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The Useful Field of View, Driving, and Dementia

by

Petrina Hough ©

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Abstract

Good attentional functioning is considered to be essential for safe driving (Parasuraman & Nestor, 1993; Shinar & Schieber, 1991). A number of studies have investigated the impact of deficits in attention in older adults on their ability to drive. Of particular interest, is research including the Useful Field of View (UFV) paradigm (Ball, 1997). This task integrates multiple aspects of attentional functioning that are important for safe driving. Poor performance on this task has been reliably correlated with crash rates. In this study, the performance of dementia patients, older adults, and young adults on the UFV task was investigated. An in-car field version of this task was created to examine the UFV in a "real-world" setting. The relationship of the unique field version of the UFV to the laboratory version was established. Significant age effects were found for performance in both measures, however, there was an even greater effect of pathology, with the dementia group performing significantly poorer than the other two groups. Performance for all three groups on both the laboratory version of the UFV and the field version, were compared to driver performance ratings from an on-road driving evaluation to assess the power of the UFV tasks to predict actual driving competence.

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The Useful Field of View, Driving, and Dementia

Driving has been considered a primarily visual task. Visual sources account for up to 95% of the information used in driving (Kline et al, 1992; Shinar and Schieber, 1991). Given the highly visual nature of driving, good eyesight is generally considered essential for safe driving (Shinar and Schieber, 1991). This is reflected in the licensing process in which standard levels of visual acuity are required to obtain, and keep, a driver's license. According to Shinar and Schieber (1991), visual skills important for driving can be affected by diseases of the eye or age-related degeneration. The high incidence of such visual deficits in older adults has led to concerns about the driving competence of this group.

Impairments in the vision of older adults are seen in visual tasks such as dynamic visual acuity, detection of lateral motion, and depth perception (Shinar and Schieber, 1991). A large scale study conducted by Johnson and Keltner (1986), demonstrated that severe binocular field loss in older adults led to a crash rate double that of those with normal visual fields. However, in general, only low correlations have been found between deficits in these visual processes and crash rates (e.g. Hills and Burg, 1977; Keltner and Johnson, 1987). In fact, Ball and Rebok (1994) state, that with the exception of Johnson and Keltner's (1986) study, correlations between basic vision and driving performance are too low to be useful in identifying at-risk drivers. They suggest that eye health and visual sensory function are not directly related to the incidence of crashes, and current visual screening techniques, that only examine static acuity and peripheral vision, are not adequate for identifying older adults likely to have problems with driving.

Carr et al (1991) have suggested a number of criteria that may be useful in determining the capability of an older driver. Certain physical impairments, breakdowns in performing "automatic" activities such as dressing and cooking, use of drugs or medication that affect cognitive or motor skills, and severe cognitive deficits, were all cited by Carr as potential indicators of driving difficulties. In some cases, licensing decisions are simply based on chronological age or a diagnosis of dementia. However, such criteria are not accurate in predicting an older adult's fitness to drive (Ball, 1991; Ball and Rebok, 1994; Brouwer and Ponds, 1994). In response to this, Ball and Rebok (1994) recommend that decisions regarding older adults' fitness to drive should be based on an "objective" measure of driving performance (p. 33).

Performance measures, therefore, should reflect the nature of the driving experience (Brouwer and Ponds, 1994). Shinar and Schieber (1991) found that the most frequent causes of automobile crashes are "attentional or higher order perceptual failings such as improper lookout (eg. observational errors), misjudgement, and distraction" (p. 507). This is particularly true for older adults. Drivers over sixty years of age are most frequently involved in crashes at intersections and when making left turns where the demands on attention are high. Failure to "see" signs and other vehicles, or failure to judge distance and speed correctly when making turns, are the most commonly cited causes of crashes for older adults (Brouwer et al, 1991; Kline, 1986). Ball and Rebok (1994) have suggested that this type of crash is not a result of poor vision, but an "inability to attend to visual information" (p. 22).

A number of studies have identified well-functioning attentional processes as essential to safe driving (e.g. Parasuraman and Nestor, 1993; Crook et al, 1993; Brouwer and Ponds, 1994; Brouwer et al, 1991; Ball, 1991; Ball and Rebok, 1994). According to Parasuraman and Nestor (1993), driving requires three types of attention; sustained, selective, and divided attention. Sustained attention is the ability to maintain an alert state for a prolonged period of time. Vigilance tasks are generally used to measure sustained attention. In studies of sustained attention, age differences have not been consistently found. In research that has produced age differences, Giambra and Quilter (1988) have suggested that age differences in sustained attention tasks with a memory demand may be due to deficits in memory, not attention. Overall, there do not appear to be great impairments in the ability to sustain attention in healthy older adults, however, sustained attention has been demonstrated to decline in persons with dementia. McDowd and Birren (1990) have noted the importance of this type of attention for driving. In spite of this, there are few studies that have directly studied sustained attention and driving in healthy adults, and none with dementia patients (Parasuraman & Nestor, 1993).

Selective attention requires active attentional control to discriminate between relevant and irrelevant stimuli (Brouwer and Ponds, 1994). McDowd and Birren (1990) stated that the ability to selectively attend to stimuli, or filter information, is the "most basic function" of attention (p. 226). Ignoring irrelevant information is necessary to enable processing of information relevant to a particular goal (Simone & Baylis, 1997). A prominent theory of selective attention is the inhibition hypothesis, which states that the selection of one stimulus requires the inhibition of another stimulus. This theory suggests that with increasing age, inhibitory functioning is impaired, and a subsequent increase in intrusions of irrelevant and distracting information occurs. Older adults are therefore less effective at attentional filtering (Hasher & Zacks, 1988). Negative priming experiments have been conducted to test the inhibition hypothesis (e.g. Hasher & Zacks, 1988; Tipper, 1991; McDowd & Oseas-Kreger, 1991; Kramer, Humphrey, Larish, Logan, & Strayer, 1994; Tipper & Cranston, 1985). To complete a negative priming task, a subject must overcome an inhibitory mechanism to access previously ignored stimuli. Older adults are expected to show less negative priming than young adults, as they do not have to overcome an inhibitory mechanism. This theory is supported by a number of studies that demonstrated significantly reduced negative priming in older adults as compared to young adults (Tipper, 1991; McDowd & Oseas-Kreger, 1991; Hasher, Stoltzfus, Zacks, & Rypma, 1991; Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994).

Other tasks, such as visual search, are commonly used to examine the selective attention abilities of older adults. A typical visual search task requires the subject to locate a target within a field of distracting stimuli. The quantity and characteristics of the distracting stimuli are usually varied. A number of studies have demonstrated significant age differences in the ability to perform visual searches (e.g. Plude & Hoyer, 1985; Kosnik, Winslow, Kline, Rasinki, & Sekuler, 1988; Nebes & Madden, 1983). Tasks that require this type of attention appear to be particularly difficult for older adults. Age differences in performance increase with the difficulty and complexity of the task (Crook et al, 1993).

