answer. Clear guidelines for participant responses and for scoring procedure is set forth by the standardized version of the MMSE (Molloy, Alemayehu, & Roberts, 1991). The test was administered by a researcher and the testing took place on Lakehead University campus. Administration of the MMSE took approximately 5 minutes to complete.

Trail Making Test, Parts A and B

The Trail Making Test is a neuropsychological instrument to examine visual attention, visual search, mental flexibility, and motor functioning. The Trail Making

Tests consists of two parts: A and B. In part A, participants join numbers 1 to 15 randomly distributed on a sheet of paper. The participants begin at a circle marked *Begin* then connect the numbers then end at a circle marked *End.* Part B is similar to Part A however the participant must switch from number (1 to 8) to a corresponding letter (A to G). The participant begins at the *Begin* circle then move from number to letter (1-A-2-B-3-C, etc) then ends at the circle marked *End.* Both parts of the Trail Making Test are to be completed as fast as possible without lifting the pencil from the page. The score for each task of the Trail Making test is the time needed to complete the task. Completion of both tasks of the Trail Making Test took approximately 5 minutes.

Road Test

The older adults with a valid driver's license performed real-life road tests on a standardized circuit (Appendix G). The road test was similar to the route used by the Ministry of Transportation of Ontario for the G2 licensing examination. A trained expert evaluated and scored the participant based on the number of errors or deductions. The Manitoba Highways and Transportation Driver and Vehicle Licensing form was used in some previous research and was used in this study for consistency. The road test took approximately 30 to 45 minutes to complete.

Visual Tests

Visual Acuity

The visual acuity test is to control for any problems that may arise from the visual attention test and to serve as a validity indicator. The 20 ft 116-830 Snellen eye chart from AMG Medical Inc. was used in this study. Corrected visual acuity for distance was at least 20/40 for participation in the study.

Visual Search

A serial visual search program was created by B. Weaver for this study. The participant was required to indicate a target in a field of distractors. The test became progressively more difficult by increasing the number of distractors in the frame. The test took approximately 10 minutes to complete.

Useful Field of View Attention Analyzer

The Useful Field of View Attention Analyzer is a test of visual function and visual attention administered and scored by a computer. Participants must detect, identify, and localize visual stimuli presented on a TTX Model 1777, 17" pure flat colour with a touch computer screen. The UFOV software Model 2003, Version 6.0.7 (Visual Resources, Inc., Chicago, IL, U.S.A.) automatically adjusts the duration of presentation based on the responses to reach the perceptual threshold. The UFOV software is installed on an IBM compatible computer with Microsoft Word Professional 2000. The UFOV test bases scores on the accuracy of the results and not the reaction time of the response. The test is used as a measure of risk for performing daily activities and cognitive functioning and can be utilized by health care professionals, employers, drivers licensing boards, and insurance companies. The present study had participants complete the test in a darkened room on Lakehead University campus. The length of time needed to complete the test was 15 minutes.

The UFOV Attention Analyzer is divided into three parts: processing speed, divided attention, and selective attention. In the speed processing speed task, the participant will be presented an object, a car or a truck, centrally-located in a white box. The participant will indicate which image they saw by touching the screen. The researcher will present the standardized instructions to the participant and conduct 4 practice trials so the participant understands and is comfortable with the task. As the experimental trial continues, the time interval in which the object is presented will decrease from 250 ms to 12.5 ms. The test ends when the participant can no longer discriminate between the presented objects.

The divided attention task requires the participant to identify a central image, a car or truck, while locating a peripheral object. The peripheral object, a car and never a truck, is presented in one of 24 locations representing all visual angles (10°, 20° and 30°) as well as in all directions (4 cardinal and 4 oblique). The duration of image presentation is varied between 240 ms to 40 ms to determine the participants' perceptual threshold.

The final task, selective attention, has the participant identify a central image while locating a peripheral object similar to the divided attention task however 47 triangles are also present as distractors. This task evaluates the participants' ability to discriminate between visual information.

The UFOV Attention Analyzer automatically provides the duration of the presentation that the participant achieved 75% accuracy. For each subtest, the cue duration was used in analysis.

Inhibition of Return

The static paradigm test of IOR used the paradigm used by McAuliffe 2001, 2006. The IOR test was presented on an IBM compatible Microsoft Word Professional

2000 computer with an Envision 17" colour monitor. Responses were made by pressing the bottom button on a RB-530 response pad interfaced with USB port. Participants were seated approximately 40 to 45 cm away from the computer screen. Initially a prompt was presented on a blank screen to inform participants that when they were ready to press the top button on the response pad to begin the trial. Initially, a two placeholder boxes (1° square) were shown on opposite sides of a central fixation point (filled in circle, 0.2°). The placeholders could be presented horizontally or vertically around the central fixation point. This initial display was presented for 1000 ms. Following the initial display, a peripheral cue of a smaller hollow box (0.5° square) was presented for 200 ms. The peripheral cue was presented 5.5° to the left, right, top or bottom of the central fixation point. There was a delay of 200 ms in which the initial display was increased in size. To re-orient the participant the central fixation point increased in size from 0.2° to a 0.4° for 200 ms. After the reorientation to the central fixation point, there was an additional delay of 400 ms. Finally, the target (a solid white 0.5° square) was presented 5.5° to the left, right, top, or bottom of the central fixation point. The target appeared for 1000 ms. The SOA was 1000 ms. Participants were asked to remain fixated on the central fixation point and to respond as quickly as possible only to the target object. Twenty percent of the trials were catch trials in which the sequence was similar except that no target would be presented. Participants were instructed not to respond. Any errors, failure to respond within the time or with the incorrect key, were discounted from analysis.

The cues and targets had the same probability of appearing in the left, right, top, or bottom positions. Cues and targets presented inside the placeholder boxes were placeholder-present (object) trials. Cues and targets presented outside the placeholder boxes were placeholder-absent (location) trials. The filler trials consisted of situations in which: (1) trials when the cue appeared inside a placeholder box and the target appeared outside the placeholder box, and (2) trials when a cue appeared outside a placeholder box and the target appeared inside the placeholder box. The purpose of the filler trials, as explained by Jordan and Tipper (1998), were to ensure the cue could not predict the location of the target.

Participants completed 40 practice trials before the testing of 320 trials. There were 64 placeholder present (object) trials (32 cued targets and 32 uncued targets) and 64 placeholder absent (location) trials (32 cued targets and 32 uncued targets). There were also 128 filler trials and 64 catch trials. Participants were given a break after every 80 trials. The data of interest is the mean and median response times for correct responses and error percentages.

Attention Network Test

The Attention Network Test (ANT) is a task designed to measure the efficiency of three attention networks: alerting, orienting, and executive control. A Java applet for execution of the ANT was installed from http://www.sacklerinstitute.org. The apparatus used for this test was IBM compatible Microsoft Word Professional 2000 computer with an Envision 17" colour monitor. Participants were seated approximately 65cm away from the screen and made responses using two buttons, the left and right arrows, on the keyboard. The stimuli presented were the same as in Fan, McCandliss, Sommer, Raz, and Posner (2002).

The stimuli were presented on a gray background and a central fixation cross was present during the entire test. The target was an arrow pointed in either the left or right direction and was located either 1.06° above or below the fixation cross. The target could be presented alone or as a central arrow in a group of 5 arrows.
If the target was a single arrow the visual angle was 0.55°. When the target was presented in a group, the arrow was flanked by two arrows on each side in either the same direction (congruent condition), or in opposite direction (incongruent). If the target was in a group of arrows each single arrow (visual angle 0.55°) was separated by a visual angle of 0.06° and comprised a total visual angle of 3.08°. The participant was asked to identify the direction of the single target or central arrow and respond with the corresponding key on the keyboard. The location of the target was uncertain except when a cue was presented.

Each trial consisted of five events. First, a fixation period for a random variable duration between 400 and 1600 ms. Second, this was followed by presentation of a warning cue for 100 ms and then third, another fixation period lasting 400ms. Fourth, the target alone or with flankers would appear for 1700 ms or until the participant responded. If a response was made before the 1700 ms time limit, the target and flankers disappeared immediately which was then followed by post-target fixation period. Finally, the post-target fixation period was dependent on the first fixation and the reaction time (RT) (3500 ms minus duration of the first fixation minus RT). The next trial would then begin. Each trial lasted 4000 ms.

In order to measure alerting and/or orienting, there were four warning conditions in the task: no cue, center cue, double cue, and spatial cue. For no cue trials, a fixation period was presented for 100 ms and contained no alerting or spatial cues. For center cue trials, alerting was involved with the presentation of an asterisk over the fixation cross for 100 ms. Double cue conditions occurred over 100 ms and had two warning cues corresponding to the two possible target locations, top and bottom. The spatial cue involved presentation of the cue over the location where the target would appear. The spatial cue task involved both alerting and orienting. The variable duration of the first fixation was used to produce additional uncertainty about the onset of the cue. Each of the three networks was produced from the difference in reaction time on the conditions based on their 'operational definition' (Fan, et al, 2005):

$$\textit{Alerting effect} = RT_{no\ cue} - RT_{center\ cue}$$

$$\textit{Orienting effect} = RT_{centre\ cue} - RT_{spatial\ cue}$$

$$\textit{Conflict effect} = RT_{incongruent} - RT_{congruent}$$

A testing session consisted of 24-trial full-feedback practice and three test blocks with no feedback. Each block of the test consisted of 96 trials (4 cue conditions X 2 target locations X 2 target directions X 3 flanker conditions X 2 repetitions). The presentation of the trials within the blocks was randomly ordered. Participants were instructed to remain fixated on the central fixation cross for the duration of the experiment and to respond as quickly and accurately as possible. The feedback during the practice period allowed participants to increase speed and accuracy and took approximately 2 minutes. Each experimental block took approximately 5 minutes.

Driving Simulator

The driving simulator located at Lakehead University mimicked the Ministry of Transportation of Ontario G2 licensing examination road test (Appendix G). All participants completed this portion of the study. In addition, participants were able to practice on the driving simulator in order to become familiar with the set up and operation of the system. The relationship between the on-road test and simulator of licensed drivers served as a validity indicator for unlicensed drivers. The estimated time required to complete the simulator was 30 minutes.

Statistical Analysis

The correlations coefficients were computed between the visual tests and the driving simulator evaluation to examine the strength of the relationship. The correlations were complemented with scatterplot graphs. Sequential regression analysis was implemented to identify relative predictors in driving ability. Age was inserted at the first step of the model and followed by entering the visual attention test to complete the model. The change in the model was used to determine the extent that the visual attention test influences driving simulator scores after controlling for age. In addition, receiver-operator-characteristic (ROC) curves were created to determine a cutoff score on the visual attention test that could predict the results of the driving evaluation.

The differences between younger and older adults on the visual attention tests and the driving simulator evaluations older and younger drivers were examined with univariate analysis of variance (ANOVA) tests. The dependent variable was the visual attention test and the grouping variable was age. In addition, correlation coefficients and sequential regressions were completed in the same manner separately on the younger adults and the older adults.

To determine if the driving simulator is a valid test of driving ability, correlations coefficients were calculated to evaluate the relationship between the road tests and various ratings of the driving simulator test.

Results

The 52 individuals tested for the study ranged in age from 18 to 83 (mean = 42.15, SD = 26.61), two individuals were excluded from analysis because they were not in the age groups of interest. The total number of participants included in the analysis study is 50; 21 male and 29 female. The younger group (N=30) included individuals ranging in age from 18 to 24 with a mean of 20.27 and standard deviation of 1.799. The younger group had 14 males and 16 females. The group of older adults (N=20) ranged in age from 66 to 83 with a mean of 74.60 and standard deviation of 5.286. The gender split for the older adults was 7 males and 13 females.

