Cognitive screening for the safe driving competence of older people with mild cognitive impairment or early dementia

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Title

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Abstract

With a predictable relationship between driving safety and mild cognitive impairment (MCI) or early dementia yet to be firmly established, this project aimed first to describe the on-road driving preformance of a group of older people with MCI or early dementia, and second to validate a new cognitive screening instrument, the Maze Task, developed to indicate the likely competence of older drivers with MCI or early dementia. 115 community-dwelling older drivers with MCI or early dementia were recruited through their association with the Memory Clinic, RGH. Partcipants completed the Maze Task, and immediately thereafter, a standardized on-road driving test. 70% of participants failed the on-road test, most broke an important road law, and nearly half required physical intervention to prevent a car crash. Almost 50% of those with MCI failed the driving test, while 75% of those with early dementia failed the same test. On-road driving faults were related to poor planning and observation skills, an inability to monitor and control the speed of the car, poor car positioning, confusion with pedals, and a lack of anticipatory or defensive driving. These results raise concern about the safe driving competence of older drivers with MCI or early dementia, and highlight the need for cognitive screening of driving ability. The Maze Task was found to be simple, brief to administer and score, and safe and acceptable to study participants. Maze Task scores were not influenced by sociodemographic variables. The association between the Maze Task and known measures of attention, visuoconstructional skills, and executive functions of planning and foresight may explain its predicitve validity. That is, the Maze Task discriminated with high accuracy those participants who passed the on-road test from those who failed the same test. Cognitive screening of older drivers in the primary care setting, with the Maze Task, requires further investigation.

Keywords

Older drivers, mild cognitive impairment, dementia, cognitive screening

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

Associated with the ageing of the Australian population is an increasing number of older drivers (aged 65 years and above). The trips that older people make by car connect them to health and social services, and to social activities that make it possible to live with quality. This increased dependence on driving is unfortunately with substantial cost. When the exposure data are taken into account, older drivers are at very high risk of crash, injury, and fatality. Dementing disorders associated with ageing are thought to contribute to impairment of driving ability, and thus the accident involvement of older drivers.

It may be estimated that there are 162,500 older drivers with cognitive impairment associated with the dementing process on Australian roads, and that 107,250 accidents per year may be attributable to these drivers. Driving with moderate or severe dementia represents a significant risk to road safety. Mild cognitive impairment (MCI) and early dementia are less reliable predictors of driving performance, and the point at which driving becomes unsafe is not easy to determine. Thus, with a predictable relationship between driving and MCI or early dementia yet to be firmly established, the aims of this study were, first, to describe the on-road driving performance of a group of older people with MCI or early dementia, and second, to validate a new cognitive screening instrument developed to indicate the likely driving competence of older people with MCI or early dementia. The instrument, named the Maze Task, was developed by the researcher as a timed pencil and paper test of attention, visuoconstructional skills, and executive functions of planning and foresight. These are cognitive domains considered on grounds of empirical evidence or conceptual plausibility to be critical to driving ability.

The voluntary study participants were 115 community-dwelling older drivers with MCI or early dementia, recruited through their association with the Memory Clinic, at the Repatriation General Hospital, Adelaide, South Australia. Participants completed the Maze Task, and immediately thereafter, an on-road driving test along a predetermined route.

Some 70% of the participants failed the on-road driving assessment, most broke an important road law, and nearly half required physical intervention by the driving assessor at least once during the assessment. Of the participants with MCI, almost half failed the on-road assessment, while three-quarters of those with early dementia failed the same test. Participant driving faults were related to poor planning and observation, an inability to monitor and control car speed, poor positioning of the car on the road, confusion with pedals, and a lack of anticipatory or defensive driving. These results raise concern about the safe driving competence of older drivers with MCI or early dementia. For reasons of individual and public road safety, a recommendation to preclude all older individuals with dementia, even in its early stage, from driving motor vehicles may well be appropriate. Frequent supervision and evaluation of older drivers with MCI may also be in order. The need to find a method of cognitive screening for driving impairment is highlighted.

The Maze Task fulfils all essential criteria for a cognitive screening instrument. The Maze Task was found to be simple, brief to administer and score, and safe and acceptable to the study participants. Maze Task scores were not related to participant age, gender, educational attainment, or country of birth, thereby providing a culture-free assessment. The association between the Maze Task and known measures of attention, visuoconstructional skills, and executive functions of planning and foresight may explain the Maze Task's predictive validity. That is, the Maze Task was able to discriminate, with high accuracy, those participants who passed the on-road test from those who failed the same test. It had good sensitivity and specificity. Highly specific tests tend to minimize the number of false-positive results, but increase the number of false negative results. MCI and early dementia tend to be slowly progressive, so those individuals with initial false-negative results would be identified on rescreening. The potential of the Maze Task, therefore, is that the most competent and the most dangerous drivers can be identified without a road test. It is hoped that the Maze Task may eventually serve as an adjunctive screening measure in the license renewal process of older drivers in Australia. This process currently includes screening of physical and sensory functions. Despite the important role of cognition in driving competence, and the high prevalence of cognitive impairment in the older population, cognitive screening is presently neglected. Population screening using the Maze Task requires further investigation.

1. INTRODUCTION

1.1   OLDER DRIVERS IN AUSTRALIA

Australia has around 10.4 million registered private passenger vehicles (ABS, 2003a). With an older population (aged 65 years and above) now proportionally around 12%, it may be estimated that up to 1.3 million passenger vehicles are registered to older drivers (ABS, 2003b). This is attributable to an increasing number of older people with driver's licenses, a more active and healthier older population, a greater amount of disposable income, the growing reluctance of individuals to change their modal transport behaviours once they enter retirement, and cars and roadways which are better engineered (Alsnih & Hensher, 2003; Kostyniuk & Shope, 2003). The trips that older people make by car connect them to the goods, services, activities, and social links that make it possible for them to live with quality and independence, and reduce the risk of premature morbidity and mortality by decreasing isolation and depression (Fildes, Lee, Kenny & Foddy, 1997; Fonda, Wallace & Herzog, 2001; Johnson, 2002; Kostyniuk & Shope, 2003; Marottoli et al., 2000; Odenheimer, 1993; Siren & Hakamies-Blomqvist, 2004; Stacey & Kendig, 1997).