The third type of attention identified by Parasuraman and Nestor (1993) is divided attention. Divided attention, or dual-task performance, requires the coordination and performance of several tasks together. Driving is a real-world example of divided attention as it requires the performance of multiple tasks simultaneously. A driver must operate his or her vehicle, search for traffic signs, monitor other cars and traffic, and navigate in unfamiliar environments. Performance on divided attention tasks has been shown to decline with age, particularly with complex tasks (e.g. Camicoli, Howieson, Lehman, & Kaye, 1997; Guttentag, 1988; Jennings & Jacoby, 1993). Ponds, Brouwer, and van Wolffelar (1988) suggested that many tasks used to examine dual-task performance did not reflect the dynamic nature of divided attention in everyday life. To more accurately reflect the "real life" requirements of divided attention, Ponds et al. used two continuous performance tasks. The first task was a "compensatory tracking task" (Ponds et al., 1988, p. 152). This task simulated driving a car. The nose of the "car" appeared on a computer screen and the subject's task was to keep the car on a straight course by turning a "steering wheel". The second task was a "self-paced visual choice-reaction time task" called the dot-counting task (Ponds et al., 1988, p. 152). Subjects were required to count the number of dots appearing in a section of the computer screen. If there were nine dots, subjects were required to press a "yes" button, if there not nine dots, subjects were to press a "no" button. Even though age differences in single task performance were accounted for, older adults still performed significantly more poorly than young adults in the dual-task condition. The poorer performance of older adults was a result of a decline in the tracking task in the dual-task condition. Performance in the dot counting task did not decline as significantly. Ponds et al. (1988) concluded that "aging impairs the ability to divide attention". They proposed that performing two tasks simultaneously requires a third "supervisory" task. The supervisory task is to coordinate the performance of the two individual tasks in the dual-task assignment. Older adults may be less efficient in this capacity, thus producing the divided attention deficits.

Brouwer, Waternik, and Wolffelaar, and Rothengatter (1991) replicated Ponds et al.'s (1988) study. The compensatory tracking task remained the same, but responses in the dot counting task could now be given verbally as well as by pressing a response button manually. Brouwer et al. found that older adults performed better in the dual-task condition if they were able to respond verbally for the dot counting task. This reflects a point raised by Ponds et al. (1988) that multiple motor responses, such as steering and pressing a button, may contribute to the age differences found in their dual-task paradigm. Brouwer et al. (1991) state that "difficulty integrating responses" may be responsible for older adults' decline in dual-task performance (p. 573). The improved performance of older adults in a condition where competing motor responses are absent, provides evidence for this point.

Crook, West, and Larrabee (1993) used a different kind of driving simulation task to test divided attention ability. They argued that a task should reflect skills necessary for successful everyday living. Dividing attention between a number of activities is common in everyday life, and Crook et al. (1993) state that driving is a good example of a real life dual-task. Subjects in this study were required to monitor a computer screen which displayed a set of traffic lights and brake and accelerator pedals. When the traffic lights were green, subjects were to press on the "accelerator pedal". When the lights changed to red, they were to switch and press on the "brake pedal". The time it took subjects to switch back and forth from one pedal to the other, was recorded. In the dual-task condition, subjects were also required to monitor auditory input simulating a weather and traffic report. Subjects were asked to remember as much as possible from these reports for a later recall test. Age differences were present in the single task condition, and were amplified in the dual-task condition. Reaction times were significantly lower for older adults, and they recalled significantly less information from the weather and traffic reports. This study did not include any measures to account for single task performance differences, so it is difficult to comment on the exact nature of the divided attention deficits in this study. However, the purpose of this study was to highlight an efficient way to determine age differences in functioning to promote their inclusion in clinical test batteries. Dual-task paradigms certainly appear to reliably identify age differences in a wide variety of areas.

Korteling (1994) examined dual-task performance in a driving simulator. Subjects were required to perform two perceptual motor tasks: a car following task, and a vehicle steering task. The driving simulator was a mock car including all features which would appear in a real vehicle. The "windshield" was a computer display screen which showed a straight highway. The first task required subjects to steer their car so that they remained in the center of their lane directly behind a car shown traveling in front of them (displayed on the computer screen). The second task required subjects to maintain a specified distance between their car and the car displayed in front of their car on the screen. To maintain the specified distance, subjects had to use their brake and accelerator pedals. In one condition, pushing down on the accelerator caused the car to speed up as in a real vehicle. In another condition, pushing down on the accelerator caused the car to slow down. In this condition, subjects had to modify an existing "psycho-motor" routine in order to complete the task. Korteling found that age differences in task performance were not significant except in the condition which required subjects to reverse the use of the accelerator pedal. The performance of young adults was not affected by reversing the accelerator pedal, but the performance of older adults declined significantly. Older adults were not able to "unlearn" the usual response. This supports the view that older adults are less able to modify previously learned skill routines which have become largely automatic. Korteling suggests that these results may be important in examining the kinds of driving mistakes older adults make on the road. He states that problems may occur when older drivers are required to make changes to long existing routines such as adjusting to a new car, navigating in a new city, or adapting to changes in previously familiar intersections.

Ponds et al. (1988) suggest that the age differences identified in the divided attention studies discussed above, may actually be an underestimate of the decline in attentional functioning experienced by older adults. They state that a real world task such as driving in heavy traffic, requires not only dual-task capabilities, but the integration of visual search and focused attention abilities. Given the sensitivity of both visual search and divided attention activities to increased age, the age effects in each area may be expected to be exacerbated in a situation which requires the coordination of all kinds of attentional processing. Other studies have found that automatic tasks, such as vehicle control, are unaffected by multiple demands, while "effortful" decision making, such as judgement of distance, is impaired (Brown, 1977). These results may account for the high crash rates of older adults on left turns, in high density traffic, and in intersections, as multiple attentional demands are greatest in these situations.

In a number of studies, as described above, older adults have demonstrated deficits in meeting the kinds of attentional demands that appear necessary for driving. Reliable correlations have been found between crash statistics and a variety of attentional tasks. An early study by Kahneman, Ben-Ishai, and Lotan (1973) related an auditory selective attention task to crash risk in commercial drivers. Performance on visual selective attention tasks are also moderately correlated with crash rates and driving performance (Brouwer and Ponds, 1994; Parasuraman and Nestor, 1993). The largest correlations were found in tasks that required the ability to re-orient from one thing to another, or "switch" back and forth; abilities crucial in traffic situations. Older adults with Alzheimer's Disease are particularly impaired in the ability to disengage or reorient attention (Parasuraman and Nestor, 1993). Limited research exists involving older adults suffering from dementia. A key study by Duchek, Hunt, and Ball (1997) studied the role of selective attention in driving for patients with Alzheimer's Disease. They suggest that selective attention measures are useful in identifying unsafe drivers. Such measures appear valuable in evaluating both healthy older adults and those with dementia such as Alzheimer's Disease.

It has been suggested that to accurately assess the complex task of driving, an equally complex task is required. In keeping with this suggestion, attention and driving performance has been studied using the "useful field of view" (UFV) paradigm (e.g. Ball, 1997; Ball, Beard, Roenker, Miller, & Griggs, 1988; Ball et al, 1990; Ball & Owsley, 1991; Ball & Rebok, 1994; Owsley, Ball, Sloane, Roenker, & Bruni, 1994). The UFV is defined as "the visual field over which information can be acquired during a brief glance" while attention is engaged in a central task (Ball & Rebok, 1994, p. 588). The premise behind this task is that when attention is directed centrally, the area of peripheral vision that is accurately perceived, is reduced. The UFV task itself includes a number of variables: central and peripheral targets, distance and visual angle of the peripheral target from the central visual field, "salience" of peripheral target when placed in a field of distracting stimuli, and length of time the targets are present. This test provides a measure of the speed of visual processing, the ability to divide attention, and the ability to selectively attend to a target against distracting background stimuli.

Older adults show a significant decline in the size of their UFV in comparison to young adults (Ball et al, 1990; Ball, 1997). Reductions in the size of the UFV are seen in older adults with normal vision, so the attentional factors mentioned above, not visual acuity, appear to contribute to a significant age-related reduction in the size of the useful field of view.

The relationship between older adults' performance on the UFV task and accident frequency appears to be strong. Ball (1991) found that UFV performance was reliably correlated with frequency of accidents at intersections. Subjects who performed poorly on the UFV task, were approximately 15 times more likely to have had an accident at an intersection than those subjects who performed well. Interestingly, a subset of the subjects predicted to have an accident record based on their poor UFV performance, in fact had no recorded accidents. These subjects reported avoidance of demanding driving situations such as driving at rush hour and driving at night. Ball (1991) suggested that these drivers had avoided accident involvement by modifying or regulating their own driving due to knowledge of vision impairments.