The Trail Making Test Part B was removed from analysis after it was discovered that two different versions were used. Thus it was not a valid measure and therefore does not provide any prediction value.

Initially the data were evaluated using SPSS Missing Values Analysis to determine the pattern of missing values. It was found that the variables associated with the driving simulator and the on-road evaluations had missing values making up > 5%. The initial driving simulator evaluation is the primary measure intended for use as the dependent variable. There were 11 missing cases from the initial evaluation variable that comprised 22% of the missing data.

The SPSS Missing Values Analysis also indicated several outliers which was confirmed with the SPSS EXPLORE program based on standardized scores in excess of 3.29 ($p < .001$, two tailed test). Boxplots were used to investigate the outlying cases separated by age group. The impact of the univaritate outlying scores was reduced by changing the scores to a value one value greater than or less than the next closest value. For the group of younger adults outliers were found on the following variables, the alerting and orienting measures of the ANT and general accuracy on the ANT, driving simulator evaluation, second examiner driving score, and the total mistakes calculated by the driving simulator. For the group of older adults, outliers on the alerting and orienting measures of the ANT and the overall accuracy. As well, the processing speed of the UFOV test was found to have outliers. No multivariate outliers were found using Mahalanobis distance with $p < .001$.

The Short Form Health Survey, SF-12, to determine physical and mental health was included in the study as a measure to determine normalcy of the sample population. A one sample t test was conducted on the SF-12 scores to examine if the scores are significantly different from the norms from the U.S. population. With alpha set at .05, the sample mean on the Physical Component Summary scale of the SF-12 was 51.41 (SD=7.17) was not significantly different than the norm 50.12, $t(49) = 1.27, p = .209$. The confidence interval for the mean Physical Component Summary ranged from 49.37 to 53.45. The sample mean on the Mental Component Summary scale of the SF-12 was 52.42 (SD=6.39) and found to be significantly different from the U.S. norm of 50.04, $t(49)=2.64, p = .011$. The confidence interval for the mean Mental Component Summary ranged from 50.60 to 54.24. The t tests indicate that overall the participants reported similar physical health on the Physical Component summary (Table 1) and significantly better health status on the Mental Component Summary (Table 2) when compared to the normative data.

The primary research question was to examine the predictive value of the visual attention tests for safe driving ability in older adults. Descriptives on the various visual attention tests are presented in Table 3. Correlations coefficients were calculated among the different visual attention tests and the driving simulator evaluation. Using the Bonferroni method to control for Type I errors across the 13 correlations, a p value of less than .003 (.05 / 13 = .003) was required for significance. Significant correlations were found between the cognitive and visual attention tests (Table 4). The overall mean of the ANT was found to have a significant correlation with all subtests of the UFOV (Subtest 1: $r(50) = .590, p < .001$; Subtest 2: $r(50)= .828, p < .001$; Subtest 3: $r(50)= .879, p < .001$). There were no significant correlations found between the Location IOR and the Object IOR measures. Also, part A of the Trail Making Test was found to be significantly correlated with the subtests of the UFOV, all measures from the ANT and the visual search task. The correlations indicate that the visual attention measures to some degree are measuring the same observed variable.

Next correlations coefficients were computed between the visual attention tests and the driving simulator evaluations and its components (Table 5). The overall mean of the ANT was found to have significant correlation with the final driving score ($r(39) = .77, p < .001$). Each subtest of the UFOV (Subtest 1: $r(39) = .61, p < .001$; Subtest 2: $r(39) = .67, p < .001$; Subtest 3: $r(39) = .72, p < .001$) as well as the Trail Making Test Part A ($r(39) = .57, p < .001$) were found to be correlated with the final driving score. The scatterplot graphs between the driving simulator evaluation and the Trail Making

Test Part A, UFOV Subtest 3, and the overall mean of the ANT are presented in Figures 1, 2, and 3, respectively.

Sequential regression analyses were next performed using final driving score as the dependent variable (Table 5). Initially age was entered as a predictor variable into the equation followed by a visual attention measure to determine if the visual attention measure could improve prediction of the driving simulator evaluation. It was found that addition of the UFOV subtest 1(Adjusted $R^2 = .53$, $F(1,36) = 5.01, p = .032$), overall mean of the ANT (Adjusted $R^2 = .58$, $F(1,36) = 9.58, p = .004$), and location IOR (Adjusted $R^2 = .49$, $F(1,35) = 4.52, p = .041$) significantly predicted the final driving evaluation score (Table 6). Although the visual attention tests showed to be significant, the change in prediction remained low. The entering of age into the regression showed adjusted R^2 ranging from .48 to .49. Both the addition of the UFOV subtest 1 and the location IOR increased the predictability by 5%. The overall mean of the ANT explained 10% of the variability in driving scores.

The ROC curves were used to evaluate if visual attention tests could be used to discriminate between good and poor drivers. The state variable used was the final score on the driving simulator. Participants who had a score lower than 100 were considered to have passed the road test, and anything greater was a fail. ROC curves indicated that several of the visual attention tests had higher discriminating power. The Trail Making Test Part A ($AUC = .77, p = .002$, CI from .64 to .90). Sensitivity was at 61% and specificity at 82% when the Trail Making Test was at 20.5 msec (Figure 4). The UFOV Subtest 2 ($AUC = .86, p < .001$, CI from .75 to .96) had sensitivity at 73% and specificity at 94% with the cutoff established at .184 msec (Figure 5). The UFOV

Subtest 3 ($AUC = .82, p < .001$, CI from .71 to .94), showed sensitivity of 67% and specificity of 88% when the cutoff is .120 (Figure 6). Finally, the overall mean of the ANT ($AUC = .91, p < .001$, CI from .83 to .99). The overall mean of the ANT had sensitivity of 73% and specificity of 88% at 590 msec (Figure 7). The different visual attention tests show considerable overlap of the confidence intervals indicating that each could potentially be used to distinguish between good and poor drivers.

The second research question involved identifying age differences between the visual attention tests, the driving performance, and the predictability of the visual attention tests for driving ability. Descriptives for younger adults on the visual attention tests were presented in Table 7, and for older adults in Table 8. Univariate analysis of variance (ANOVA) tests were conducted in order to determine if the younger adults differ from older adults in visual attention tests and driving evaluations (Tables 9 through 21). The dependent variable was one of the visual attention tests: Trail Making Test part A, the three subtests of the UFOV, the three levels of the ANT, visual search, and IOR. The ANOVA tests illustrate that there are significant age differences on the visual attention tests with the exception of the location IOR test, ($F(1,48) = 1.24, p = .271$).

Separate correlation coefficients were calculated for each age group between the visual attention tests. Using the Bonferroni method, the significance value was determined to be .003 (.05/13). The correlation table for the younger adults (Table 22) revealed a significant relationship between the orienting test of the ANT and the overall mean of the ANT, $r(30) = .53, p = .003$ and a significant negative relationship between UFOV subtest 2 and the visual search task with the target absent, $r(30) = -.59$, $p = .001$.

A strong relationship, although not significant, was found between the overall mean of the ANT and the UFOV subtest 2 $r(30) = .41, p = .024$. The older adult correlation table (Table 23) revealed significant correlations between the UFOV subtest 2 and the Trail Making Test Part A $r(20) = .64, p = .003$ and also with the ANT overall mean $r(20) = .64, p = .002$.

Examination of the correlations between visual attention tests and driving evaluations for each age group reveals that in younger adults (Table 24) the final driving score is positively correlated with UFOV subtest 2 ($r(30)= .47, p =.043$), the overall mean of the ANT ($r(30) = .45, p = .013$), and negative correlated with location IOR ($r(30) = -.39, p =.032$) and visual search when no target is present ($r(30) = -.38, p = .040$). Although the correlations did not meet significance using the Bonferroni method, ($p = (.05/14) = .003$), the strength of the correlations suggest a medium effect. In older adults, the sample size used in the correlations between visual attention tests and driving evaluation has dropped to nine subjects (Table 25). The UFOV subtest 1 remains significant ($r(9) =.68, p =.044$), however some other tests show strong relationships but are not significant, for example, the overall mean of the ANT showed a positive correlation of .618, $p = .076$.

Regressions analyses were run on the separate age groups using the final driving score as the dependent variable. Age was added in the first step then followed by the visual attention test as the next step. In the younger adults (Table 26), the final driving score was predicted by UFOV subtest 2 (Adjusted $R^2 = .187, F(1, 27) = 7.351, p = .012$), the overall mean of the ANT (Adjusted $R^2 = .218, F(1,27) = 8.699, p = .007$), and location IOR (Adjusted $R^2 = .136, p = .029$). The number of cases drops in the group of older adults (Table 27) and the regression reveals only one statistically significant predictor, the UFOV subtest 1 (Adjusted $R^2 = .585$, $F(1,6) = 10.446$, $p = .018$). The overall mean of the ANT (Adjusted $R^2 = .177$, $F(1,6) = 2.292$, $p = .181$) and object IOR (Adjusted $R^2 = .261$, $F(1,5) = .357$, $p = .125$) also showed a strong relationship with final driving score. For both age groups the overall mean of the ANT was a predictor of driving performance.

The final research goal was to test if a driving simulator is a valid measure of on-road driving performance. Correlations coefficients were computed between the different ratings of the driving simulator run and the on road evaluation (Table 28). Significance value p of less than .01 was determined using the Bonferroni method to reduce Type I errors ($p = .05 / 5 = .01$). Driving simulator evaluations and on-road driving assessments were available for only 9 participants and was found to be significant for those cases, $r(9) = .71$, $p = .031$. Although the correlation between the driving simulator evaluation and the on road driving evaluation is not significant the small sample size with the strong correlation coefficient indicates a strong relationship. This suggests that the driving simulator is a valid measure of driving performance.

Correlation coefficients were computed between the rating for simulator runs (3 different ratings), a computer-generated list of mistakes, and the on-road driving evaluation. To reduce Type I errors across the 10 correlations the p value of less than 0.01 was required for significance. The correlation for rater reliability was found to be significant, $r(37) = .83$, $p < 0.001$. The correlation between raters was found to be $r(39) = .79$, $p < 0.001$ and $r(37)=.60$, $p < 0.001$, indicating interrater reliability. The computer-generated mistakes was found to be highly correlated with the simulator ratings from both raters, $r(33)=.71$, $p<.001$ and $r(33) = .79$, $p < .001$.

Discussion

The primary research goal was to establish if the visual attention tests UFOV, IOR, ANT, and visual search can predict driving ability. Our results indicate variability in the predictive value of the different visual attention tests. No published studies to date have examined the ability for ANT to predict driving scores. The visual attention that most consistently predicted driving performance was the overall mean of the ANT; however, the components of the ANT were not predictive of driving performance. A positive correlation was found between the overall mean of the ANT and the final driving score. In addition, the sequential regression showed that after age (48%), the addition of the overall mean of the ANT increased the prediction of driving scores by 10%. This result was also found when examining the age groups separately; in younger adults the overall mean of the ANT could explain 22% of the variance in driving scores and in older adults 18%. The ROC curves showed that the overall mean of the ANT has high sensitivity and specificity for classifying drivers that passed the driving simulator run and those that failed. The overall mean of the ANT is a mean of the response times for all the conditions of the test. Although the alerting, orienting, and conflict resolution networks are anatomically separate there is interaction between the networks and it is possible that during driving all networks are being activated.