The increased dependence of older Australians on driving is, unfortunately, with substantial cost. The older driver is at very high crash risk while driving. When the distance traveled is taken into account (that is exposure data) the fatality rate and injury severity escalates, despite evidence suggesting that older drivers frequently avoid situations of high risk such as inclement weather conditions and the peak hours of traffic (FORS, 1995; Fildes, 1997; OECD, 2001). Older drivers in Australia are also more at risk of being responsible for causing a crash. The odds are more than five to one (5.7 to 1) that an older driver (aged 80-84 years) involved in a fatal crash will be responsible for that crash. This figure is high compared to middle aged drivers (0.75 to 1) and young adolescent drivers (2.2 to 1). The crashes of older drivers tend to have the following characteristics: multi-vehicles; occurring during the daylight hours of weekdays; occurring at intersections or roundabouts; at low speed, and; involving failure to give way, improper turns, disregarding traffic signals or angle collisions (FORS, 1995).

Factors thought to contribute to impairment of driving ability, and thus the accident involvement of older drivers, relate to the normal biological changes associated with ageing. These have been comprehensively covered in the empirical literature, and include gradual decline in vision, hearing, reaction time, physical mobility, and psychomotor performance (Ball & Rebok, 1994; Campbell, Bush & Hale 1993; Eby, Molnar, Shope, Vivoda, Fordyce, 2003; FORS 1995, 1996; Ivers, Mitchell & Cumming, 1999; Johnson, 2003; Lyman, McGwin & Sims, 2001; Maltz & Shinar, 1999; Owsley et al., 1998; Reuben, Silliman & Traines, 1988; Richardson &Marottoli, 2003; Stefano & Macdonald, 2003; Stelmach & Nahom, 1992; Wallace 1997). Other related factors include how well older people adapt their driving behaviour to compensate for declining abilities, and the possible incompatibility of vehicles and roads with drivers' physical and functional capacities (Ball et al., 1998; Bedard, Guyatt, Stones & Hirdes, 2002; Gallo, Rebok & Lesikar, 1999; Marottoli et al., 1993; Wang & Carr, 2004).

It has also been suggested that while age-normal biological changes *per se* may contribute to some older driver crashes, it is the more pronounced changes associated with the chronic medical conditions associated with today's ageing population (AIHW, 2004a), particularly neurodegenerative and vascular diseases, that are in all contributing to crash rates (Dobbs, Triscott & McCracken, 2004; Johansson et al., 1997; O'Neill et al., 1992). Medications complicate the issue further (Drummer et al., 2004). This evolution represents a shift from a general approach of "why do older drivers have higher accident risk?" to a focus on high-risk subgroups, or "which older drivers have higher accident risk" (Hu, Trumble, Foley, Eberhard & Wallace, 1998). It was Waller, as long ago as 1967, who first hypothesised that cognitive decline associated with the dementing process may account for an increased risk of motor accidents in older drivers.

1.2   THE CONTINUUM FROM NORMAL AGEING TO DEMENTIA

The use of diagnostic criteria for the classification of dementia in both research and clinical settings has yielded three broad cognitive states: the first state is normal age-related decline; the second is cognitive impairment beyond normal ageing which is not sufficient enough to warrant a diagnosis of dementia, otherwise known as mild cognitive impairment (MCI); and the third state is dementia of which there are various types (Petersen et al., 2001; Petersen, 2003). Figure 1.1, below, depicts the theoretical continuum for those individuals who progress from normal ageing through to MCI and to dementia. There is some overlap in the boundaries between normal ageing and MCI, and between MCI and early dementia. A brief review of the features of normal cognitive ageing, MCI, and dementia is provided below.
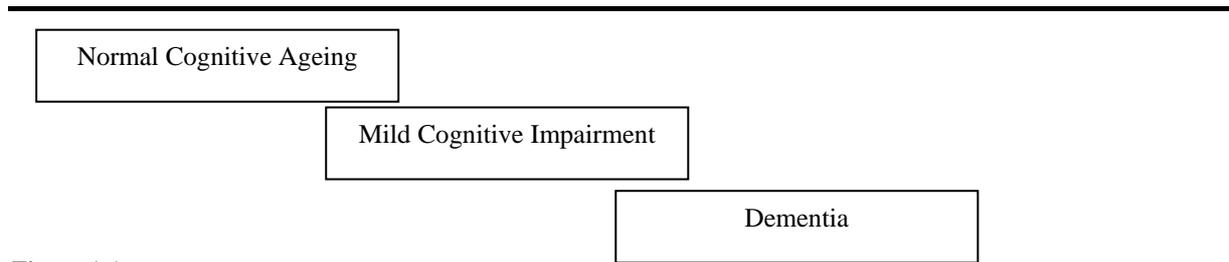
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┌─────────────────────────────────┐
│   Normal Cognitive Ageing       │
└─────────────────────────────────┘
        ┌─────────────────────────────────┐
        │   Mild Cognitive Impairment     │
        └─────────────────────────────────┘
                ┌─────────────────────────────────┐
                │          Dementia               │
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Figure 1.1

Theoretical continuum from normal cognitive ageing through to MCI and to dementia*

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* Note: Adapted from Petersen (2003)

1.2.1   Normal Cognitive Ageing.

The features of normal cognitive ageing have been well covered elsewhere in the literature. Overall, a decline in information processing speed, loss of efficiency in acquiring new information, cognitive inflexibility, and reduction in working memory function is indicated (Anstey, Hofer & Luszcz, 2003; La Rue, 1992; Nilsson, 2003; Salthouse & Meinz, 1995).