Although self-regulation of driving led to decreased crash frequency in Ball's study, Rebok et al (1990) stated that the expectation that all older drivers will regulate their own driving is unrealistic. Some older drivers may not acknowledge that their skills have declined, or are simply unaware of their driving difficulties. Particularly, older drivers with dementia appear to lack awareness of their declining abilities. In Rebok's study, Alzheimer patients still rated their driving skills highly after completing driving simulator tests in which they made a high number of errors. Perhaps due to declining abilities combined with a lack of insight, 30 to 40% of dementia patients have at least one automobile crash before they cease driving (Blaustein et al. 1988; Friedland et al., 1988). In cases such as these, Ball (1997) states that measures of visual attention, such as the UFV task, can reliably distinguish between safe and unsafe drivers. The findings of Owsley et al. (1991) support this statement. They found that the best predictor of accident frequency in their study was a combination of the UFV visual attention task and mental status.

The strong relationship between performance on the UFV task and crash rates suggests that the task is evaluating abilities important for driving. Intuitively, the ability to perceive objects in the periphery when attention is directed forward appears essential to good driving. Road signs, vehicles, and pedestrians often appear at the fringes of the visual field. Given that a reduction in the size of the useful field of view is likely to be experienced by older adults, and is correlated with a high risk for certain kinds of crashes, the relationship between UFV task performance and driving performance is potentially valuable as a tool to assess driving competence.

Ball (1997) calls for further research using the UFV paradigm in conjunction with other outcome measures to provide "converging evidence of the relationship between attentional skills and driving performance" (p.47). The need for on-road measures of driving performance is emphasized as a way of providing more accurate and thorough information about subjects' driving than can be gleaned from crash statistics (Ball, 1997).

A need for research on attention and driving using large, well-controlled samples was also identified. According to Ball and Owsley (1991) medical conditions, motor abilities, and medication histories, could be of great importance in determining performance on tests of attention and driving. Of particular significance, is the effect of dementia on driving performance. In the past, studies of aging and attention have focused on healthy older adults. Due to the increasing numbers of adults suffering from various forms of dementia, there is now a growing body of literature examining attentional functioning in adults with Alzheimer's Disease and other cognitive impairments. In general, attentional deficits present in older adults have been found to be present in an even greater degree in dementia patients, and deficits specific to those suffering from dementia may also exist. Investigation of the extent of declines in attentional functioning in dementia patients will be important for the evaluation of driving ability in this group. Given the growing numbers of older adults, and the corresponding increase in age-related diseases such as dementia, research on the impact of deficits in attention on driving will be vital to ensure safety on the roads.

In the present study, the performance of older adults, young adults, and dementia patients on the UFV task was examined. The effect of visual angle and distance on identification of peripheral distractors was investigated. A driving exam was also given to each participant. This driving test was conducted on city streets with regular traffic, and included left turns, yields, entering traffic, and merging onto, and exiting, a freeway. Adjustment of speed in response to signs, perception of pedestrians and other peripheral stimuli, as well as navigation using street signs was also included.

The power of the laboratory UFV task for predicting driver performance was examined. To more directly test the impact of altered UFV on driving performance, a "field" version of the UFV task was created. As in the laboratory UFV task, focus on a central target was required as the driver had to attend to operating the vehicle. Signs placed in the periphery mimicked peripheral targets in the laboratory UFV task, and an auditory task provided additional demands on attention. Of particular interest, were the differences in performance between healthy older adults, young adults, and dementia patients on the identification of the peripheral signs and responding to the auditory task.

Performance on the laboratory version of the UFV and the field version of the task was compared to determine the extent to which the lab task was related to field performance. To extend the comparison, performance on the laboratory task and the field version were compared with performance on the open road test. Several measures of comparison were built into this driving exam. Driving errors and overall driving performance were assessed to produce ratings of driving competence. Two kinds of driving error were particulary important. These are what Dobbs et al (1997) have identified as hazardous and discriminating errors. Hazardous errors are driving maneuvers where a crash would have occurred had surrounding traffic not adjusted to compensate for the error, or where a crash would have occurred had the driving evaluator not directly intervened. Discriminating errors are maneuvers which may not directly lead to a crash, but are still considered potentially dangerous mistakes. These include misjudgements, vehicle wandering, and insufficient observation of signs or other vehicles. Discriminating errors are a reasonable signal of declining skill as they reliably appear most often in drivers with dementia, followed by healthy older drivers, and young drivers (Dobbs, 1995). The driving measures used in this study were a pass/fail criteria, total points, accident risk rating, and overall driving rating based on the number and type of errors made in the driving exam.

Method

Participants.

The sample was recruited from patients attending clinics within the Northern Alberta Geriatric Programs and referred for a Clinical Driving Consultation administered by Rehabilitation Medicine and Neuropsychology. One hundred and forty four cognitively impaired adults were recruited for the patient group. Most of this group had been diagnosed with dementia of the Alzheimer type. The old and young control groups consisted of 71 older healthy adults, and 28 young adults, respectively. All participants in the control groups were volunteers from the community and currently driving. The mean ages of the three groups was 72.6, 69.5, and 35.6 for the patient group, older adults, and young adults respectively. Mean scores for each group on the Mini-Mental State Examination (MMSE; Folstein et al., 1975) were 23.6, 28.8, 29.6, respectively. Static visual acuity was measured using a standard Snellen eye chart (See Table 1 for Means). All participants, including the patient group, were currently driving and held a valid driver's licence.

Table 1. Mean (and Standard Deviation) for Visual Acuity by Group.

	Left Eye	Right Eye	Binocular
Dementia	58.66/20, 88.43	82.93/20, 145.97	41.97/20, 59.50
Older Adults	62.82/20, 130.74	63.87/20, 112.75	43.45/20, 94.22
Young Adults	22.83/20, 5.20	23.50/20, 4.38	20.83/20, 1.90

The Useful Field of View Task.

Procedure.

The UFV task was administered to all participants as part of a larger battery of cognitive tests. The entire battery took approximately 16 hours to complete, and was administered in three sessions. The UFV task was administered in the second session, and took between 20 and 45 minutes to complete. The task was presented on a 15 inch computer monitor equipped with a touch screen to record participant responses. Participants were seated approximately 0.5 meters away from the screen, and viewed the stimuli through two-diopters. The diopters acted to halve the apparent distance between the participant and the screen. This allowed the visual angles of the stimuli from the participant to be doubled in size, and examine a greater area of the visual field.

Participants were required to respond to a centrally presented stimulus and identify the location of a peripherally presented target. Variables were added to test the ability to simultaneously attend to stimuli in the periphery such as the visual angle of the peripheral target, and the presence of distracting stimuli in the periphery.

No Distractor vs. Distractor

Practice.

There were 120 trials included in the task. The first 24 trials were practice trials. The participant was required to perform a discrimination task presented in the central visual field. A word was presented in the middle of the screen for a duration of 300 ms, and the participant decided if it was the target word. The words were presented in white on a black background. In the initial trials, the target word was “beans”. The target word appeared on 50% of the trials. Non-target words came from a variety of categories such as clothing and furniture. The presentation of the target word was followed by a visual noise screen to destroy the afterimage, then the response screen appeared with a "yes" and a "no" touch area. The participant responded "yes" or "no" by touching either the "yes" or "no" box appearing on the screen (See Figure 1). A target and non-target practice trial was included for each trial type (described below).

Main Task.