Although the various subtests of the UFOV were found to have a strong relationship with overall driving performance, the subtests were not the best at predicting overall driving scores. Strong relationships were indicated by the correlation coefficients with correlations between the subtests and driving simulator score ranging from .61 to .72. In the whole sample the regression model indicated that only a small proportion of the variance could be explained by UFOV Subtest 1 (5%) after age (48%). In older adults, the UFOV Subtest 1 explains 59% of the variance in driving scores but was did not significantly predict driving in younger adults. In younger adults, the UFOV Subtest 2 could explain 18% of the variance in driving scores. The ROC curves suggested the UFOV Subtest 2 had a high discriminating power for classify drivers as pass or fail on the driving simulator evaluation.

In opposition with our hypothesis the IOR test was not found to be a consistent predictor in driving performance. No significant correlations were found between both location IOR and object IOR and driving performance on the driving simulator. When evaluating the entire sample, age and the location IOR component explained 49% of the variance in the driving simulator score with most of the effect attributed to age (44%). Age differences were found in object IOR but not in location IOR, a result reported by McCrae and Adams (2001). Examination of the age groups separately indicated that location IOR could explain a small proportion of the variance in younger adults but had no effect in older adults. This finding is inconsistent with the recent study by Bédard and others (2006) who found location IOR accounted for 29% of the variability in driving scores. The conflicting results between the two studies could be explained by the small number of participants that completed the driving simulator evaluation. Also, the IOR paradigms were programmed on different computers, and although the same paradigm was used, a variation could influence the IOR effect being captured. Also, the studies differed in the driving evaluation method utilized.

The ability for the visual attention tests to predict driving ability was not robust in the younger adults. Significant correlations were not found between any of the visual attention tests and the driving simulator score for younger adults. The lack of significant correlations could result from the restriction of range in the younger adults. Strong relationships between the visual attention tests and driving scores in older adults were apparent despite the low sample size.

Overall processing speed may not explain the ability for the overall mean of the ANT to predict driving performance. UFOV Subtest 1 is a test of processing speed and although it is correlated with the final driving score, the regression model indicated that only a small proportion of the variance (5%) could be explained after age (48%). Regressions for older adults indicated that UFOV Subtest 1 could explain 59% of the variance in driving scores. In addition, some of the other tests used in this study, the Trail Making Test and visual search, that have large processing speed component showed no significant results. Part A of the Trail Making Test was correlated with the final driving score but did not have any predictability in regression analysis or discriminating ability in ROC curves. Thus, the more elaborate attention tests provide more information about the attention networks in order to predict driving ability.

As a preliminary study the results provide evidence to justify a larger scale study increasing the number of participants as well as the addition of participants that range in age from 30 to 60. The inclusion of adults in middle age allows the visual attention tests to be subjected to all members of the driving population as opposed to groups with a high crash risk. Also, it would be important to increase the sample size, a limitation to the present study. Another important group to incorporate would be ex-drivers varying in cognitive ability. Various attempts were made to recruit individuals from this group for this study but were unsuccessful.

The relationship between the driving simulator and the on road evaluation is important for validating the driving simulator as a measure of driving performance. The strong relationship between the on road evaluation and the driving simulator score is an indicator that the simulator can be used to assess driving performance in older adults. On the other hand, it is unclear to what extent error plays in the driving simulator scores. Older adults expressed difficulty adapting to the driving simulator which likely influenced their driving ability and significant differences were found between the driving simulator evaluations. Also, the score that determined a pass or fail on the driving simulator test was the median of the distribution. Unfortunately, using this score categorized all older adults as failing the driving simulator evaluation. One possible method to rectify this weakness would be to allow older adults more practice to assimilate to the driving simulator. In addition, evaluation of various components of the driving score could determine if older adults consistently perform poorly and remove that component from the final driving score.

Further research should investigate methods to predict which individuals are particularly susceptible to the effects of simulator adaptation syndrome. A limitation of the present study is a reduction in the sample size because eleven of the participants developed simulator adaptation syndrome. The symptoms of simulator adaptation syndrome include dizziness and nausea much like motion sickness. Furthermore, all of the participants that could not complete the driving evaluation were older adults. It is unclear if simulator adaptation syndrome is influenced by the age of the individual.

One method that may reduce simulator adaptation syndrome is the use of acupressure bands. The bands stimulator a pressure point on the wrist and are sold in pharmacies to reduce motion sickness.

Another area for further research would be if training on the visual attention measures could improve driving performance. Mazer and others (2001, 2003) found that UFOV training could improve scores in stroke patients while Roenker and colleagues (2003) found training could improve driving scores in older adults. The ANT was found to be a good predictor of driving ability at all ages and may also be influenced by training.

Conclusions

Using a variety of statistical techniques it can be concluded that performance on a driving simulator can be predicted by some visual attention tests; however, the influence of age is an important factor in performance. Visual attention tests could be used as a screening tool to distinguish drivers who require more investigation into driving health and abilities. The creation of a screening tool has implication for both personal and public health. Individuals experiencing driving difficulties could be assessed earlier and, with intervention, prolong driving cessation for their personal benefit and remain safe drivers for the benefit of public health. Previous research has shown that visual attention tests can predict driving performance and this study contributes by adding another visual attention test, the ANT, as a potential screening tool. A major strength of this study is the use of the ANT which, unlike other visual attention tests, has an anatomical framework. This preliminary study, limited in sample size and age groups, provides some support towards identifying the anatomical areas of the brain that influence driving behaviour. A weakness to this study is the lack of ex-drivers in the sample which would increase the range of driving scores. A major caveat to this study is the prevalence of simulator adaptation syndrome. Future research should focus on methods to reduce the incidence of simulator adaptation syndrome.

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Table 1.
Descriptive Statistics and t-tests for SF-12 Physical Component

	N	Minimum	Maximum	Mean	SD	*t* test	*p*
All	50	31.60	63.24	51.41	7.17	1.27	.209
Age 18 to 34	30	34.72	63.24	52.99	5.54	-0.33	.744
Age 65 to 74	9	33.48	61.28	50.97	8.14	2.69	.027*
Age 75 and older	11	31.60	56.61	47.45	9.21	3.16	.010*
Male	21	31.60	61.28	51.52	8.59	-0.16	.875
Female	29	34.72	63.24	51.33	6.10	1.96	.060

* Correlation is significant at the .05 level (two-tailed).

Table 2.
Descriptive Statistics and t-tests for SF-12 Mental Component

	N	Minimum	Maximum	Mean	SD	*t* test	*p*
All	50	32.48	62.86	52.42	6.39	2.64	.011*
Age 18 to 34	30	32.48	61.13	50.95	6.19	1.57	.127
Age 65 to 74	9	43.34	60.76	52.45	7.17	0.15	.888
Age 75 and older	11	46.28	62.86	56.40	4.88	4.31	.002*
Male	21	35.65	62.86	51.14	6.43	0.30	.767
Female	29	32.48	61.89	53.35	6.31	3.35	.002*

* Correlation is significant at the .05 level (two-tailed).

Table 3.
Descriptive statistics for cognitive visual attention and driving simulator evaluations

Variable	Minimum	Maximum	Mean	SD
Trail Making Test Part A	7.90	55.00	23.19	11.68
UFOV Subtest 1	0.017	0.070	0.022	0.013
UFOV Subtest 2	0.017	0.500	0.120	0.157
UFOV Subtest 3	0.023	.500	.225	0.182
ANT – Alerting	-49	69	26	28
ANT – Conflict resolution	-11	168	46	37
ANT – Orienting	12	310	145	65
ANT - mean RT	447	1065	635	147
ANT – accuracy	83	100	97	3
Ratio cued/uncued without placeholder (Location IOR ratio)	0.95	1.25	1.09	0.06
Ratio difference between two above (Object IOR ratio)	-0.22	0.30	0.07	0.12
Visual Search - No target	-200.01	1388.88	497.72	344.74
Visual Search - Target Present	47.09	1037.91	294.62	177.43
Final Driving Score	30	235	114	49

Table 4.
Intercorrelation between cognitive and visual attention tests

		UFOV			ANT					IOR		Visual Search	
	TMT Part A	Subtest 1	Subtest 2	Subtest 3	Alerting	Conflict resolution	Orienting	Overall Mean	Accuracy	Location	Object	No Target	Target Present
TMT Part A													
UFOV													
Subtest 1	.51*												
Subtest 2	.80*	.59*											
Subtest 3	.81*	.50*	.82*										
ANT													
Alerting	-.47*	-.37	-.55*	-.44*									
Conflict resolution	.47*	.31	.42*	.48	-.35								
Orienting	.35*	.38	.43*	.29	-.36	.22							
Overall Mean	.77*	.59*	.83*	.88	-.42*	.50*	.50*						
Accuracy	-.43*	-.63*	-.64*	-.35	.46*	-.41*	-.42*	-.39					
IOR													
Location	.08	.05	.07	.11	-.15	.12	-.12	.01	-.13				
Object	-.19	-.17	-.17	-.25	.19	.11	.07	-.23	-.11	-.29			
Visual Search													
No Target	.41*	.12	.37	.51*	-.26	.30*	.25	.50*	-.11	.09	-.15		
Target Present	.31*	.16	.39	.38	-.17	.19	.45*	.52*	-.15	-.08	-.03	.65*	

* Correlation is significant at the .003 level (two-tailed).

Table 5.
Correlations between cognitive and visual attention tests and driving simulator evaluation

	Driving Evaluation					
	Starting/stopping/ Backing	Signal /right of way/inattention	Moving in roadway	Passing/ Speeding	Turning	Total Score
TMT Part A	.61*	.57*	.37	.42	.11	.57*
UFOV						
Subtest 1	.52*	.53*	.34	.49*	.26	.61*
Subtest 2	.62*	.64*	.43	.54*	.19	.67*
Subtest 3	.55*	.52*	.47*	.66*	.21	.72*
ANT						
Alerting	-.34	-.29	-.31	-.02	-.01	-.23
Conflict resolution	.18	.22	.17	-.17	.03	.06
Orienting	.25	-.01	.27	.04	.12	.19
Overall Mean	.67*	.54*	.45	.64*	.34	.77*
Accuracy	-.08	-.14	-.06	-.04	.02	-.07
IOR						
Location	.03	-.10	-.21	-.27	-.04	-.22
Object	-.36	-.13	.07	-.19	-.28	-.25
Visual Search						
No Target	.34	.19	.24	.21	.19	.35
Target Present	.22	.38	.001	.20	.18	.26

* Correlation is significant at the .003 level (two-tailed).