1.2.2   MCI.

Clinical criteria for MCI are given in Table 1.1. The risk factors for developing MCI itself, and prevalence rates for MCI, have not been well characterized. A prospective study in Finland using a population based sample of individuals aged 75 years and above found general ill health to be a strong associate of cognitive decline. Yet, stronger predictors of both cognitive decline and mortality were age, the Apolipoprotein E (APOE) genotype, manifest vascular disease, and diabetes (Tilvis et al., 2004). A population-based study of MCI in Finland found 5.3% of participants aged 60 to 76 years met MCI clinical criteria (Hanninen et al., 2002). The Leipzig Longitudinal Study of the Aged in Germany (Busse et al., 2003) found a prevalence rate for MCI among people aged 75 years and above of 3.1%, and an annual incidence rate of 8.5 per 1000 person years. The epidemiology of MCI for Australia remains unreported, but is expected to follow a similar pattern to these studies.

Table 1.1

Clinical criteria for MCI*

1.	Memory complaint, preferably corroborated by an informant
2.	Memory impairment at level of > 1.5 SD of age/education psychometric norms
3.	Clinical Dementia Rating (CDR) score of 0.5
4.	Intact general cognitive function
5.	Essentially preserved activities of daily living (ADLs)
6.	Not demented according to diagnostic criteria

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Note: *Adapted from Davis &Rockwood (2004), Kawas (2003), and Petersen (2003)

Large proportions of people with MCI will progress to dementia. Within patients demonstrating MCI, risk factors for progression to dementia include higher age, the APOE genotype, memory complaints, poor orientation to both time and place, concomitant cardiovascular disease, fewer years of education, and lower premorbid IQ (Amieva, et al., 2004; Arnaiz et al, 2004; Artero, Tierney, Touchon & Ritchie, 2003; Comijs et al., 2004; Jones, Laukka, Small, Fratiglioni & Backman, 2004; Rivas-Vazquez, 2004). Analyses indicate that approximately 15% of people with MCI develop dementia in 1 year, 40% over 2 years, 53% over 3 years, and 100% over 5 years (Amieva et al., 2004; Burns & Zaudig, 2002; Comijs et al, 2004; Ingles, Fisk, Merry & Rockwood, 2004; Luis et al, 2004; Palmer et al., 2003; Ritchie & Touchan, 2000; Small et al., 2003;). Given these high rates of conversion, some researchers contend that MCI is not a separate nosological entity but rather a state representing very early dementia (Fellgiebel et al, 2004; Morris et al., 2001; Ritchie, Artero & Touchon, 2001). The term "prodromal" dementia has been suggested as a potentially more useful concept than MCI (Dubois, 2000). Dementia prevention and disease modifying strategies are tending now to focus on non-diseased older individuals at risk of converting to dementia. Thus detection of MCI is critical, and MCI has become the new clinical and research frontier.

1.2.3   Dementia.

Dementia is a term used to describe the global impairment of higher cortical functions including memory, the capacity to solve the problems of day to day living, the performance of learned perceptuo-motor skills, and the correct use of social skills and control of emotional reactions, all in the absence of gross clouding of consciousness. Impairments are irreversible and progressive, and represent a significant decline from previous functioning (Royal College of Physicians' Committee on Geriatrics, 1981). Individuals pass through three clinical stages, as they gradually progress from the earliest (barely perceptible) to the most severe (profoundly incapacitating) manifestations of the disease. There exist a wide variety of clinical presentations, due not only to the varied etiology, but also variation in symptom presentation between individuals and across time. The four most common types of dementia are Alzheimer's disease, Vascular dementia, Frontotemporal dementia, and Dementia with Lewy bodies.

There are four major classes of cognitive functions impaired in dementia: receptive functions which involve the abilities to acquire, process, classify and integrate information; memory and learning by which information is stored and recalled; executive functions control volition, planning, programming, and monitoring of complex goal-directed behaviours which enable individuals to engage in independent, purposive, self-serving, socially appropriate behaviour, and expressive functions through which information is communicated or acted upon (Lezak, 1995; Luria, 1973; Sacks, 1985; Walsh, 1994). Cardinal cognitive symptoms of dementia are given in Table 1.2. Cognitive decline is associated with functional decline, risk of delirium episodes, and loss of independence in self-care abilities and other activities of daily living (ADLs) (Lichtenberg, Murman & Mellow, 2003).

Table 1.2

Cardinal cognitive symptoms of dementia*

Receptive functions	Poor attention, Distractibility, Disorientation (initially for time, later for place), Agnosia (a failure to recognise objects or people despite having knowledge of their characteristics)
Memory and learning	Impaired short-term memory (significant difficulty forming new memories, misplacing objects, forgetting names), Impaired long-term memory (remote, well learned memories are lost later)
Executive functioning	Poor skills of Computation, Reasoning, Judgment, Concept formation, Abstracting and generalizing, Ordering, Organizing, Planning, Analysis, Synthesis, Monitoring or inhibition of behaviour and emotional reactions
Expressive functions	Apraxias (a failure to carry out physical tasks despite having intact motor function), Aphasia (disorders of expressive and receptive language)

Note.   **Adapted from O'Brien, Ames & Burns (2000); Strub & Black (1981)*

Except for advancing age, a family history (including the APOE genotype), and cerebrovascular and cardiovascular diseases, no gender, race, environmental or health-behavioural factors strikingly increase the risk of dementia (Fitzpatrick et al., 2004; Heininger, 2000; Khachhaturian et al., 2004; Knopman, Boeve & Petersen, 2003; Pedersen, Gatz, Berg & Johansson, 2003; Qiu et al., 2004; Tsuang & Bird, 2002). In Australia, around 5% of 65 year olds suffer a dementing illness, rising exponentially to around 35% among those aged greater than 85 years. Most people with dementia have relatively long survival. Incidence rates for dementia rise from approximately 1 new case per 100 people per year for 65 year olds to 9 new cases per 100 people per year for those aged 85 years and above (Access Economics, 2003; Piguet et al., 2003). These rates follow a similar pattern to that observed throughout the developed world (Clark & Trojanowski, 2000; Evans et al., 2003; Fitzpatrick et al., 2004; Herbert, Scherr, Bienias, Bennett, & Evans, 2003; Hybels & Blazer, 2002; Kay, 1999; Wancata, Musalek, Alexandrowicz & Krautgartner, 2003).