The next 48 trials included the discrimination task as described above, as well as the simultaneous presentation of a peripheral target (See Figure 2). These 48 trials were divided into two blocks of 24 trials. the second block a repetition of the first. The repetition of trials, called replication in this study, was included to minimize differential practice effects for different trial types. The peripheral target was a small filled circle which appeared at one of twelve different locations. The circle could appear along one of six radial spokes (two horizontal cardinal spokes and four oblique spokes) and at one of two eccentricities (60 mm and 110 mm). The order in which the peripheral target appeared at each of the locations was randomly determined. The participant was required to identify the location of the circle on a grid, touching the area where the circle had appeared. This screen followed the yes/no decision screen. As the intent of this study was to examine the size of the peripheral visual field when attention is centrally engaged, a measure of central focus was required. Therefore, the participants were instructed to attend to the central target. To insure that this was the case, trials for which the participant incorrectly identified the central target were presented again at the end of the task.

The last set of 48 trials were divided into two blocks of trials as described above. In these trials, the central target was presented in the same manner as above, but the target word was changed to "grape". The target word appeared on 50% of the trials. Participants were asked to respond "yes" when grape appeared, and "no" to other words. The former target "beans" was not presented in these trials. In addition, the peripheral stimulus in these trials appeared with distracting stimuli (small dots) placed at the other eleven target locations (See Figure 3). As in the early trials, the participant had to respond to the central target, and then identify the location of the peripheral stimulus.

To receive a score on an individual trial, the participant had to correctly carry out the central discrimination task. The number and placement of accurately located peripheral stimuli determines the area of the participant's useful field of view. The effect of the destructor stimuli (small dots) on the ability to identify the location of the peripheral stimuli was examined. Performance on the UFV task was assessed individually and across the three participant groups.

The Driving Test.

Procedure.

To assess the ability to respond to multiple attentional demands while driving, a driving exam was designed to include several measures of attention, as well as basic driving skills. The driving exam included a closed road section, and an open road section on city streets with regular traffic.

Closed Course: Field Version of UFV task.

The closed road course was a 4 km circular loop of road located in an area closed to outside traffic. The basic closed course included two stop signs, and four right hand turns. The field version of the UFV task was presented as part of the closed course evaluation. The driver was accompanied by a driving instructor from the Canadian Automobile Association (Alberta), and an examiner from the research group. The driving instructor evaluated driver errors and overall performance, while the research examiner administered the attention tasks on the closed course. The testing vehicle was a mid-size car equipped with dual-brakes.

Method.

Four laps of a section of the closed road course were included in the field UFV road test. For each lap, the driver was required to attend to a different combination of tasks in addition to operating the vehicle and obeying existing road signs. On the first lap, no additional tasks were given to the driver. This provided a baseline measure of driving ability. For the second lap, an auditory task was administered. A tape was used to present the names of instances of four different categories (musical instruments, toys, water craft, and birds). The items were presented at a rate of one every two seconds. Approximately 50 percent of the overall occurrences were from the bird category. The drivers were instructed to honk the car horn when they heard the name of a bird. For the third lap, a visual identification task was administered. Twenty-one signs containing various letters of the alphabet were placed on either side of the road. The letters on the signs were 12 inches in height, and were painted in black on a blue background. The driver was required to read the letters as they appeared on the signs, while driving.

The fourth lap of the road course included both the auditory word identification and visual identification tasks. The drivers were required to identify the letters on the signs as they appeared, as well as honk the car horn in response to a target category. For this lap, words from different categories were used (natural phenomena, furniture, clothing, and animals). The target category was animals. Approximately fifty percent of the overall occurrences were from the animal category.

The response measures evaluated for the road course were the accuracy of the driver's performance on the word and letter identification tasks, as well as the level of driving performance. Omissions, such as failure to honk the car horn or identify signs when appropriate, or intrusions, such as false target reports indicated by honking at non-target words, or incorrect letter identifications, will be considered. The effect of load on task performance will also be examined. The mean baseline performance level for each group on each task (accuracy of performance in single task condition) will be established. Then, baseline line performance will be compared with mean performance in the same task in the double-task condition.

Differences in performance for the healthy older adults, young adults, and dementia patients, will be evaluated. Lap times for each group will also be examined to assess whether speed is affected by attentional demands.

Open Road Exam.

The open road part of the driving exam, included 37 maneuvers including left turns, yields, entering traffic, and merging onto a freeway. For the open road course, driving errors were examined. Major errors fall in to two categories: hazardous, and discriminating (Dobbs, 1997; Dobbs, Heller, & Schlopflocher, 1998). The overall driving measures used in this study were overall driver rating. a pass/fail criteria, and accident risk rating based on the number and type of errors made in the driving exam. Ratings were assigned according to scoring procedures described by Dobbs (1997). The overall driving rating consisted of a five point scale ranging from "very poor" to "excellent". The accident risk rating scale ranged from 1 (very high risk) to 8 (very low risk). The pass/fail criteria was a dichotomous scale (0-1) representing whether a person passed or failed the driving exam. A comparison between performance on the UFV laboratory task and the driving measures for the open road course will done to determine if the lab task is related to driving performance on the road test.