Table 6.
Association between age, visual attention test, and total driving score

Variable*	R	Adj-R^2	*p* (model)	F-Change	*p*(F-change)	*b***	*p*(*b*)**
Age	.705	.484	.001			1.34	.001
TMTA	.708	.474	.000	0.289	.594	0.47	.594
Age	.705	.484	.001			1.11	.001
UFOV Subtest 1	.747	.534	.001	5.008	.032	2145.38	.032
Age	.705	.484	.001			0.99	.016
UFOV Subtest 2	.729	.505	.001	2.612	.115	115.59	.115
Age	.705	.484	.001			0.65	.284
UFOV Subtest 3	.726	.501	.001	2.311	.137	140.30	.137
Age	.705	.484	.001			1.45	.001
Alerting	.709	.475	.001	0.354	.556	-0.17	.556
Age	.705	.484	.001			1.48	.001
Conflict resolution	.706	.470	.001	0.040	.843	0.05	.843
Age	.705	.484	.001			1.46	.001
Orienting	.707	.473	.001	0.233	.632	0.06	.632
Age	.705	.484	.001			0.39	.353
ANT Overall Mean	.776	.581	.001	9.568	.004	0.23	.004
Age	.705	.484	.001			1.49	.001
ANT Accuracy	.705	.469	.001	0.001	.970	0.12	.970
Age	.676	.441	.001			1.46	.001
Location IOR	.720	.491	.001	4.532	.041	190.76	.041
Age	.676	.441	.001			1.42	.001
Object IOR	.676	.426	.001	0.015	.902	-6.78	.902
Age	.705	.484	.001			1.89	.001
Search No Target	.733	.511	.001	3.062	.089	-0.04	.089
Age	.705	.484	.001			1.60	.001
Search Target Present	.712	.479	.001	0.691	.411	-0.03	.411

* Each model had age entered at the first step followed by the visual attention test. The F-change statistics represent the change in the model after entering the visual attention test.
** Regression coefficients and p-values are based on the final model consisting of age and the visual attention test

Table 7.
Descriptive statistics for cognitive, visual attention, and driving evaluations for younger adults

Variable	Minimum	Maximum	Mean	SD
Trail Making Test Part A	7.90	26.80	15.92	4.40
UFOV Subtest 1	0.017	0.020	0.017	0.001
UFOV Subtest 2	0.017	0.233	0.029	0.045
UFOV Subtest 3	0.023	0.153	0.089	0.029
ANT - Alerting	-4	69	34	22
ANT - Conflict resolution	-10	73	33	21
ANT - Orienting	69	206	128	42
ANT - mean RT	447	649	536	53
ANT - accuracy	93	100	97	2
Ratio cued/uncued without placeholder (Location IOR ratio)	0.95	1.25	1.08	0.06
Ratio difference between two above (Object IOR ratio)	-0.13	0.30	0.09	0.11
Visual Search - No target	-200.01	663.10	354.29	182.56
Visual Search - Target Present	103.22	434.37	246.00	79.46
Final Driving Score	30	180	95	36

Table 8.
Descriptive statistics for cognitive, visual attention, and driving evaluations for older adults

Variable	Minimum	Maximum	Mean	SD
Trail Making Test Part A	15	55	34	11
UFOV Subtest 1	0.017	0.070	0.030	0.019
UFOV Subtest 2	0.030	0.500	0.258	0.166
UFOV Subtest 3	0.220	0.500	0.429	0.106
ANT - Alerting	-49	60	14	31
ANT - Conflict resolution	-11	168	67	46
ANT - Orienting	12	310	170	84
ANT - mean RT	600	1065	784	112
ANT - accuracy	83	100	96	5
Ratio cued/uncued without placeholder (Location IOR ratio)	0.99	1.24	1.104	0.06
Ratio difference between two above (Object IOR ratio)	-0.22	0.21	0.02	0.11
Visual Search - No target	135.86	1388.88	712.87	417.62
Visual Search - Target Present	47.09	1037.91	367.54	249.44
Final Driving Score	135	235	176	34

Table 9.
Analysis of Variance for Trail Making Test Part A

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	3964.70	3964.69	69.85	.001
Error	48	2724.43	56.76		
Total	49	6689.13			

Table 10.
Analysis of Variance for UFOV Subtest 1

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	0.002	0.002	14.191	.001
Error	48	0.007	0.000		
Total	49	0.009			

Table 11.
Analysis of Variance for UFOV Subtest 2

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	0.625	0.625	51.688	.001
Error	48	0.580	0.012		
Total	49	1.205			

Table 12.
Analysis of Variance for UFOV Subtest 3

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	1.386	1.386	281.07	.001
Error	48	0.237	0.005		
Total	49	1.623			

Table 13.
Analysis of Variance for ANT Alerting

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	4752.12	4752.12	38.79	.011
Error	48	32942.30	686.30		
Total	49	37694.42			

Table 14.
Analysis of Variance for ANT Orienting

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	20850.01	20850.01	5.36	.025
Error	48	186563.92	3886.75		
Total	49	207413.92			

Table 15.
Analysis of Variance for ANT Conflict resolution

Source	*df*	*SS*	*MS*	*F*	*P*
Age Group	1	13776.96	13776.96	12.41	.001
Error	48	53295.22	1110.32		
Total	49	67172.18			

Table 16.
Analysis of Variance for ANT Overall Mean

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	738643.32	738643.32	111.28	.001
Error	48	318601.40	6637.53		
Total	49	1057244.72			

Table 17.
Analysis of Variance for ANT Accuracy

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	46.41	46.41	4.08	.049
Error	48	546.47	11.385		
Total	49	592.89			

Table 18.
Analysis of Variance for Location IOR

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	0.005	0.005	1.240	.271
Error	48	0.183	.004		
Total	49	0.188			

Table 19.
Analysis of Variance for Object IOR

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	0.059	0.059	4.708	.035
Error	48	0.579	.013		
Total	49	.638			

Table 20.
Analysis of Variance for Visual Search Target Absent

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	1542974.06	1542974.06	17.30	0.001
Error	48	4280295.83	89172.83		
Total	49	5823269.89			

Table 21.
Analysis of Variance for Visual Search Target Present

Source	*df*	*SS*	*MS*	*F*	*p*
Age Group	1	177270.79	1777270.79	6.232	.016
Error	48	1365313.21	28444.03		
Total	49	1542584.00			

Table 22.
Intercorrelation between cognitive and visual attention tests in the group of younger adults

		UFOV			ANT					IOR		Visual Search	
	TMT Part A	Subtest 1	Subtest 2	Subtest 3	Alerting	Conflict resolution	Orienting	Overall Mean	Accuracy	Location	Object	No Target	Target Present
TMT Part A													
UFOV													
Subtest 1	.26												
Subtest 2	-.20	-.01											
Subtest 3	.21	.09	.29										
ANT													
Alerting	.20	.24	-.26	-.25									
Conflict resolution	-.24	-.05	.04	.03	.10								
Orienting	.12	-.21	.37	-.08	-.01	-.03							
Overall Mean	.05	.09	.41	.30	-.06	.32	.53*						
Accuracy	.19	-.03	-.03	.38	-.33	-.18	-.12	.37					
IOR													
Location	.01	-.08	.06	-.02	-.01	.03	-.25	-.41	-.09				
Object	.18	-.13	-.22	.11	.27	.18	-.04	.00	-.12	-.20			
Visual Search													
No Target	-.11	.09	-.59*	-.33	-.02	.22	-.34	-.31	-.06	.01	.02		
Target Present	.01	-.14	.11	.01	-.01	.29	.08	.10	.03	-.18	.09	.34	

*Correlation is significant at the .05 level (two-tailed).
** Correlation is significant at the .01 level (two-tailed).

Table 23.
Intercorrelation between cognitive and visual attention tests in the group of older adults

		UFOV			ANT					IOR		Visual Search	
	TMT Part A	Subtest 1	Subtest 2	Subtest 3	Alerting	Conflict resolution	Orienting	Overall Mean	Accuracy	Location	Object	No Target	Target Present
TMT Part A													
UFOV													
Subtest 1	.26												
Subtest 2	.64*	.43											
Subtest 3	.43	.19	.61*										
ANT													
Alerting	-.56	-.34	-.56*	-.36									
Conflict resolution	.34	.14	.17	.21	-.40								
Orienting	.20	.32	.30	.02	-.43	.12							
Overall Mean	.45	.46	.64*	.57	-.35	.21	.43						
Accuracy	-.46	-.63*	-.75*	-.33	.69*	-.45*	-.43	-.46					
IOR													
Location	-.14	-.05	-.14	-.22	-.21	.09	-.14	-.13	-.11				
Object	.02	-.02	.25	.14	-.10	.40	.40	.07	-.34	-.37			
Visual Search													
No Target	.06	-.20	.11	.18	-.14	.05	.25	.30	.06	.02	-.02		
Target Present	.09	.00	.23	.22	-.07	.00	.47	.54	-.08	-.16	.09	.65*	

*Correlation is significant at the .003 level (two-tailed).

Table 24.

Correlations between cognitive and visual attention tests and driving simulator evaluation in younger adults

	Driving Evaluation					
	Starting/stopping /Backing	Signal /right of way/inattention	Moving in roadway	Passing/Speeding	Turning	Total Score
TMT Part A	.04	.05	-.02	-.05	-.09	-.07
UFOV						
Subtest 1	-.13	.01	-.11	.30	.32	.22
Subtest 2	.27	.69	.39	.08	.31	.47
Subtest 3	.55	.36	.36	.10	.16	.30
ANT						
Alerting	-.12	-.25	-.21	.19	.08	-.05
Conflict resolution	-.33	.04	.07	-.20	.11	-.03
Orienting	-.07	.08	.34	-.04	-.01	.18
Overall Mean	.36	.26	.39	.32	.15	.45
Accuracy	.15	-.01	-.12	.05	-.09	-.06
IOR						
Location	.06	-.17	-.22	-.39	-.18	-.39
Object	-.07	.18	.27	.12	-.22	.09
Visual Search						
No Target	-.37	-.32	-.16	-.38	-.05	-.38
Target Present	-.39	.25	.09	.30	.07	-.10

* Correlation is significant at the .003 level (two-tailed).

Table 25.
Correlations between cognitive and visual attention tests and driving simulator evaluation in older adults

	Driving Evaluation					
	Starting/stopping /Backing	Signal /right of way/inattention	Moving in roadway	Passing/Speeding	Turning	Total Score
TMT Part A	.40	.88	.01	-.35	.13	.31
UFOV						
Subtest 1	.34	.63	.16	.34	.33	.68
Subtest 2	.20	.46	-.24	.03	-.02	.07
Subtest 3	-.31	.31	-.24	.45	.32	.24
ANT						
Alerting	-.16	-.20	-.39	-.01	-.18	-.40
Conflict resolution	.60	.57	.37	-.52	-.17	.22
Orienting	-.02	-.35	-.01	-.22	.31	-.02
Overall Mean	.46	.45	-.32	.20	.75	.62
Accuracy	-.04	-.22	.23	.09	.26	.23
IOR						
Location	.10	.04	-.32	-.28	.38	.01
Object	-.62	-.46	.14	-.51	-.37	-.68
Visual Search						
No Target	.05	.03	-.12	-.52	.39	-.02
Target Present	.05	.24	-.69	-.01	.22	-.14

* Correlation is significant at the .003 level (two-tailed).

Table 26

Association between age, visual attention test, and total driving score for younger adults

Variable*	R	Adj-R^2	*p*(model)	F-Change	*p* (F-change)	*b***	*p*(b)**
Age	.194	.003	.304			-4.09	.285
TMTA	.217	-.024	.522	0.272	.606	-0.80	.606
Age	.194	.003	.305			-3.14	.405
UFOV Subtest 1	.274	.006	.350	1.091	.306	6925.94	.306
Age	.194	.003	.305			-2.78	.411
UFOV Subtest 2	.493	.187	.023	7.351	.012	360.59	.012
Age	.194	.003	.305			-2.30	.546
UFOV Subtest 3	.319	.035	.235	1.927	.176	320.09	.176
Age	.194	.003	.000			-4.08	.287
Alerting	.211	-.026	.000	0.199	.659	-0.14	.659
Age	.194	.003	.305			-3.80	.318
Conflict resolution	.194	-.034	.595	0.007	.934	-0.03	.934
Age	.194	.003	.305			-5.11	.184
Orienting	.308	.028	.260	1.713	.202	0.21	.202
Age	.194	.003	.305			-5.37	.113
ANT Overall Mean	.522	.218	.014	8.699	.007	0.33	.007
Age	.194	.003	.305			-3.82	.337
ANT Accuracy	.194	-.004	.597	0.000	.997	-0.02	.997
Age	.194	.003	.305			-4.06	.244
Location IOR	.442	.136	.053	5.313	.029	-223.68	.029
Age	.194	.003	.305			-3.59	.363
Object IOR	.198	-.032	.583	0.047	.831	13.28	.831
Age	.194	.003	.305			-0.14	.443
Search No Target	.401	.099	.094	3.968	.057	-2.74	.057
Age	.194	.003	.305			-3.73	.324
Search Target Present	.215	-.024	.527	0.249	.622	-0.04	.622

* Each model had age entered at the first step followed by the visual attention test. The F-change statistics represent the change in the model after entering the visual attention test.