1.3   DRIVERS WITH MCI OR EARLY DEMENTIA IN AUSTRALIA

Lipski (2002) estimated that there may be up to 80,000 demented drivers on Australian roads. This estimate is not based on recent evidence of the size of the older driving population, and does not explicitly account for

severity of cognitive impairment. Bridging census data, driving statistics, and MCI and early dementia prevalence rates requires logical reasoning when no empirical evidence is available. There are around 1.3 million private motor vehicles registered to people aged 65 years and above in Australia. If it is assumed that each of these vehicles is driven by just one older person, and that all individuals with MCI or early dementia are still driving, then according to the epidemiological data, approximately 5% (65,000) of these drivers will suffer early dementia, and another 5% (65,000) of drivers will suffer MCI. There may be up to 130,000 licensed drivers with MCI or early dementia on Australian roads. Moreover, at least 50% of individuals may continue to drive for up to three years following the onset of dementia, well into the moderate stage of the dementing illness (Carr et al., 2000; Dobbs, 2004; Foley, Masaki, Ross & White, 2000; Friedland et al., 1988; Hopkins et al., 2004). Thus, there may be an additional 32,500 (2.5%) licensed drivers with moderate dementia on Australian roads. In total, there may be approximately 162,500 older drivers on Australian roads with cognitive impairment associated with the dementing process.

It has been estimated that up to 50% of people driving with a dementing disorder have a "crash" (any contact between the vehicle and another object that may or may not result in property damage or personal injury) within a few years of diagnosis, 80% of those who have a "crash" continue to drive, 40% of those have at least one more crash, and as many as 27% of those asked to stop continue to drive (Carr et al., 2000; Dobbs, 2004; Foley et al., 2000; Friedland et al., 1988). If these proportions are applied to the estimated total population of Australian drivers with cognitive impairment associated with the dementing process (162,500), then the potential "crash" numbers per year are substantial (Table 1.3).

Table 1.3
Estimated potential crash numbers in Australia per year (2004)

Dobbs (2004) model	Estimated population per year (2004)
N drivers with MCI/dementia	162,500
N who have one crash (50% of above)	81,250
N who continue to drive following a crash (80% of above)	65,000
N who have subsequent crashes (40% of above)	26,000
Total number of potential crashes (sum of 1st & 2nd incidents)	107,250

It is clear from numerous review articles, editorials and investigations that driving with moderate to severe dementia poses a significant risk to individual and public road safety, and driving should be precluded in this population (Donnelly & Karlinsky 1990; Dubinsky et al., 1992; Freedman & Freedman, 1996; Graca, 1986; Hecker & Snellgrove, 2003; Johansson & Lundberg, 1997; Kazniak, Keyl & Albert, 1991; Lundberg et al., 1997; OECD, 2001; O'Neill, 1996; Post, Whitehouse & Fairhill, 1995; Rabins, Blacker & Bland, 1997; Reuben et al., 1988). MCI and early dementia are less reliable predictors of driving performance, and thus the issue of driving ability is under debate in Australia.

Lipski (1997; 2000; 2001; 2002) has adopted the view of the American Academy of Neurology (Dubinsky, Stein & Lyons, 2000). Academy guidelines recommend that people with mild dementia be precluded from driving. Recommendations also include driving evaluation and close supervision for people with MCI. Lipski argues that the definition of early dementia is broad and represents a vast, heterogeneous degree of cognitive impairments. Individuals with such impairments can still steer a car, even though they may be completely disoriented in time and place. They can rely heavily on their fixed perseverative implicit memory to drive familiar routes, but in the event of a sudden change in traffic conditions would be unable to rapidly process new stimuli. Lipski asks if a driver with early dementia is deemed safe to drive a motor vehicle, at what point will the driver be deemed unsafe. Drivers diagnosed with early dementia have usually already been in the MCI phase for 3 to 4 years before presentation. They have a continuing cognitive decline and there is no established objective end-point at which they should be retested or disqualified from driving before they pose a risk to public road safety.

There are few prospective studies on the actual on-road driving performance of people with early dementia, and not all of these studies also examine the relationship between MCI and driving performance. Hunt and colleagues (1993) examined the driving ability of 12 participants with incipient AD (otherwise known as MCI), 13 participants with mild AD, and 13 healthy control participants, revealing that all control and incipient AD participants were judged to be safe, while 40% of drivers with mild AD were unsafe drivers. In a follow-up study of 58 controls, 36 participants with MCI, and 29 participants with mild AD, employing the Washington University Road Test, Hunt and colleagues (1997) reported that 3% of controls, 19% of those with MCI, and

41% of participants with early AD failed the driving test. Duchek and colleagues (2003) longitudinally assessed the on-road driving performance of healthy older adults, and those with MCI and early stage AD, also finding that driving performance decreased as a function of severity of cognitive impairment. Nearly half of the 29 participants with early AD failed the driving test, whereas only 14% of the 21 participants with MCI, and 3% of the 58 healthy older controls failed. After repeated testing, there was evidence of a decline in driving skills across all three groups of drivers, including the healthy controls, but the greatest decline in longitudinal driving performance was in the mild AD group. Fitten and colleagues (1995) examined the on-the-road, behind-the-wheel performance of 15 patients with mild AD, and12 patients with mild vascular dementia. Compared to age and gender matched control groups, the groups with AD and vascular dementia had significantly lower mean scores on the driving test and made more errors in complex stages of the driving course. It was concluded that type and degree of cognitive impairment are better predictors of driving skills than age or medical diagnosis *per se*. Overall, evidence suggests that a classification of MCI or diagnosis of early dementia is a clear warning sign that an individual may not be competent to drive safely.