Figure 1. Practice Trials

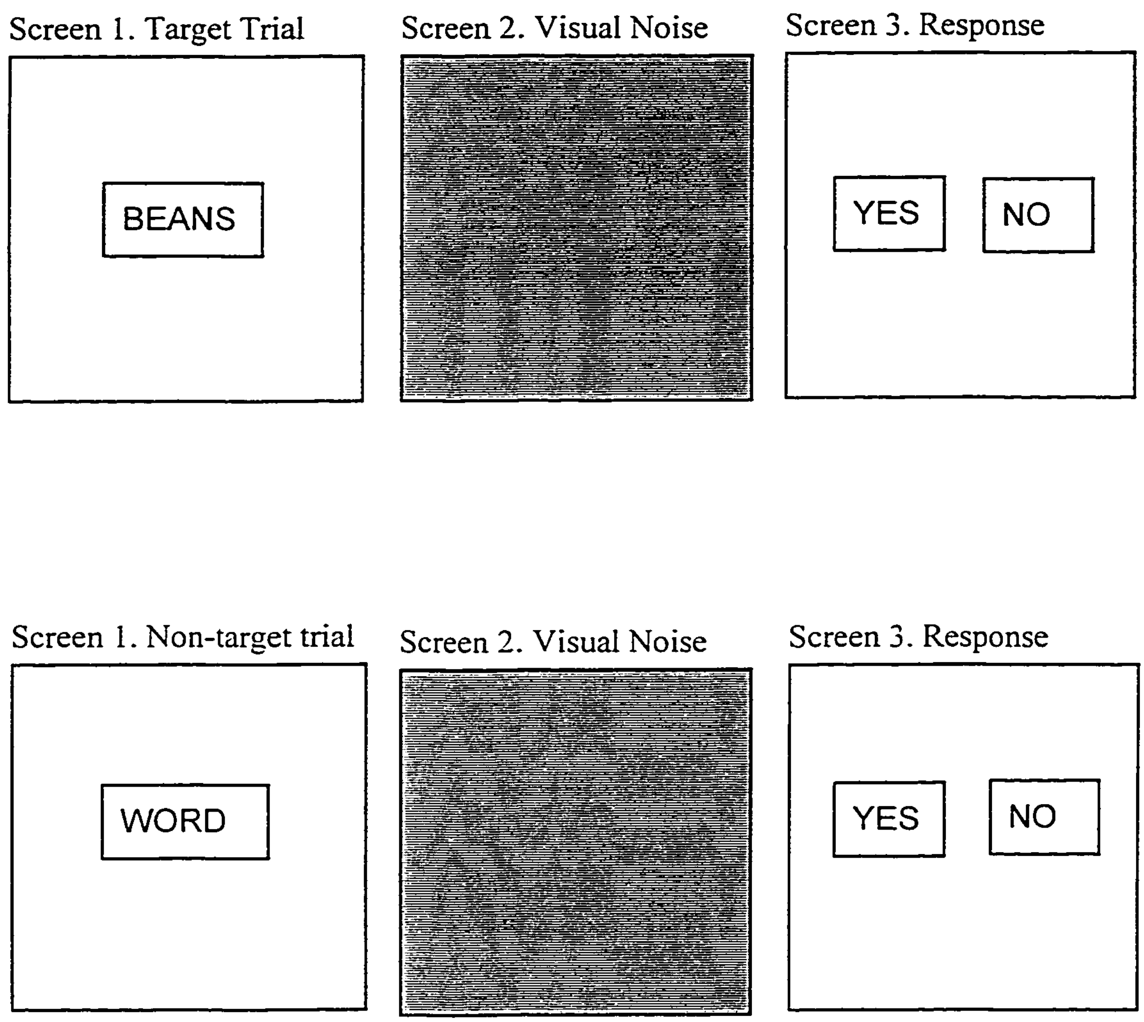


Figure 2. Peripheral Target with No Distracting Stimuli

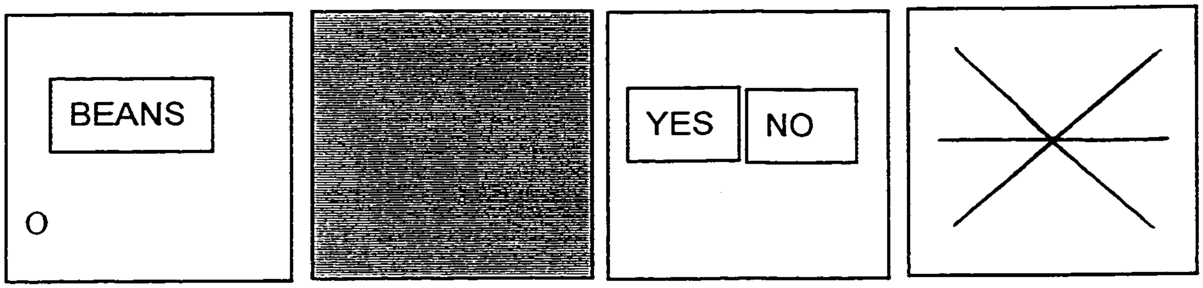
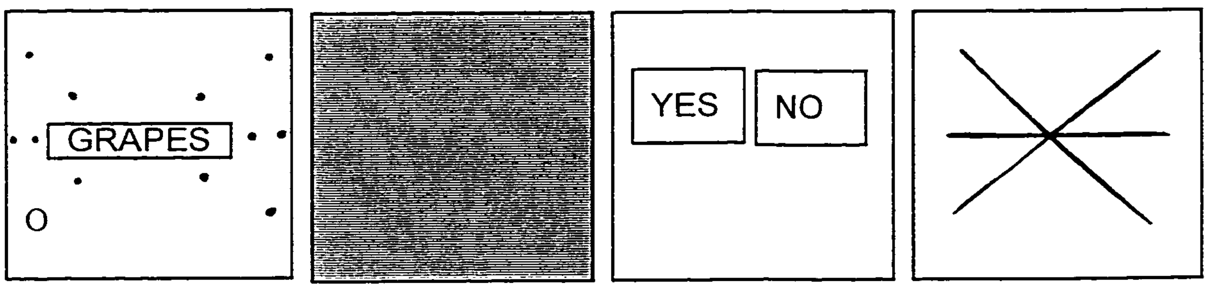


Figure 3. Peripheral Target with Distracting Stimuli



Results

The analyses were conducted in three parts. First, performance on the laboratory UFV task and the field UFV task were examined using analysis of variance techniques. A listwise exclusion procedure was used for the analyses of the UFV tasks which eliminated cases with missing data. This resulted in the exclusion of 17 cases in the Field UFV Task, whereas no cases were excluded in the Laboratory UFV Task. One case from each of the young adult and older adult groups, and 15 from the dementia group were excluded. The sample used for the analysis of the Field UFV (full sample minus the 17 with missing data) was used for a comparison of selected measures from each task using correlational techniques. Finally, the selected measures from both the Laboratory and Field UFV were correlated with the driving measures. It may be of interest to note that the Laboratory UFV data were re-analyzed using the Field UFV sample with the finding that no conclusion would be altered (largest F change = 2 points).

UFV Laboratory Task

Performance on the Laboratory version of the UFV Task was evaluated using a 2 by 2 by 2 by 6 by 3 repeated measures design. All factors were within subjects factors except the last factor (Group). The within subjects factors were Distraction (No Distraction vs. Distraction), Distance (Close Peripheral Targets vs. Far Peripheral Targets), Axis (1, 2, 3, 4, 5, 6), and Replication (Block 1 vs. Block 2). The between subjects factor was Group (Dementia vs. Older Adults vs. Young Adults).

Overall, the main effect of Group was significant, (M Dementia= 27.12, SD= 4.75; M OA= 45.44, SD= 14.62; M YA= 64.02, SD=4.75; $F(2, 240)= 97.39$, $p<.001$). For the within subjects factors, a significant main effect was found for Distance, $F(1, 240)=19.69$, $p<.001$. Identification of peripheral targets located close to the central stimulus was significantly higher than for those targets located at a greater eccentricity (M Close= 25.98, SD= 14.34; M Far=22.31, SD= 13.17). A significant Group by Distance interaction was found, $F(2, 240)= 4.01$, $p<.05$. The performances of the three groups were significantly different from each other in both the Close and Far conditions. The dementia group scored the lowest (M Close= 18.9, SD= 12.22; M Far=15.7, SD= 10.13), followed by the older adults (M Close= 32.83, SD= 10.19; M Far= 28.02, SD= 10.50), and then the young adults (M Close= 44.96, SD= 4.21; M Far= 41.71, SD= 4.05).

For Distraction, a significant main effect was found, $F(1, 240)= 251.24$, $p<.001$. Participants performed significantly better in the No Distraction condition (M=29.81, SD= 16.20) than in the Distraction condition (M=18.48, SD= 12.32). There was a significant Group by Distraction interaction, $F(2, 240)=17.86$, $p<.001$. The pattern for this interaction was for the Older adults, relative to the other two groups, to show a greater decline in performance from the No Distraction to Distraction condition. (See Table 2 for means). Although this finding was unexpected, it is most likely due to ceiling and floor effects. The dementia group was performing close to the lower end of the scale, with 75% of the group scoring less than 15/48, so it is possible that their performance was subject to a floor effect. It may be that the dementia patients would have shown greater decline in scores if a floor effect were not present. Also, the young adults were performing close to the ceiling in the No Distraction condition which may have affected the difference scores. In this condition, all the young adults scored between 46/48 and 48/48. The smaller standard deviation measures for these two extreme conditions (Dementia- Distraction, Young Adults- No Distraction) are consistent with the suggestion of floor and ceiling effects, respectively.

Table 2. Mean (and standard deviation) for Number Correct over 48 Trials

	Distraction	No Distraction	Difference
Dementia	12.76 (8.43)[a]	21.88 (14.73)[b]	9.12
Older Adults	22.01 (10.69)[b]	38.85 (11.10)[c]	16.84
Young Adults	38.93 (6.77)[c]	47.75 (.59)[d]	8.82

*Values with different superscripts are significantly different at the 0.05 level.

A main effect of Replication was found, $\underline{F}(1, 240) = 87.43$, $\underline{p} < .001$. The significant improvement in scores form the first set of trials to the second set is most likely due to practice. The Group by Replication interaction was non-significant, $\underline{F}(2, 240) = 2.54$, $\underline{p} > .05$.