** Regression coefficients and p-values are based on the final model consisting of age and the visual attention test

Table 27.
Association between age, visual attention test, and total driving score in older adults

Variable*	R	Adj-R^2	P (model)	F-Change	*p*(F-change)	*b***	*p*(b)**
Age	.384	.025	.308			2.61	.323
TMTA	.491	-.012	.437	0.744	.422	0.90	.307
Age	.384	.025	.308			3.29	.081
UFOV Subtest 1	.830	.585	.030	10.446	.018	2108.16	.018
Age	.384	.025	.308			2.67	.338
UFOV Subtest 2	.397	-.124	.598	0.073	.796	24.33	.796
Age	.384	.025	.305			3.33	.227
UFOV Subtest 3	.525	.034	.541	1.064	.342	122.73	.342
Age	.384	.025	.308			2.33	.367
Alerting	.526	.035	.379	1.073	.340	-0.75	.340
Age	.384	.025	.308			2.54	.351
Conflict resolution	.433	-.083	.536	0.301	.603	.024	.603
Age	.384	.025	.308			3.39	.273
Orienting	.442	-.073	.521	0.361	.570	-0.13	.570
Age	.384	.025	.308			0.16	.956
ANT Overall Mean	.619	.177	.235	2.292	.181	0.17	.181
Age	.384	.025	.308			2.46	.371
ANT Accuracy	.423	-.095	.553	0.233	.646	.2.16	.646
Age	.339	-.033	.412			4.02	.319
Location IOR	.444	-.124	.578	0.512	.506	-212.24	.506
Age	.339	-.033	.412			0.91	.715
Object IOR	.687	.261	.202	3.387	.125	-214.15	.125
Age	.384	.025	.308			3.78	.244
Search No Target	.466	-.043	.479	0.539	.490	-0.03	.490
Age	.384	.025	.308			3.85	.200
Search Target Present	.520	.027	.388	1.016	.352	-0.05	.352

* Each model had age entered at the first step followed by entering the visual attention test. The F-change statistics represent the change in the model after entering the visual attention test.
** Regression coefficients and p-values are based on the final model consisting of age and the visual attention test

Table 28.
Intercorrelations between driving evaluations

	Initial Evaluation	Playback Rating 1	Playback Rating 2	Simulator Mistakes	On Road Evaluation
Initial Evaluation[a]					
Playback Rating 1[a]	.83*				
Playback Rating 2[a]	.79*	.87*			
Simulator Mistakes[a]	.71*	.74*	.79*		
On Road Evaluation[b]	.71	.61	.11	.21	

[a] Pairwise N = 38
[b] Pairwise N = 9
* Correlation is significant at the .01 level (two-tailed).

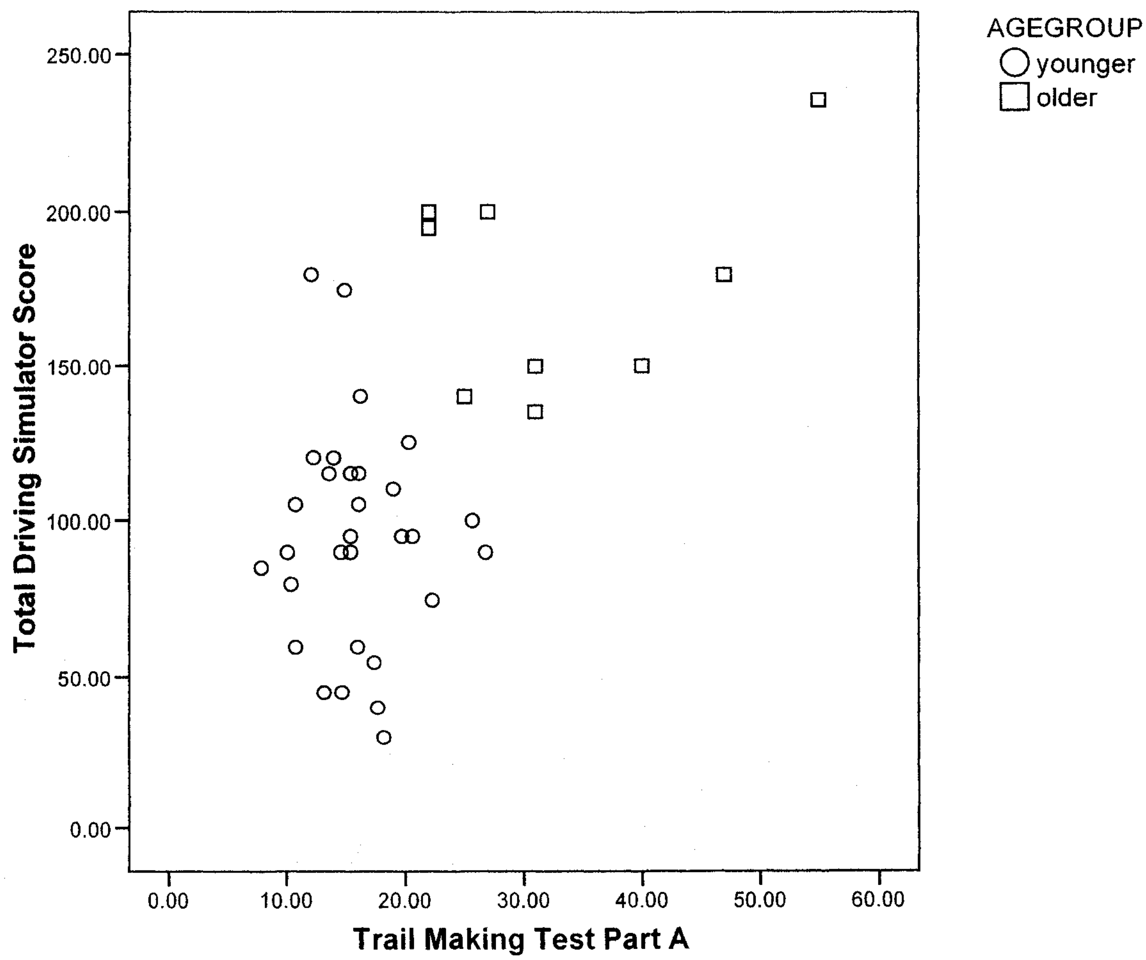

Figure 1. Score on the Trail Making Test Part A and the final driving score on the driving simulator (lower driving score is better).

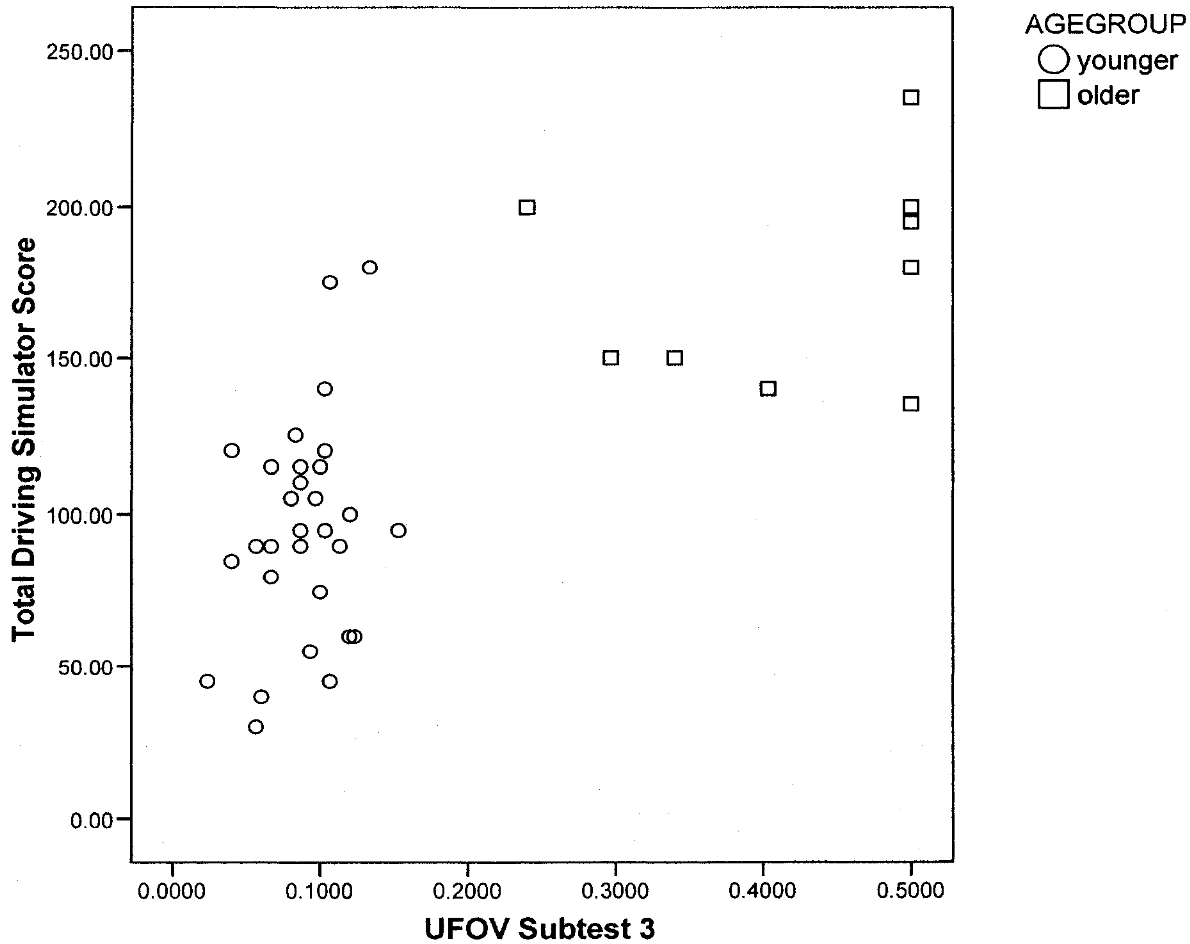

Figure 2. Response threshold of UFOV Subtest 3 and final driving score on the driving simulator (lower is better)