1.4   IDENTIFICATION OF AT RISK DRIVERS WITH MCI OR EARLY DEMENTIA

Given the risk profile of older drivers with cognitive impairment, researchers have investigated various ways of determining driving competence. Three approaches are reviewed below.

1.4.1   Driving Simulators and On-road Driving Assessments.

Studies have examined the suitability of driving simulators and on-road driving assessments in determining driving competence. Although the use of driving simulators is very appealing because they are uniform and safe, evidence indicates that performance in driving simulators is not strongly related to on-road driving performance (Barbas & Wilde, 2001; Byslma, 1997; Lundberg et al., 1997; Rizzo, McGehee, Dawson & Anderson, 2001). Moreover, older people have been shown to perform poorly on driving simulators, irrespective of their ability to drive, simply because they lack familiarity and confidence in the use of computers and electronic "games" (Turkington, Sircar, Allgar & Elliott, 2001). In contrast, on-road tests provide a reliable and valid functional assessment of driving ability in a "live" situation, and are currently considered the "gold standard" for assessment of driving fitness (Dobbs, 1997; Fox, et al., 1997; Hunt, Morris, Edwards & Wilson, 1993). Yet not all driving assessments are the same, and theoretical and practical concerns have been raised. Assessments are performed on different types of courses and with evaluators of differing qualifications and expertise in assessing older people. Second, the time and costs associated with widespread on-road driving assessment for individuals with cognitive impairment are potentially enormous, particularly since those drivers who do pass, would subsequently require re-testing in the future. Finally, there are also concerns regarding public and individual road safety, the liability of assessors, and the reluctance of older people to participate because of fears of license cancellation (Barbas & Wilde, 2001; Dobbs et al., 2004). The problems associated with both driving simulators and on-road driving tests largely render these techniques experimental rather than practical, and dictate a need for screening of driving ability in MCI and early dementia.

1.4.2   Screening with the Mini-Mental State Examination (MMSE).

The most common tool used in both clinical and research settings to screen for general mental status is the MMSE (Folstein, Folstein & McHugh, 1975). The utility of the MMSE as a predictor of driving ability has been considered in numerous studies, with inconsistent results, save and except for the obvious conclusion that people who score poorly on the MMSE are less likely to drive safely. One study found that MMSE scores were significantly related to driving simulator and on-road driving performance (Fitten et al., 1995). Fox and colleagues (1997) suggested that a MMSE score of 18 or above, out of a possible maximum score of 30, may be useful to indicate which individuals should undertake the relatively expensive option of on-road testing to confirm driver competence. In contrast, other studies (Dobbs, 1997; O'Neill et al., 1992; Reger et al., 2004) indicated that MMSE scores do not discriminate individuals with diminished driving ability from those with preserved ability. This may reflect the fact that mental status changes are reliably observed only in the middle to late stages of dementia, when changes in driving ability would be expected to be more universal. Moreover, the MMSE does not include assessment of executive functions (Brooke & Bullock, 1999; Dobbs, 1997; Dobbs et al., 2004; Fox et al., 1997; Hecker & Snellgrove, 2003; Johansson & Lundberg, 1997; Lampl, Sadeh, Laker & Lorberboym, 2003; Odenheimer et al., 1994; O'Neill et al., 1992; Royall, Palmer, Chiodo & Polk, 2004), and has varying accuracy in people of different premorbid intelligence, social classes, ages, educational levels, and ethnicities (Boustani et al., 2003; Brodaty, Kemp & Low, 2004; de Jager et al., 2003). A normal baseline score, or unchanged score, on the MMSE should therefore give no confidence that an older person remains competent to drive.

1.4.3   Screening with Neuropsychological Tests.

A frequent assumption in the literature has been that understanding the driving errors of dementia patients and how they differ from those of normal older and younger drivers is important for the development of appropriate neuropsychological assessment measures of fitness to drive (e.g. Dobbs, 1997; DeRaedt & Ponjaert-Kristoffersen, 2000). Neuropsychological tests are potentially valid, reliable and economical means for identifying at-risk drivers. IQ tests and screening tests, as well as numerous specific tests of individual functions, have all been tried on the basis of their being a part of current clinical test practice by psychologists (McKenna, Jefferies, Dobson & Frude, 2004).

However, researchers suggest that neuropsychological measures do not consistently or sufficiently correlate with driving competence (Bieliauskas, et al., 1998; Hunt et al., 1993; Lundberg et al., 1997; Ott et al., 2003, Withaar, Brouwer & Van Zomeren, 2000). This may well be a reflection of methodological disparity, and the absence of logical test choice. For example, studies have used differing instruments and differing scoring systems, patients with differing levels of cognitive decline or differing diagnoses, and differing criteria for driving competency. Other studies may be limited by retrospective designs with potential selection bias, indirect assessment of driving, or small sample sizes (Barbas & Wilde, 2001). Also, neuropsychological tests are designed to produce a wide variation in scores among people, and are too often IQ-related and sometimes bear no relation to the cognitive domains specifically involved in driving behaviour (McKenna, 1998; McKenna et al., 2004).

A recent meta-analysis of 27 primary studies conducted to examine the relationship between neuropsychological functioning and driving ability in older people with dementia revealed that deficits in the specific cognitive domain of visuoconstructional skills, best predict driving ability measured by way of on-road tests and non-road tests. Attentional skill was also significantly but weakly related to on-road driving performance across the studies (Reger et al., 2004).