The main effect for Axis was found to be significant, $\underline{F}(5, 240) = 21.36$, $\underline{p} < .001$. In general, identification of peripheral targets was highest on the horizontal as opposed to the oblique angles, and higher on the right side as opposed to the left (See Table 3 for means). A further analysis of Axis was conducted. Scores from the three axes on the left side were combined, as were scores from the three axes on the right side to produce an overall measure of left and right. These measures were calculated to provide overall left and right indices to compare with the left and right side visual identification measures used in the field version of the UFV task. There was an overall significant difference between performance on the left and right sides across the groups, $\underline{t}(1,240) = -5.22$, p<.001; M Left= 17.17, SD= 11.30; M Right= 19.14, SD= 9.14).

Table 3. Mean Number Correct (and standard deviation) for each Axis by Group.

	Right Horiz. (F3)	Left Horiz. (F6)	Top Right Oblique (F2)	Top Left Oblique (F1)	Bottom Left Oblique (F5)	Bottom Right Oblique (F4)
Across Groups	10.09 (4.81)	8.26 (5.45)	8.02 (4.77)	7.48 (5.28)	7.37 (5.38)	7.06 (4.75)
Dementia	8.21 (4.78)	5.75 (4.79)	5.88 (4.25)	5.03 (4.49)	4.89 (4.60)	4.88 (3.97)
Older Adults	11.83 (3.38)	10.61 (4.15)	10.15 (3.72)	9.80 (4.30)	9.56 (4.15)	8.90 (3.61)
Young Adults	15.36 (1.03)	15.25 (1.29)	13.64 (1.75)	14.18 (1.42)	14.61 (1.64)	13.64 (2.45)

However, examined separately, the three groups showed an interesting shift in performance from left to right. The young adults performed significantly better on the left, rather than the right, t= 2.48, p<.05; M Left=32.52, SD= 2.39; M Right=31.72, SD= 2.70). The older adults demonstrated no significant difference in performance from left to right (t= -1.78, p>.05; M Left=22.23, SD= 8.50; M Right=23.26, SD= 6.74). The dementia patients showed the greatest difference between left and right, with performance on the right significantly higher than on the left. (t= -5.42, p<.001; M Left=11.7, SD= 9.53; M Right= 14.66, SD= 7.61). The differential effect of Side in the laboratory task is consistent with a reliable Group by Axis interaction in the main analysis, F(10, 240)= 2.34, p<.05.

A number of other two- and three-way interactions were significant. The Distance by

Axis interaction was significant, $F(5, 240) = 2.31$, $p < .05$, as was the Distraction by Axis interaction, $F(5, 240) = 2.47$, $p < .05$. These interactions indicate that identification of peripheral targets on the different axes is moderated by both the distance and level of distraction displayed when the target is presented. The pattern of performance on each axis was the same as in the main effect for Axis, but differences in performance on each axis were increased when targets appeared further away and with distracting stimuli. The Replication by Axis interaction was significant, $F(5, 240) = 10.23$, $p < .001$. The pattern of performance on each axis was similar in both trials, but differences between performances on each axis were smaller in the second trial. The Distraction by Replication by Axis interaction, $F(10, 240) = 9.05$, $p < .001$, was also significant. The pattern for this three-way interaction was the same as in the Distraction by Axis interaction, but the differences shown got smaller on the second set of trials. In addition, the Group by Distraction by Axis interaction, $F(10, 240) = 2.47$, $p < .05$, Group by Replication by Axis interaction, $F(10, 240) = 1.91$, $p < .05$, the Group by Distraction by Replication interaction, $F(2, 240) = 10.55$, $p < .001$, and the four-way Group by Distraction by Replication by Axis interaction, $F(10, 240) = 1.97$, $p < .05$, were significant. Each of these interactions showed the same pattern as in the respective two-way and three-way interactions, but the magnitude of the effect differed by group. In each of the interactions, the dementia group was more greatly affected than the young or older adults, demonstrating that pathology has a greater effect on performance than age. None of the other interactions were significant.

Field UFV Task

Performance on the field version of the UFV task was evaluated using a 2 by 2 by 3 repeated measures design. The first two factors were within subjects factors: Load (Letters alone vs. Letters plus Auditory Task), and Side (Identification of Letters on the Left Side vs. Identification of Letters on the Right Side). The between subjects factor was Group (Dementia vs. Older Adults vs. Young Adults).

An overall main effect for Group was found for the field UFV task, (M Dementia= 27.00, SD= 9.01; M OA= 36.27, SD= 3.69; M YA= 38.44, SD= 2.19; $F(2, 223)= 53.49$, $p<.001$). A main effect of Load was also found, $F(1)= 14.64$, $p<.001$, with performance significantly better in the Letters Alone condition (M=16.65, SD= 4.11) than in the Letters plus Auditory Task (M=14.58, SD= 5.67). The Group by Load interaction was reliable, $F(2, 223)= 8.02$, $p<.001$. The pattern of the interaction was for there to be larger effects of the conditions for the dementia and older adult groups. The dementia patients scored significantly lower than the other two groups in each condition and also demonstrated a relatively greater decrease in performance from the visual identification alone condition to the visual identification condition and auditory. The older adults showed a smaller decrement in performance from one condition to the other, while the young adults showed no significant decline in performance (See Table 4 for means).

Table 4. Mean Number (and standard deviation) of Letters Identified in Letters Alone vs. Letters plus Auditory task.

	Letters Alone	Letters plus Auditory Task
Dementia	15.06 (4.71)[a]	11.93 (5.98)[b]
Older Adults	18.50 (1.59)[c]	17.77 (2.53)[d]
Young Adults	19.44 (0.70)[e]	19.00 (1.75)[e]

*Values with different superscripts are significantly different at the 0.05 level.

There was a main effect of Side (Left vs. Right), $F(1, 223)= 23.55$, $p<.001$, with performance for visual identification of letters significantly higher on the Right side than the Left side (M Right= 16.61, SD= 4.06; M Left=14.63, SD= 5.27). The interaction between Group and Side was reliable, $F(2, 223)= 14.43$, $p<.001$. The dementia patients showed a larger left-right difference than was found for the other two groups (See Table 5 for means). The Load by Side interaction and the Group by Load by Side interaction were both non-significant, largest $F= 1.32$, $p> .05$.

Table 5. Mean (and standard deviation) number of letters identified in each group on the Left vs. Right side.

	Left	Right
Dementia	11.97 (5.32)[a]	15.03 (4.63)[b]
Older Adults	17.81 (2.41)[c]	18.43 (1.59)[d]
Young Adults	19.04 (1.87)[e]	19.40 (0.75)[e]

*Values with different superscripts are significantly different at the 0.05 level.

Other analyses of the field UFV task examined possible differences in the times taken to drive the three different laps of the course: the Practice lap, the Letters Alone lap, and the Letters plus Auditory lap. A 3 (Lap Type: Practice, Letters Alone, and Letters plus Auditory) by 3 (Group) analysis of variance was performed to identify differences in lap times according to group and condition. A main effect of LapType was found, $F(2, 223)$= 84.96, $p<.001$, with the time for the Practice lap the fastest, followed by the Letters Alone lap and Letters plus Auditory lap (M Practice= 94.73, SD= 12.88; M Letters Alone Lap= 114.69, SD= 20.56; M Letters plus auditory Lap= 114.69, SD= 20.56). The main effect of Group was significant, (M Dementia= 331.61, SD= 46.25; M OA= 306.49, SD= 31.7; M YA= 305.55, SD=24.69; $F(2, 223)$= 11.09, $p<.001$. The interaction between Group and Lap Type was significant, $F(2, 223)$= 11.09, $p<.001$. This interaction indicated a larger difference between the groups when the load conditions were introduced. Analysis of the simple effects confirmed the trends. There were no significant differences between times for each group on the Practice Lap which included no additional load tasks, $F(2, 223)$= 1.17, $p> .05$. There was a significant difference between lap times for each group on the laps which included the identification of Letters Alone, and the Letters plus Auditory Task ($F(2, 223)$ Letters Alone= 9.58, $p< .001$; $F(2, 223)$ Letters plus Auditory= 11.96, $p<.001$). In both laps in which a load was present the dementia patients drove significantly slower than the other two groups and showed the greatest increase in lap times relative to the practice lap (See Table 6 for means).