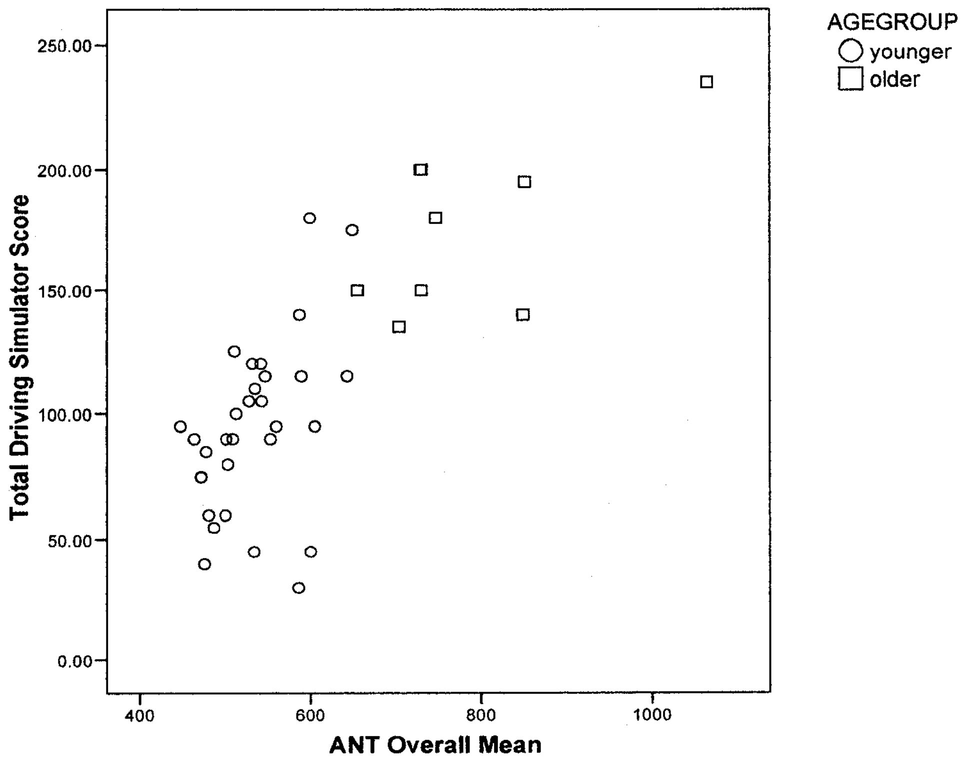

Figure 3. Overall mean of the ANT and the final driving score on the driving simulator (lower is better)

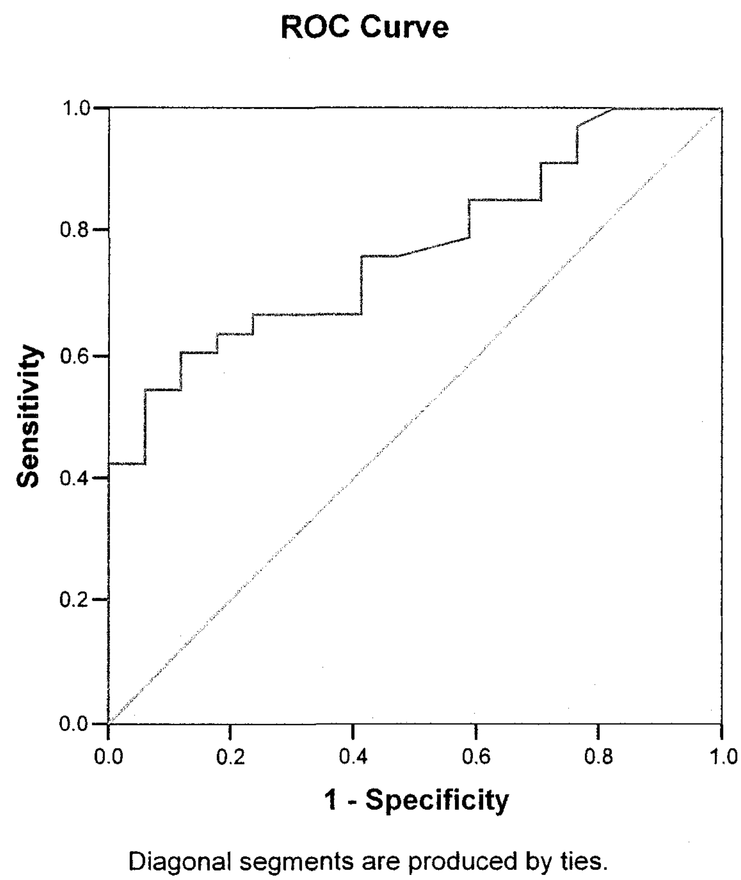

Figure 4. ROC Curve for Trail Making Test Part A.

Sensitivity and specificity table for various cutpoints. Established cutpoint is shaded.

Variable	Cut Point	Sensitivity	Specificity
	10.5	1.000	0.118
	15.5	0.788	0.412
Trails A (sec)	20.5	0.606	0.824
	25.5	0.485	0.941
	30.5	0.394	1.000

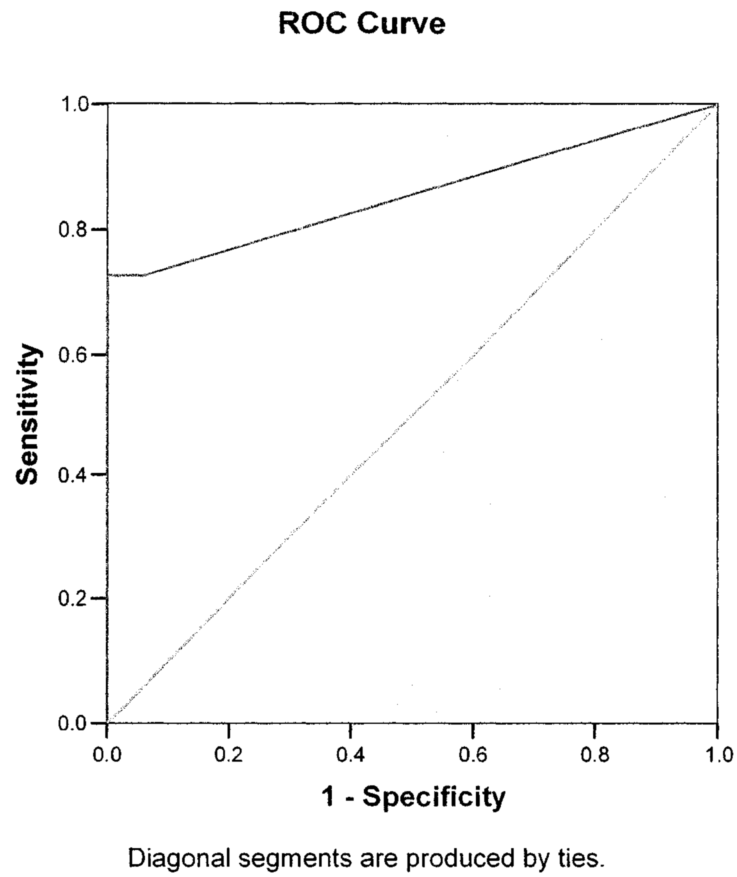

Figure 5. ROC Curve for UFOV Subtest 2

Sensitivity and specificity table for various cutpoints. Established cutpoint is shaded.

Variable	Cut Point	Sensitivity	Specificity
	0.000	1.000	0.000
UFOV Subtest 2 (msec)	0.184	0.727	0.941
	0.025	0.727	1.000

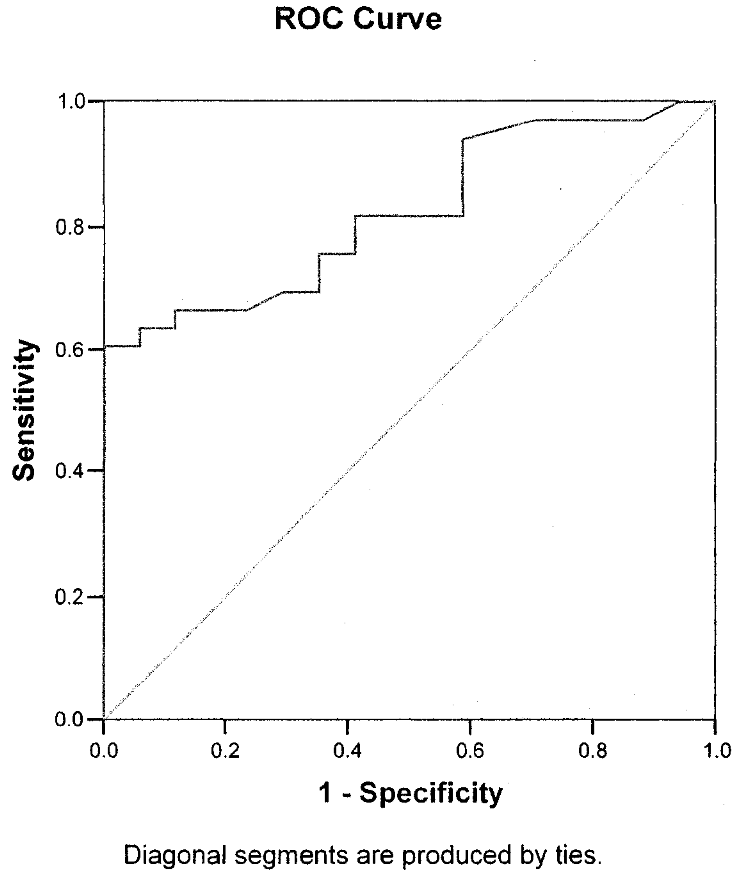

Figure 6. ROC Curve for UFOV Subtest 3

Sensitivity and specificity table for various cutpoints. Established cutpoint is shaded.

Variable	Cut Point	Sensitivity	Specificity
	.030	1.000	0.059
	.060	0.970	0.118
UFOV Subtest 3 (msec)	.090	0.818	0.520
	.120	0.667	0.882
	.150	0.606	0.941
	.180	0.606	1.000

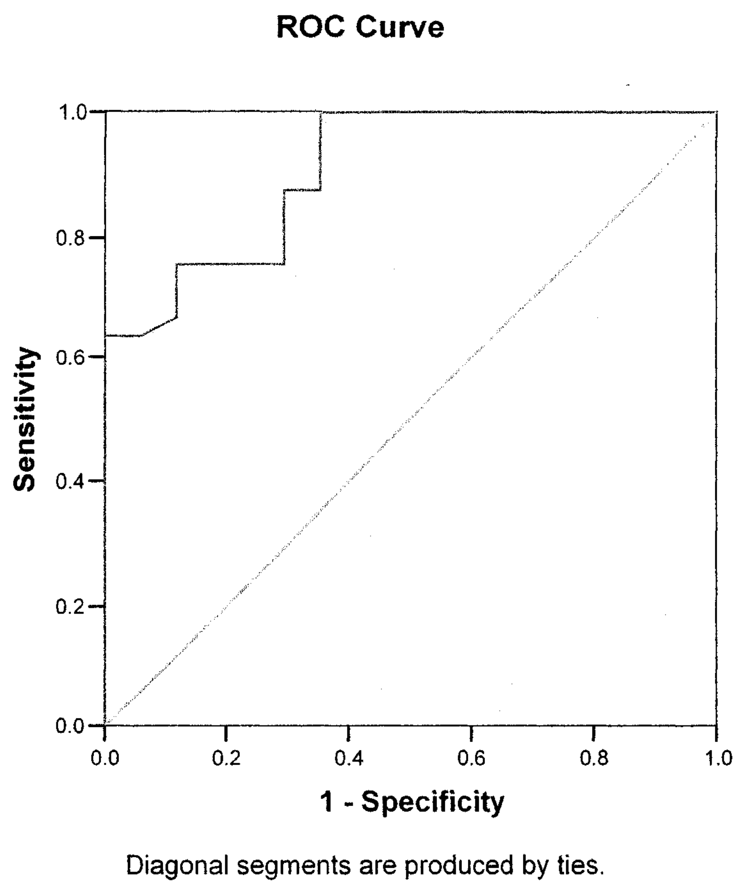

Figure 7. ROC Curve for ANT Overall Mean

Sensitivity and specificity table for various cutpoints. Established cutpoint is shaded.

Variable	Cut Point	Sensitivity	Specificity
	510	1.000	0.647
	530	0.939	0.647
ANT Overall (msec)	550	0.758	0.706
	570	0.758	0.824
	590	0.727	0.882
	610	0.636	1.000

Appendix A: Information Letters

Current drivers recruited from previous driver retraining study

INFORMATION LETTER

Predictive Value of Testing Visual Attention Mechanisms for
Safe Driving Ability in Older Adults

Dear Participant:

We are conducting research to examine the role of visual attention as a predictor of driving ability. As a participant, you will be required to: (1) provide consent to use information from a previous study, (2) complete some questionnaires, (3) use a driving simulator for a road test on a driving simulator, and (4) perform visual acuity, colour blindness, and visual attention tests.