So, although the utility of neuropsychological testing in identifying domain-specific impairment is promising, no valid screening test (or battery of tests), that indicates a driver's likely competence in terms of cognitive performance has been developed and actually taken up. In a review of 10 studies of driving and dementia, Adler, Rottunda and Dyksen (1996) suggested that although the incorporation of psychometric tests into driving evaluation is deemed important, researchers disagree on which tests are the best predictors and the stage at which driving should be discontinued. The quest for valid formulae to predict on-road performance is ongoing, and predicated on the simple reality that cognitive impairment affects behaviour, and therefore in some cases, will sabotage the ability to drive in a safe manner (McKenna et al, 2004).

1.5   SUMMARY AND STATEMENT OF THE OBJECTIVES OF THE PROJECT

Associated with the ageing of the Australian population are an increasing number of drivers with cognitive impairment associated with the dementing process. Even in its early stage, dementia brings about cognitive impairments, which may reduce driving competence. Similar deficits are evident for MCI, a prodromal form of dementia. A relationship between driving and MCI or early dementia is yet to be firmly established. This may be achieved by meeting the two objectives given below:

1.   Describe the on-road driving performance of a group of older people with MCI or early dementia.

2.   Validate a new cognitive screening instrument developed to indicate the likely competence of older drivers with MCI or early dementia. The conceptual development of this instrument, called the Maze Task, is described in the next section.

2.   DEVELOPMENT OF THE MAZE TASK

The Maze Task was developed by the researcher as a timed pencil and paper test of attention, visuoconstructional skills, and executive functions of planning and foresight. These are cognitive domains considered on grounds of empirical evidence or conceptual plausibility to be critical to driving ability, as described below.

2.1 COGNITIVE SKILLS ESSENTIAL FOR DRIVING COMPETENCE

The cognitive domain most frequently explored in relation to driving ability is attention (Reger et al, 2004). LaBerge (1995, 1997) made a distinction between three aspects of attention: selection, preparation, and maintenance. Selection is a rapid process, which typically is used in search tasks to separate a target from distractors. Preparation is a slower process, which occurs when an individual recruits attention in order to concentrate on an upcoming stimulus without being distracted by irrelevant events. Maintenance of attention is the ability to allocate attention toward a stimulus source over a relatively long duration of time. Parasuraman and Nestor (1991), and Duchek and colleagues (1997; 1998) have argued that selective attention is most specific to driving deficits in dementia. Identifying important information in the environment while ignoring irrelevant information may be especially important driving skills that older people with MCI or early dementia lack.

Drivers can compensate for declines in selective attention by driving more slowly, thereby allowing more time for information processing (Hakamies-Blomqvist, 1993). However, safe driving requires that a number of complex decisions are made while selecting attention between concurrent tasks, in a limited time frame determined for example, by external changes in traffic lights and movements of other traffic (OECD, 2001; Stutts, 2003). Tests of attention, therefore, are essentially timed.

Commonly researched timed neuropsychological tests of attention that inconsistently correlate with driving ability include Trail Making Tests A and B (Clark et al, 2001; Hunt et al, 1997; Odenheimer et al, 1994; Stutts, 1998) and the Digit Symbol Substitution Test (Carr, LaBarge, Dunnigan, & Storandt, 1998; Fox et al., 1997). Trails A and B provide assessment of speed of attention, sequencing, mental flexibility, and of visual search and motor function. The individual is required to connect, by marking pencil lines, 25 encircled numbers randomly arranged on a page in proper order (Part A), and connect 25 encircled numbers and letters in alternating order (Part B). Performance is scored according to time in seconds to complete each task, and number of errors. Digit Symbol is a subtest of the Wechsler Adult Intelligence Scale-Revised (WAIS-R, 1981). A pairing task provides a measure of ability to attend to, process, and remember symbols and pair them with the correct numbers. Using a key, the individual draws each symbol under its corresponding number in less than 120 seconds. Performance is scored according to the number of symbols correctly drawn within the time limit.

Visuoconstructional deficits are commonly observed in early dementia, as their neurological bases involve a number of loci in a widespread neural network (Benton, 1990; Zec, 1993). Deficits are represented by a disturbance in formative activities such as assembling, building, and drawing, so that an individual is unable to put together parts to make a whole (Benton, 1990). Unfortunately, the concept still requires better operational definitions (Benton, 1994). The importance of visuoconstructional skills to driving has been noted (Johansson & Lundberg, 1997; McKenna et al., 2004; Meyers, Volbrecht, Kaster & Bundgaard, 1999; Mitchell et al., 1995). Safe drivers must position the car accurately on the road and maneuver the vehicle correctly. Visuoconstructional skills are also important to judging distances and predicting the development of traffic situations.

Commonly researched neuropsychological tests of visuoconstructional skills which, again, inconsistently correlate with driving ability include the Block Design Test (Clark et al., 2001; Fox et al., 1997; Galski et al., 1996; Hunt et al., 1993; Reger et al 2004) and the Clock Drawing Test (CDT; Reger et al., 2004). Block Design is a subtest of the WAIS-R, and measures perceptual organizational ability. The individual is required to replicate a maximum set of 14 modeled or printed two-dimensional geometric patterns within time limits using two-colour cubes. Scores for completed correct designs constructed within the time limits are summed. The CDT (Brodaty & Moore, 1997; Shulman, Shedlestsky & Silver, 1986) is widely used in primary-care settings as well as secondary and tertiary health care centres, because of its ease of use (Burns, Lawlor & Craig, 1999; Heinik et al, 2004). It was originally developed to assess visuospatial and constructional abilities. Numerous versions with numerous scoring methods have been proposed. In the Memory Clinic setting, the individual is asked to freely draw a clock on a blank sheet of paper and set the hands to a specified time (e.g., 1.45), and the representation may then be simply scored as correct or incorrect. The CDT, which is brief, has not been taken up, perhaps because it evaluates global cognition and is therefore a poor screening tool for MCI and early dementia

(Diegelman et al., 2004; Nishiwaki et al., 2004; Powlishta et al., 2000); CDT performance relies heavily on age and education (Ainslie & Murden, 1993; Brodaty et al., 2004); and consensus has not yet been reached regarding a standardized administration and scoring approach (Kaplan, 1990; Royall et al., 1998; Scanlan, Brush, Quijano & Borson, 2002; Shulman, 2000). These factors can compromise screening accuracy.