For the auditory load task, it was possible to administer a maximum of 60 stimulus words depending on the speed at which the participant drove. Two measures were calculated: Hits and False Positives. Hits is a measure of how many times the participant correctly responded (honked) to a target word. False Positives is a measure of how many times the participant made an incorrect response (honked) to a non-target word. Both measures were calculated as a percentage out of the total number of words administered to each participant. A one-way analysis of variance produced a main effect of Group for Hits, $F(2, 223)= 50.61$, $p<.001$, with the dementia group demonstrating the lowest score (M= 48.4%, SD= 28.12), followed by the older adults (M= 75.7%, SD= 20.40) and then the young adults with the highest score (M= 91.3%, SD= 10.40). The False Positives measure also produced a reliable main effect for group. $F(2, 223)= 6.47$, $p<.002$. However, the results were notably different from those obtained for Hits. The older adults demonstrated the highest False Positive score (M= 11.3%. SD= 19.48) followed by the dementia group (M= 5.8%; SD= 11.65). then the young adults (M=1.0%, SD= 3.13). In order for there to be a False Positive. there must be an active response from the participant. To the extent that the person is unable to do the load task while driving, both low Hits and low False Positives would be expected. just as was found for the dementia group. Thus, caution is recommended when interpreting this score, because the lower False Positive scores of the dementia patients could have been due to lack of responding, inattentiveness, and related problems rather than to purposefully with-holding responses to non-targets. This may explain the lower False Positive score of the dementia group compared to the older adults. Given this. Hits may be a more accurate measure of performance on this task.

Table 6. Mean Lap Times (and standard deviation) in seconds by Group.

	Practice	Letters Alone	Letters plus Auditory
Dementia	95.84 (14.54)[a]	115.59 (19.92)[b]	120.18 (23.15)[c]
Older Adults	92.99 (10.11)[d]	105.27 (13.34)[e]	108.22 (14.87)[f]
Young Adults	93.95 (10.40)[d]	106.35 (8.54)[e]	105.25 (8.90)[e]

*Values with different superscripts are significantly different at the 0.05 level.

Comparison of the Field UFV task and the UFV laboratory Task

A number of measures were included in this analysis to determine the relationship between the field UFV task, the laboratory task, and driving performance. In addition, mental status as measured by the MMSE was compared to UFV performance to determine the relationship between these two measures in this study.

Correlations between MMSE scores and the UFV total score were moderately high for the dementia group individually and the three groups combined. However, the correlations between the scores for the older and young adults individually were non-significant. These correlations are presented in Table 7.

Table 7. Correlation Between the MMSE score and Total Lab UFV score for each Group

	Across Groups	Dementia	Older Adults	Young Adults
MMSE	.677*	.540*	.176	.118

*$p<0.05$

To determine the relationship between the UFV laboratory task and the Field UFV task, scores reflecting overall performance on each task were correlated. The Total Score from the laboratory task was correlated with Total Letters Correct and Hits from the field version. The Total Letters Correct is a sum of the scores for letter identification in the Letters Alone and Letters plus Auditory conditions. Correlations were calculated for all participants together and for each group separately. Correlations were moderately high for the dementia group and all participants together. Correlations between scores for the young and older adults were non-significant, except for the correlation between the Total Score for the laboratory UFV and Total Letters Correct for the older adults. These correlations are presented in Table 8.

Table 8. Correlation between Mean Total Score for the Lab UFV and Score for Total Letters Correct and Correct Word Recognition (Hits) for the Auditory Task.

Lab UFV		Field UFV	
		Total Letters Correct (over Letters Alone and Letters plus Auditory)	Hits
Total Score	Across Groups	.567*	.565*
	Dementia	.333*	.404*
	Older Adults	.411*	.128
	Young Adults	.376	-.011

*p<0.05

To compare performance on the left and right sides for the laboratory and field tasks, the composite left and right axis measures from the laboratory task were correlated with left and right side performance for Letters Alone and Letters plus Auditory task from the field version. Correlations were calculated for each group individually and for all groups together. A similar pattern of performance was found for this set of correlations as for the comparisons of the total scores. The highest correlations were found when the groups were combined. Significant correlations were found for the dementia group and older adults. Correlations for the young adults were non-significant. These correlations are presented in Table 9.

Table 9. Correlations Between Performance on the Laboratory UFV and the Field UFV for the Left and Right Sides

Lab UFV	Group	Field UFV		
		M Number Correct Left Side		
		Letters Alone	Letters + Auditory	Total Left
M Number Correct Left Side	Across Groups	.422*	.482*	.517*
	Dementia	.211*	.208*	.249*
	Older Adults	.275*	.340*	.371*
	Young Adults	.155	.267	.278
		M Number Correct Right Side		
		Letters Alone	Letters + Auditory	Total Right
M Number Correct Right Side	Across Groups	.338*	.457*	.475*
	Dementia	.186*	.278*	.288*
	Older Adults	.208	.381*	.364*
	Young Adults	.138	.186	.232

*p<0.05

To determine the relationship between the lab UFV, the Field UFV, and on-road driving performance, three measures of driving performance were correlated with the

Total Score for the lab UFV task, and the Total Letters Correct for the field UFV. The driving measures used were overall driver rating, pass/fail, accident risk rating, and total points (See Table 10 for Means). As above, the highest correlations were found when the comparison was made across all three groups. All correlations were significant for the groups together. Correlations were moderately high for the dementia group and again, all correlations were significant. Correlations for the older adults were significant for some of the measures, while correlations for the young adults were all non-significant. The correlations are presented in Table 11.

Table 10. Means and Standard Deviation for Driving Measures.

	Overall Driver Rating	Accident Risk Rating	Total Points	Pass/Fail
Across Groups	2.60, .76	5.36, 1.89	65.82, 82.35	.45, .50
Dementia	2.19, .70	4.30, 1.67	99.97, 91.40	.31, .46
Older Adults	2.99, .50	6.27, 1.15	31.77, 48.11	.58, .50
Young Adults	3.37, .38	7.57, .84	6.11, 6.80	.70, .47

Table 11. Correlations Between Driving Measures, Lab UFV, and Field UFV.

		Lab UFV Total Score	Field UFV Total Letter Identification
Across Groups	Overall Driver Rating	.353*	.339*
	Pass/Fail	.364*	.368*
	Accident Risk Rating	.644*	.616*
	Total Points	-.503*	-.539*
Dementia	Overall Driver Rating	.292*	.247*
	Pass/Fail	.314*	.310*
	Accident Risk Rating	.497*	.458*
	Total Points	-.345*	-.388*
Older Adults	Overall Driver Rating	.005	.055
	Pass/Fail	.253*	.245
	Accident Risk Rating	.204	.262*
	Total Points	-.237*	-.361*
Young Adults	Overall Driver Rating	-.004	.186
	Pass/Fail	.222	-.130
	Accident Risk Rating	.103	.002
	Total Points	.069	.300

*$p<.05$

Discussion

Given the growing number of older drivers, distinct needs for research examining the effects of aging on driving competence have been identified. The present study addressed a number of research needs outlined in the literature as they relate to attention. Investigation of the relationship between attention and driving has been emphasized, as attentional processes are involved in many aspects of driving (Parasuraman & Nestor, 1993). In this study, the relationship between attentional processes and driving was directly studied using a laboratory version of the UFV task, and a field version of the UFV administered while driving. Few studies on driving have included dementia patients, and the need for research using large, well-controlled samples has been highlighted. In the present study, both tasks were completed by large samples of young adults, healthy older adults, and dementia patients. Differences in performance between each group in each task were important, as well as the relationship between the laboratory UFV task and the field UFV task.