Part 1 involves providing consent to use information obtained from a previous driver retraining study. The information from the previous study will be demographic information, driving history and patterns, medical history and current medication use, Trail Making Test, the cognition test Standardized Mini-Mental State Examination, and the information from the road test.

Part 2 includes the completion of the Short-Form-12 Health Survey SF-12. This portion will take place on the Lakehead University Campus in a private room and will take an estimated 5 minutes to complete.

Part 3 involves completing a road test on a driving simulator. The driving simulator is found in a room on Lakehead University campus. The driving simulator will take 10-15 minutes to complete.

Part 4 involves performing visual acuity and colour blindness test, and the attention tests: visual search, Useful Field of View Attention Analyzer, inhibition of return test, and negative priming test. The portion will take approximately 35 to 45 minutes.

The data collected will be kept strictly confidential. Your data will be coded by an assigned participant number to insure anonymity and confidentiality. The data will be stored at the Lakehead University Department of Psychology for a period of seven (7) years. You may obtain a summary of the findings from the researchers upon completion of the study.

Individuals will benefit from participation by receiving an evaluation of their driving ability at the completion of the study. There are no major physical or psychological risks associated with participation in the study. Some individuals may develop symptoms of motion sickness during the test. If the participant feels uncomfortable at any time, they are free to withdraw from the study at any time.

If you would require additional information please do not hesitate to contact one of us.

Sincerely,

Marie Parkkari. MSc Candidate
Dept. of Psychology, Lakehead University
Email: mjparkka@lakeheadu.ca

Michel Bédard, Ph.D.
Canada Research Chair in Aging & Health
(www.chairs.gc.ca)
Public Health Program, Lakehead University
Phone: (807) 343-8630
Email: michel.bedard@lakeheadu.ca

Bruce Weaver, M.Sc.
Public Health Program, Lakehead University
Phone: (807) 346-7704
Email: bruce.weaver@lakeheadu.ca

Former drivers, Older Adults

INFORMATION LETTER

Predictive Value of Testing Visual Attention Mechanisms for
Safe Driving Ability in Older Adults

Dear Participant:

We are conducting research to examine the role of visual attention as a predictor of driving ability. As a participant, you will be required to: (1) complete some questionnaires, (2) complete a road test on a driving simulator, and (3) perform visual acuity and attention tests.

Part 1 involves the completion of a several questionnaires for demographic information, driving patterns, information regarding current medical ailments and any prescribed medications, the Short Form-12 Health Survey, the Trail Making Tests A and B, and finally the cognition test, Standardized Mini-Mental State Examination. This portion will take place on the Lakehead University Campus in a private room and will take an estimated 10 to 15 minutes to complete.

Part 2 involves completing a road tests on a driving simulator. The driving simulator is found in a room on Lakehead University campus. The driving simulator will take 10 to 15 minutes to complete.

Part 3 involves performing visual acuity and visual search tests, and a colour blindness test. The visual attention tests to complete are: Useful Field of View Attention Analyzer, inhibition of return test, and negative priming test. The portion will take approximately 35 to 45 minutes.

The data collected will be kept strictly confidential. Your data will be coded by an assigned participant number to insure anonymity and confidentiality. The data will be stored at Lakehead University for a period of seven (7) years. You may obtain a summary of the findings from the researchers upon completion of the study.

Individuals will benefit from participation by receiving an evaluation of their driving ability at the completion of the study. There are no major physical or psychological risks associated with participation in the study. Some individuals may develop symptoms of motion sickness during the test. Participants are free to withdraw from the study at any time.

If you would require additional information please do not hesitate to contact one of us.

Sincerely,

Marie Parkkari. MSc Candidate
Dept. of Psychology, Lakehead University
Email: mjparkka@lakeheadu.ca

Michel Bédard, Ph.D.
Canada Research Chair in Aging & Health (www.chairs.gc.ca)
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Phone: (807) 343-8630
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Bruce Weaver, M.Sc.
Public Health Program, Lakehead University
Phone: (807) 346-7704
Email: bruce.weaver@lakeheadu.ca

Comparison group of Younger Drivers

INFORMATION LETTER

Predictive Value of Testing Visual Attention Mechanisms for Safe Driving Ability in Older Adults

Dear Participant:

We are conducting research to examine the role of visual attention as a predictor of driving ability. As a participant, you will be required to: (1) complete some questionnaires, (2) complete a road test on a driving simulator, and (3) perform visual acuity and attention tests.

Part 1 involves the completion of a several questionnaires for demographic information, driving patterns, information regarding current medical ailments and current prescriptions, the Short Form-12 Health Survey, and the Trail Making Test Parts A and B. This portion will take place on the Lakehead University Campus in a private room and will take an estimated 10 to 15 minutes to complete.

Part 2 involves completing a road test on a driving simulator. The driving simulator is found in a room on Lakehead University campus. The driving simulator will take 10-15 minutes to complete.

Part 3 involves performing visual acuity and visual search tests, and a colour blindness test. The visual attention tests to complete are: Useful Field of View Attention Analyzer, inhibition of return test, and negative priming test. The portion will take approximately 35 to 45 minutes.

The data collected will be kept strictly confidential. Your data will be coded by an assigned participant number to insure anonymity and confidentiality. The data will be stored at Lakehead University for a period of seven (7) years. You may obtain a summary of the findings from the researchers upon completion of the study.

Individuals will benefit from participation by receiving an evaluation of their driving ability at the completion of the study. There are no major physical or psychological risks associated with participation in the visual attention tests in the study. Some individuals may develop symptoms of motion sickness during the test. Participants are free to withdraw from the study at any time.

If you would require additional information please do not hesitate to contact one of us.

Sincerely,

Marie Parkkari, MSc Candidate
Dept. of Psychology, Lakehead University
Email: mjparkka@lakeheadu.ca

Michel Bédard, Ph.D.
Canada Research Chair in Aging & Health
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Bruce Weaver, M.Sc.
Public Health Program, Lakehead University
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Caregivers of Former Drivers

INFORMATION LETTER

Predictive Value of Testing Visual Attention Mechanisms for
Safe Driving Ability in Older Adults

Dear Participant:

We are conducting research to examine the role of visual attention as a predictor of driving ability. As a participant, you will be required to: (1) complete some questionnaires, (2) complete a road test on a driving simulator, and (3) perform visual acuity and attention tests.

Part 1 involves the completion of a several questionnaires for demographic information, driving patterns, information regarding current medical ailments and current prescriptions, the Short Form-12 Health Survey, and the Trail Making Test Parts A and B. This portion will take place on the Lakehead University Campus in a private room and will take an estimated 10 to 15 minutes to complete.

Part 2 involves completing a road test on a driving simulator. The driving simulator is found in a room on Lakehead University campus. The driving simulator will take 10-15 minutes to complete.

Part 3 involves performing visual acuity and the visual attention tests to complete are: visual search, Useful Field of View Attention Analyzer, inhibition of return test, and Attention Network Test. The portion will take approximately 35 to 45 minutes.

The data collected will be kept strictly confidential. Your data will be coded by an assigned participant number to insure anonymity and confidentiality. The data will be stored at Lakehead University for a period of seven (7) years. You may obtain a summary of the findings from the researchers upon completion of the study.

Individuals will benefit from participation by receiving an evaluation of their driving ability at the completion of the study. There are no major physical or psychological risks associated with participation in the visual attention tests in the study. Some individuals may develop symptoms of motion sickness during the test. Participants are free to withdraw from the study at any time.

If you would require additional information please do not hesitate to contact one of us.

Sincerely,

Marie Parkkari, MSc Candidate
Dept. of Psychology, Lakehead University
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Michel Bédard, PhD
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Public Health Program, Lakehead University
Director, Centre for Education and
Research on Aging and Health
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Phone: (807) 343-8630
Email: michel.bedard@lakeheadu.ca

Bruce Weaver, MSc
Public Health Program, Lakehead University
Phone: (807) 346-7704
Email: bruce.weaver@lakeheadu.ca

Appendix B: Consent Forms

Current drivers recruited from previous driver retraining study

To be on letterhead

CONSENT FORM

My signature on this form indicates that I agree to participate in the Research Program on Visual Attention and Driving.

I understand that my participation in this study is conditional on the following:

1. I have read the cover letter and have had the study explained to me.
2. I fully understand what I will be required to do as a participant in the study.
3. I am a volunteer participant and may withdraw from the study at any time without any reprisal.
4. There are no major physical or psychological risks associated with participation in this study.
5. My data will be confidential and stored at Lakehead University for a period of seven (7) years.
6. I will receive a summary of the project, upon request, following the completion of the project.

I consent that information on demographics, driving patterns, medical history, Trail Making Test, Standardized Mini-Mental State Examination, and information from the on-road test from a previous study may be used in this present study.

____

Signature of Participant Date

____

Signature of Witness Date

I agree to participate in the Driving and Visual Attention Project.

____

Signature of Participant Date

I wish to obtain a summary of the findings	Yes	No
I wish to obtain a driving simulator evaluation	Yes	No

Address:

____

____

____

Former drivers, Older Adults

To be on letterhead

CONSENT FORM

My signature on this form indicates that I agree to participate in the Research Program on Visual Attention and Driving.

I understand that my participation in this study is conditional on the following:

1. I have read the cover letter and have had the study explained to me.

2. I fully understand what I will be required to do as a participant in the study.

3. I am a volunteer participant and may withdraw from the study at any time without any reprisal.

4. There are no major physical or psychological risks associated with participation in this study.

5. My data will be confidential and stored in the Lakehead University Department of Psychology for a period of seven (7) years.

6. I will receive a summary of the project, upon request, following the completion of the project.

I agree to participate in the Driving and Visual Attention Project.

Signature of Participant Date

Signature of Guardian Date

I agree to allow my primary care physician to confirm my medical history and medication use.

____

Signature of Participant Date

____

Signature of Guardian Date

____

Signature of Witness Date

I wish to obtain a summary of the findings Yes No

I wish to obtain a driving simulator evaluation Yes No

Address:

____

____

____

Comparison group of Younger Drivers

To be on letterhead

CONSENT FORM

My signature on this form indicates that I agree to participate in the Research Program on Visual Attention and Driving.

I understand that my participation in this study is conditional on the following:

1. I have read the cover letter and have had the study explained to me.
2. I fully understand what I will be required to do as a participant in the study.
3. I am between the ages 18 and 30.
4. I am a volunteer participant and may withdraw from the study at any time without any reprisal.
5. There are no major physical or psychological risks associated with participation in this study.
6. My data will be confidential and stored at Lakehead University for a period of seven (7) years.
7. I will receive a summary of the project, upon request, following the completion of the project.

I agree to participate in the Driving and Visual Attention Project.

____

Signature of Participant Date

I wish to obtain a summary of the findings Yes No

I wish to obtain a driving simulator evaluation Yes No

Address:

____

____

____

Caregivers of Former Drivers

CONSENT FORM

My signature on this form indicates that I agree to participate in the Research Program on Visual Attention and Driving.

I understand that my participation in this study is conditional on the following:

8. I have read the cover letter and have had the study explained to me.
9. I fully understand what I will be required to do as a participant in the study.
10. I am a volunteer participant and may withdraw from the study at any time without any reprisal.
11. There are no major physical or psychological risks associated with participation in this study.
12. My data will be confidential and stored at Lakehead University for a period of seven (7) years.
13. I will receive a summary of the project, upon request, following the completion of the project.