2.2 THE ROLE OF EXECUTIVE FUNCTIONING IN DRIVING COMPETENCE

New conceptual understanding of the executive functions affected by the dementing process offers the potential to develop new screening instruments, which may be more accurate. Although attention and visuoconstructional skills represent a necessary foundation of ability to drive (Barbas & Wilde, 2001; Duchek et al, 1997; Johansson & Lundberg, 1997; Meyers et al, 1999; Mitchell, et al, 1995; Reger et al, 2004), these competencies, like all cognitive skills, require adequate supervision by the executive system of the brain, or the prefrontal cortex (McKenna, 1998; Royall, 2000; Trombly, 1995). The prefrontal cortex is the single largest cortical region in the human brain. It functions as an enormous association region, connected through cortical projections to all areas of the brain, providing it with the capacity to integrate multimodality information and respond accordingly. In addition, it is rich in connections from limbic and subcortical regions, such as the cingulate gyrus, hippocampus, basal ganglia, and the thalamus. This complex brain region plays an important role in executive functioning, a shorthand description of a multidimensional construct relating to a variety of loosely related higher-order cognitive processes including; abstraction, initiation, planning, directing and sustaining attention, perseveration, set shifting and monitoring of progress (Diesfeldt, 2004; Lezak, 1995; Rezai et al, 1993, Salthouse, Atkinson & Berish, 2003; Spreen & Strauss, 1998). These processes enable individuals to successfully carry out social and instrumental activities, such as engaging with others, planning activities, solving problems, and interacting with the environment to meet needs. Deficits in higher cognitive processing are directly related to behavioural disorganization and functional decline exhibited by poor impulse control, disinhibition, stimulus-driven behaviour, emotional lability, tactlessness, irritability, apathy, impaired motivation, reduced spontaneity, diminished verbal output, reduced motor output, poor organization, poor planning, impaired response set, disturbances in motor programming, impaired judgment, and poor abstraction (Chiu et al, 2004; Stern & Prohaska, 1996; Swanberg, Tractenberg, Mohs, Thal & Cummings, 2004). Notably, it is quite possible to find impairment in planning, flexibility of thought, and judgment without major change in general intellectual status (Spreen & Strauss, 1998).

Driving is a complex goal-directed activity. Executive abilities are thought to be important for dual task coordination (Logie, Cocchini, Della Sala, Baddeley, 2004), and necessary for car positioning, maintaining safe distances, driving on roundabouts, journey planning, estimating risk, and for adapting behaviour such as adjusting speed to traffic conditions (Radford & Lincoln, 2004). Thus, cognitive functions proposed to be critical to driving ability must include attention, visuoconstructional skills, and executive functioning.

It is likely that all dementias present with executive dysfunction, which is not well detected by traditional dementia scales within the structured testing situation. That is, most neuropsychological tests give the individual an explicit, brief task to solve. Typically the psychologist prompts task initiation and task success is well defined. Rarely is the individual required to plan and organize his or her behaviour over longer periods of time or to set priorities in the face of two or more competing tasks. It is, however, these kinds of abilities that are a large component of everyday activities (Lezak, 1995; Royall, 2000; Royall et al, 2004, Spreen & Strauss, 1998). Only recently, with improved understanding of neural systems in general, and frontal-subcortical connections in particular, has executive dysfunction been considered to have important implications for the etiology of MCI and early dementia (Chen et al, 2000; Guarch, Marcos, Salmero & Blesa, 2004; Hashimoto et al. 2004; Juby et al, 2002; Logie et al, 2004; Nathan, Wilkinson, Stammers & Low, 2001; Ownby, Loewenstein, Schram & Acavedo, 2004; Royall, Chiodo & Polk, 2004; Storandt & Beaudreau, 2004; Swanberg et al, 2004; Voss & Bullock, 2004).

Neuropsychological test scores sometimes reflect the integrity of both the cognitive domain in question and its executive control (Royall, Cordes & Polk, 1998). In the case of Trails A and B, Digit Symbol, Block Design, and CDT, a patient's performance requires the separate qualitative analysis of the executive control demanded by the testing paradigm, even though none of these tests were originally designed specifically to test executive dysfunction. For example, in addition to psychomotor speed, a major determinant of good performance on Trails A is the ability to establish and maintain response set, or rules. Patients with significant psychomotor slowing or problems directing attention tend to have difficulty with this task. Trails B provides a more challenging test of establishing and maintaining response set, as flexibility in response is required. Typical errors of individuals with frontal system impairment may include the inability to establish set, perseveration from Part A (e.g., connect only the numbers), and a failure to maintain set (e.g., lose track of the task being performed and switch from alternating between number and letter to only connecting the letters). Similarly, for the Digit Symbol task

patients with executive dysfunction will likely have difficulty establishing or maintaining set (e.g., digits rather than symbols will be paired with the digits). Qualitative aspects of performance on Block Design include an impulsive or careless approach to constructing the designs, an impaired ability to monitor performance and detect errors, difficulty in concept formation and planning as evidenced by a trial and error approach, and stimulus boundness (e.g., placing the blocks on the stimulus card). Qualitative analyses of individuals' difficulties on the freely drawn CDT also indicate executive dysfunction. For example, those with difficulty in planning and organization, or a tendency towards impulsiveness, will typically have difficulty accurately placing the numbers on the face of the clock. For those with a response set difficulties, numbers may continue until all the space is used up. Perseverative individuals often repeat one or more of the numbers (Stern & Prohaska, 1996). It may well be that such qualitative analyses of neuropsychological performance were absent in the studies reviewed by Reger and colleagues (2004). Hence, a relatively poor relationship between executive functions and measures of driving ability was shown.