For the laboratory UFV, several factors influenced performance in all three groups. All participants, regardless of group membership, had more difficulty locating a peripheral target when it was presented at a greater distance from the central target. Also, performance was impaired when distracting stimuli were present. The peripheral stimulus was detected and identified less accurately when it appeared in a field of similar stimuli. This finding is consistent with the literature on visual search. However, in interpreting the effect of distraction on identification of the peripheral stimulus, it is also important to note that the target word in the Distraction condition was changed from the word used in the No Distraction condition. This was done to decrease the likelihood of practice effects carrying over from one condition to another. Neverthless. for the participants to respond to the new target word, unlearning of the original target had to take place. It is possible that this could have contributed to the distractor effect.

Identification of the peripheral target also was impaired when the target appeared in oblique planes rather than the horizontal plane. and when the peripheral target was presented on the left hand side. This may reflect the effects of strong reading habits for attentional shifts for stimuli appearing in the horizontal plane. Stimuli appearing on the right may draw attention from habit. It is possible that a different result may be found in non-western populations that do not read left to right.

Differences in performance between the three groups were consistently found across conditions. The young adults demonstrated the highest performance in all conditions, followed by the older adults. and the dementia patients demonstrated the lowest level of performance. These results support the general finding (e.g. Ball, 1997; Ball & Owsley, 1991; Ball et al, 1990) that performance on the UFV declines with age. Ball and Rebok (1994) found that 50% of the variance in the size of the UFV was accounted for by age alone. Ninety one percent of the variance was accounted for when attentional capabilities were considered with age. Thus, the ability to locate an object in the periphery is affected by age, but even more so by cognitive impairments such as those related to dementia. The findings in this study are consistent with the earlier findings of Ball et al. In addition, to the extent that the findings for the dementia group are attributable to to UFV changes per se, reduced UFV can also be attributed to dementia.

In addition to the simple effects of condition and group membership, the groups were differentially affected by the various conditions. For example, the young adults and older adults both showed a decline in scores from the No Distraction condition relative to the Distraction condition, but the difference was greater for the older adults than for the young adults. The dementia group showed an even greater difference between scores than the older adults.

The same general pattern of group by condition interaction was found for performance in all the conditions. Declines in performance from the easy to the more difficult conditions was smallest for the young adults, followed by the older adults and greatest for the dementia group. Impairments in the UFV have been found consistently in older adults, and such impairments have been postulated to be present in an even greater degree in older adults suffering from dementia (Ball, 1991; Rebok et al, 1994). The performance of the dementia group in this study confirms the hypothesis.

It is important to note that in the more difficult conditions, where the peripheral target appeared far away, in the oblique plane, and with distracting stimuli, the majority of dementia patients were performing at or near the floor. This indicates that many in the dementia group became unable to perform the task when it became increasingly difficult. The visual attentional processes measured by the UFV task appear to reflect attention skills necessary for driving such as identifying pedestrians, signs, and other vehicles in the periphery while maintaining concentration on central driving tasks. Given that all the participants in the present study held valid driver's licenses and were currently driving, the large impairment in performance for the dementia group when faced with more complex and difficult conditions is consistent with concerns about their ability to drive safely.

To assess processes involved with the UFV in a "real-world" setting, the field UFV task was created. Group differences similar to those found in the lab UFV were found in the field version. Accurate identification of signs placed along the side of the road course while driving was highest for the young adults, followed by the older healthy adults, and lowest for dementia patients. As in the laboratory UFV task, identification of signs appearing on the right side of the road was generally better than identification on the left side. This difference was most pronounced in the dementia group. As people are required to drive on the right side of the road in North America, road signs also appear along the right side. The right versus left effect may be a product of strong habits to look for signs on the right side of the road. Similar to the laboratory task, these effects may be different in a culture that drives on the left side of the road.

When an auditory task was added as an additional load on attention, all the groups demonstrated a decrease in accuracy of letter identification. However, letter identification scores for the dementia group decreased by a greater amount than was found for the other two groups, showing that the additional demands on attention had a greater impact on the dementia patients. This result was similar to that found in the laboratory UFV task where the groups were differentially affected by increased difficulty in the task conditions. The dementia group showed greater declines in performance from easy to difficult conditions than either the young or older adults.

Lap times were recorded as an indirect measure of speed of travel. All three groups had similar lap times for the practice lap, which included no attentional tasks. Lap times for all the groups increased when the attentional tasks were added, however, the dementia patients were the most greatly affected. Lap times for the dementia group increased markedly with added load, indicating that the group was driving much slower when required to perform extra tasks. This suggests that speed was sacrificed in an effort to complete the attention tasks. This kind of trade-off in task performance was present only in the dementia group.

The field version of the UFV task is unique to this study, and therefore there is no prior literature on this measure. The laboratory version of this task has been assumed to be measuring abilities present in real-world driving, such as detecting and identifying signs and other vehicles. It was important to determine the relationship between the two tasks to confirm or disconfirm this basic assumption. The results were supportive as significant correlations were found between performance on the laboratory UFV task and the field version. Further study using this measure to examine driving and dementia would clarify the relationship between existing measures of attention and a real-world counterpart, as well as generating more evidence about the impact of age and dementia on driving competence.

To substantiate the relationship between attentional skills and driving performance, direct measures of driving were compared to performance for the laboratory and field UFV tasks. Previous studies have used retrospective measures of driving performance, such as crash statistics, to rate driving competence. Ball (1997) recommended the use of on-road measures of driving performance to provide more accurate and thorough information about driving competence. The laboratory version and the field version of the UFV task were both significantly correlated with on-road driving measures. The dementia group produced the highest correlations between performance on the laboratory and field UFV and driving measures. The older adults produced smaller correlations, and the young adults showed non-significant correlations, possibly due to a restricted range. For example, the young adults were performing close to the ceiling in all the tasks. The UFV tasks best predicted the Accident Risk Rating measure from the on-road driving exam. This measure is based on the amount and type of hazardous or risky driving behaviour observed throughout the driving exam, and assesses the likelihood that the driver will be involved in a crash. The significant correlation between the UFV measures and accident risk, specifically in the dementia group, is of particular importance. This finding supports the hypothesis that the UFV is sensitive to impairments that increase the likelihood of unsafe driving. Given this, the UFV is valuable in the development of an accurate screening process to predict which drivers are most at risk for crashes.

Overall, in this study age effects were found to be present in the laboratory and field versions of the UFV task. The findings for the laboratory version were consistent with the literature. Most importantly though, pathology, in the form of dementia, was shown to have greater effects on attentional processes and driving competence than age alone. Participants suffering from dementia consistently performed at a lower level than participants of a similar age in the healthy older adult group. In addition, when extra demands on attention were added to primary tasks, the performance of the dementia group declined to a greater extent than either the young or older adult groups. This meant that the already low performance of the dementia group was reduced even further, at times producing a floor effect for their performance.

The presence of a floor effect for the dementia group suggests that it is not solely a restricted useful field of view that is responsible for performance on the UFV tasks. The ability of the dementia group to understand and remember a complex set of instructions, as well as coordinate performance in multiple areas, could also be contributing to their low level of performance. Apart from the specific visual attentional components in the UFV tasks, basic attention skills, language comprehension, working memory, and central executive functioning are all necessary to carry out the UFV tasks. The multi-dimensionality of the UFV paradigm may be the reason that the task reliably predicts a portion of the variance in driving. It is possible that it is not the UFV per se that is predicting driving competence, but the complex nature of the task which reflects the demanding and multi-faceted nature of driving. Strictly controlled research is needed to determine the specific role of the UFV in driving competence. However, regardless of the particular processes responsible for the relationship between the UFV and driving, the task is highly sensitive to impairments that increase accident risk. Given this, the UFV task may provide a useful tool for evaluating competence to drive.

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