I agree to participate in the Driving and Visual Attention Project.

Signature of Participant Date

I wish to obtain a summary of the findings Yes No

I wish to obtain a driving simulator evaluation Yes No

Address:

Appendix C: Short Form 12 Health Survey

SF-12 Health Survey (Acute)

INSTRUCTIONS: This questionnaire asks for your views about your health. This information will keep track of how you feel and how well you are able to do your usual activities.

Please answer every question by marking one box. If you are unsure about how to answer, please give the best answer you can.

1. In general, would you say your health is:

☐	☐	☐	☐	☐
Excellent	**Very Good**	**Good**	**Fair**	**Poor**

The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

	Yes, Limited A Lot	**Yes, Limited A Little**	**No, Not Limited At All**
2. **Moderate activities** such as moving a table, pushing a vacuum cleaner, bowling, or playing golf?	☐	☐	☐
3. Climbing **several** flights of stairs	☐	☐	☐

During the past week, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

	Yes	**No**
4. **Accomplished less** than you would like	☐	☐
5. Were limited in the **kind** of work or other activities	☐	☐

During the past week, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

	Yes	No
6. **Accomplished less** than you would like	☐	☐
7. Didn't do work or other activities as **carefully** as usual	☐	☐

8. During the past week, how much did pain interfere with your normal work (including both work outside the home and housework)?

☐	☐	☐	☐	☐
Not at all	**A little bit**	**Moderately**	**Quite a bit**	**Extremely**

These questions are about how you feel and how things have been with you during the past week. For each question, please give the one answer that comes closet to the way you have been feeling. How much of the time in the past week –

	All of the Time	**Most of the Time**	**A Good bit of the Time**	**Some of the Time**	**A Little of the Time**	**None of the Time**
9. Have you felt calm and peaceful?	☐	☐	☐	☐	☐	☐
10. Did you have a lot of energy?	☐	☐	☐	☐	☐	☐
11. Have you felt downhearted and blue?	☐	☐	☐	☐	☐	☐

12. During the past week, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

☐	☐	☐	☐	☐
All of the time	**Most the time**	**Some the time**	**A little of the time**	**None of the time**

Appendix D: Demographic Information

For this study we need to know some information about you. All responses are completely confidential.

1) Date of completion of Questionnaire. __ __/__ __/__ __ __ __
MM DD YYYY

The Predictive Value 98

Appendix D: Demographic Information

For this study we need to know some information about you. All responses are completely confidential.

1) Date of completion of Questionnaire. __ __/__ __/__ __ __ __
MM DD YYYY

2) Gender: Check only one ☐ Male ☐ Female

3) Date of Birth: __ __/__ __/__ __ __ __
MM DD YYYY

4) Marital Status: Check only one

☐ Married/Cohabitating

☐ Single

☐ Widowed

☐ Separated

☐ Divorced

5a) Please indicate *each* education level that you have completed:

	Yes	No
Elementary	☐	☐
Secondary	☐	☐
College	☐	☐
University	☐	☐

5b) Please indicate your total years of education: __ __

6) Please indicate your total household pre-tax income: Check only one:

☐ 0 - $10,999

☐ $11,000 – $20,999

☐ $21,000 - $30,999

☐ $31,000 - $40,999

☐ $41,000 - $50,999

☐ $51,000 - $60,999

☐ $61,000 - $70,999

☐ $71,000 – $80,999

☐ $81,000 – $90,999

☐ ≥ $ 100,000

7) Indicate your principle place of residence. Check only one:

☐ House

☐ Apartment

☐ Senior Citizens Home

☐ Retirement Community

☐ Assisted Living Facility

Appendix E: Driving History and Patterns

1) Do you live alone: ☐ Yes ☐ No

IF NO, please indicate the people that live in your household and if they hold drivers licenses.

	Live With		Drivers License	
	Yes	No	Yes	No
Spouse	☐	☐	☐	☐
Daughter	☐	☐	☐	☐
Son	☐	☐	☐	☐
Another Relative	☐	☐	☐	☐
Friend	☐	☐	☐	☐
Other	☐	☐	☐	☐

If other, Please Specify:

____

____

2) Please indicate, as best as possible, Check only one:

☐ Area away from a major center - population less than 10,000

☐ Small urban centre - population more than 10,000 but less than 50,000

☐ Mid-urban centre - population between 50,000 and 100,000

☐ Large urban centre - population more than 100,000

3) Compared to other drivers in your age group, how would you rate your driving abilities: Check only one.

☐ A lot better

☐ Better

☐ The same

☐ Worse

☐ Much Worse

4) Please indicate how many years you have been driving: __ __

5) Currently how often would you say you drive. Check only one.

☐ Daily/Almost daily

☐ 2-3 times a week

☐ Once a week or less

☐ Never

5) Approximately, how many kilometers (miles) do you drive per week. Check only one.

☐ 0-35 (0-56)

☐ 36-70 (57.6-112)

☐ 71-100 (113.6 – 160)

☐ 101-150 (161.6 240)

☐ 151-199 (241.6 – 318.4)

☐ over 200 (over 320)

6) Would you say you are driving… Check only one:

☐ Much more than you would like

☐ More than you would like

☐ About as much as you would like

☐ Less than you would like

☐ A lot less than you would like

7) Which driving situation(s) do you find stressful, uncomfortable, or avoid when possible. Check all that apply.

☐ Turning left at intersections

☐ Driving at night

☐ Maintaining the speed limit

☐ Driving in unfamiliar situations

☐ Driving with passengers in cars

☐ Navigating parking lots

☐ Changing lanes/merging

☐ Parallel parking

☐ Driving in heavy traffic

☐ Backing up

☐ In bad weather

☐ None of these

☐Other : ____________________

Appendix F: Health Questionnaire

The following are health problems that people often have. A physician may have diagnosed some of these health problems or you may have been hospitalized for these problems. For each problem, please state whether you have HAD THE HEALTH PROBLEM IN THE PAST YEAR. You can circle YES or NO. If the problem started a long time ago but SYMPOMS LAST INTO THE PAST YEAR, CHOOSE YES.

	Yes	**No**
1) High blood pressure (whether controlled by medication or not)	☐	☐
2) Heart and circulation problems (hardened arteries, heart problems)	☐	☐
3) Stroke or effects of stroke	☐	☐
4) Arthritis or rheumatism	☐	☐
5) Parkinson's disease or other neurological disease (except stroke)	☐	☐
6) Eye trouble not relieved by glasses (glaucoma, cataracts)	☐	☐
7) Ear trouble (hearing loss)	☐	☐
8) Dental problems	☐	☐
9) Chest problems (asthma, pneumonia, emphysema, bronchitis)	☐	☐
10) Stomach problems	☐	☐
11) Bladder control problems	☐	☐
12) Bowel control problems	☐	☐
13) Trouble with feet or ankles	☐	☐
14) Skin problems	☐	☐

	Yes	No
15) Fractures (broken bones)	☐	☐
16) Diabetes or high blood sugar	☐	☐
17) Seizures or epilepsy	☐	☐
18) Sleep apnea or sleeping sickness	☐	☐
19) Narcolepsy	☐	☐
20) Dementia (Alzheimer's disease)	☐	☐
21) Physical frailty (reduced flexibility or reduced muscle strength)	☐	☐
22) Syncope	☐	☐

Other… Specify ______________________________

28) Please list all your current medication; write the specific name(s) as printed on the label(s):

1) ______________________________

2) ______________________________

3) ______________________________

4) ______________________________

5) ______________________________

6) ______________________________

7) ______________________________

8) ______________________________

9) ______________________________

10 ______________________________

Appendix G: Driving Simulator Evaluation

I. STARTING

	Deduct	Deduction
A. Fails to check traffic	5	☐☐☐☐☐
B. Fails to signal	5	☐☐☐☐☐
C. Fast or uneven get-away	5	☐☐☐☐☐
D. Rolls when on grade	5	☐☐☐☐☐
E. Starts before light green	5	☐☐☐☐☐

II. STOPPING

	Deduct	Deduction
A. Stops for no reason	5	☐☐☐☐☐
B. Stops too suddenly	5	☐☐☐☐☐
C. Over-running crosswalk	5	☐☐☐☐☐
D. Not at safe place	5	☐☐☐☐☐
E. Leaves when not safe	5	☐☐☐☐☐

III. SIGNAL VIOLATIONS

	Deduct	Deduction
A. Thru on red	5	☐☐☐☐☐
B. Thru on red (enters amber)	5	☐☐☐☐☐
C. Thru on red (right turn)	5	☐☐☐☐☐
-- Stop Sign --		
D. Does not stop	5	☐☐☐☐☐
E. Leave when not safe	5	☐☐☐☐☐

IV. VEHICLES MOVING ON ROADWAY

	Deduct	Deduction
A. Straddles traffic lane	5	☐☐☐☐☐
B. Follows too closely	5	☐☐☐☐☐
C. Fails to check changing lanes	5	☐☐☐☐☐
D. Fails to signal	5	☐☐☐☐☐
E. Cuts off vehicle	10	☐☐☐☐☐
F. Drives wrong side of street	5	☐☐☐☐☐
G. Wanders	5	☐☐☐☐☐
H. Crosses solid line	5	☐☐☐☐☐
I. Uncertain gear shifting	5	☐☐☐☐☐
J. Fails to drive in proper lanes	5	☐☐☐☐☐

V. PASSING

	Deduct	Deduction
A. Too close to pedestrians or vehicles	5	☐☐☐☐☐
B. Passes when unlawful Or unsafe	10	☐☐☐☐☐
C. Speeds up when being passed	10	☐☐☐☐☐

VI. UNCONTROLLED INTERSECTIONS/RAILWAY CROSSINGS/YIELD SIGNS/PEDESTRIAN CORRIDORS OR CROSSWALKS

	Deduct	Deduction
A. Fails to slow down or check	5	☐☐☐☐☐
B. Fails to yield	10	☐☐☐☐☐

VII.SPEED

	Deduct	Deduction
A. Exceeds stated speed limit	10	☐☐☐☐☐
B. Too fast for conditions	5	☐☐☐☐☐
C. Slows unnecessarily before or after lane change	5	☐☐☐☐☐
D. Slows thru intersection	5	☐☐☐☐☐
E. Hinder or drives too slowly	5	☐☐☐☐☐
F. Drives at uneven speed	5	☐☐☐☐☐

VIII.TURNING

	Left		Right
A. Improper signal	☐☐☐☐☐	5	☐☐☐☐☐
B. Improper approach.	☐☐☐☐☐	5	☐☐☐☐☐
C. Improper during	☐☐☐☐☐	5	☐☐☐☐☐
D. Improper after	☐☐☐☐☐	5	☐☐☐☐☐
E. Improper speed	☐☐☐☐☐	5	☐☐☐☐☐
F. Shies away	☐☐☐☐☐	5	☐☐☐☐☐
G. Strikes/over curbs	☐☐☐☐☐	5	☐☐☐☐☐
H. Fails to yield	☐☐☐☐☐	10	☐☐☐☐☐
I. Fails to establish	☐☐☐☐☐	5	☐☐☐☐☐
J. Fails to clean intersection	☐☐☐☐☐	5	☐☐☐☐☐

IX. INATTENTIVE

	Deduct	Deduction
A. Leaves signal on	5	☐☐☐☐☐
B. Signals through intersection	5	☐☐☐☐☐
C. Hesitant	5	☐☐☐☐☐
D. Fails to yield emergency vehicle	5	☐☐☐☐☐

PARTICIPANT #: _________ DATE: __________

ROAD TEST RESULTS:

☐PASS ☐ FAIL

GRAND TOTAL ____