A recent study examined the utility of executive measures as predictors of driving ability. Ott and colleagues (2003) administered a standard neuropsychological battery of timed tests examining discrete features of attention, visuoconstructional skills, and executive function to 27 participants with MCI or mild dementia. Tests included the following: Porteus Maze time and errors (Years VIII and XII; Porteous, 1959), the CDT, Animal Verbal Fluency (AVF; Tombaugh, Kozak & Rees, 1999) and Trails B time. In a forward stepwise regression analysis Porteus Maze drawing time emerged as the only significant predictor of driving ability, according to a 4-point caregiver rating. Unfortunately caregiver reports of driving ability may not be the best measure of a person's skills. Based on this result a computerized maze task, employing 10 mazes with a range of difficulty chosen from a computerized maze programme, was administered to a second sample of 40 normal older drivers and questionable to moderately demented drivers. Scoring of these mazes was complex. The total number of segments traversed determined path length. Maximum score was 100 times the correct path length (range 1400-3300). Final score was the maximum score minus 25 times the number of dead ends that are reached. The predictor variable was the grand total of all 10 scores for the different mazes. This score was significantly related to caregiver ratings of driving ability. Ott and colleagues concluded that the strength of the maze in the prediction of caregiver ratings of driving ability might reflect its overlapping relationship with attention, visuoconstructional skills and executive functioning.

However, this account by Ott and colleagues (2003) does not explain why other neuropsychological tests, such as Trails A and B, Digit Symbol, Block Design, and the CDT, which may also capture attention, visuoconstructional skills, or executive functioning, have not been shown to consistently correlate with on-road driving competence. It is known that constructs underlying executive ability are often unrelated (Diesfeldt, 2004; Lezak, 1995; Spreen & Strauss, 1998). For example, Kafer and Hunter (1997) gave 130 normal adults four tests purporting to measure planning/problem solving. A structured equation modeling approach suggested that the four tests were measuring different, unrelated constructs. The potential influences of specific executive functions on driving ability have not previously been considered.

The Porteus Maze Test (1959) was originally and uniquely designed to assess the specific executive functions of planning and foresight. Patients with planning and foresight deficits in particular make numerous errors and are unlikely to be able to complete more difficult items successfully. It is plausible to believe that planning and foresight may be related to driving ability, particularly anticipatory and defensive driving.

Thus, it is contended that along with attention and visuoconstructional skills, the critical executive functions related to driving ability are planning and foresight. A timed Maze Task may represent a novel means of screening all of these cognitive domains, and therefore driving competence in older people with MCI and early dementia.

2.3   PERFORMANCE CHARACTERISTICS AND VALIDITY OF THE MAZE TASK

A cognitive screening instrument able to predict on-road driving ability in older people with MCI or early dementia has frequently been advocated (Boustani et al., 2003; Duchek et al., 1997; Hecker & Snellgrove, 2003b; Hopkins, Kilik, Day, Rows & Tseng, 2004; Hunt et al., 1993; Lundberg et al., 2003; McKenna, 1998; Mitchell, Castleden & Fanthome, 1995; O'Neill, 2000; Reger et al., 2004; Valcour, 2001). In response to this need, a new timed Maze Task has been developed. Ideally, the Maze Task would meet all of the following criteria:
- Be extremely simple, brief to administer and score, safe and acceptable to patients.
- Be relatively free of possible confounding effects of sociodemographic variables of age, gender, educational attainment, and country of birth.

- Provide an assessment of discrete cognitive domains required for safe driving including attention, visuoconstructional skills, and executive functions of planning and foresight.
- Discriminate, with high accuracy, older drivers with MCI or early dementia who pass a standardized on-road driving assessment from older drivers with MCI or early dementia who fail the same on-road assessment.

<u>**3 METHOD**</u>

This study was designed as an evaluation of a screening instrument, using a convenience sample of community-dwelling older drivers with MCI or early dementia.

3.1 PARTICIPANTS

The voluntary participants were consecutively referred first-time patients of the outpatient Memory Clinic, at the Division of Rehabilitation, Aged Care, and Allied Health, Repatriation General Hospital (RGH) in Adelaide, South Australia.

3.1.1 Participant Inclusion Criteria

Participants who met all of the following criteria were eligible for this study:
- Male or female aged 65 years or older.
- Residing in the community.
- A licensed motor vehicle driver.
- An incident classification of mild cognitive impairment (MCI) (CDR score=.5), or diagnosis of probable dementia (all dementia types included) of mild severity, according to DSM-IV (1994) criteria.
- A Mini-Mental State Examination score (MMSE; Folstein, Folstein & McHugh, 1975) at initial assessment ranging from 18-30 points.
- Exhibit sufficient visual, hearing, and communication capabilities to complete an on-road driving assessment. Glasses and hearing aids were permitted.
- Written informed consent was given by the participant in accordance with the requirements of NHMRC Guidelines on Human Experimentation.

3.1.2 Participant Exclusion Criteria

Participants meeting one or more of the following criteria were excluded;
- Aged 64 years or younger.
- Residing in a care facility (e.g., hostel or nursing home)
- Unlicensed to operate a motor vehicle.
- Classification of mild cognitive impairment (MCI) or diagnosis of probable dementia (of any type), according to DSM-IV (1994) criteria, not met, or not incident.
- A MMSE score at initial assessment of 17 points or less.
- Unable to exhibit sufficient visual, hearing and communication capabilities to complete an on-road driving assessment.
- Cognitive impairment resulting from acute cerebral trauma or injuries secondary to chronic trauma; hypoxic cerebral damage; vitamin deficiency states such as folate, Vitamin B12 and other B complex deficiencies; infection such as cerebral abscess, neurosyphilis, meningitis or encephalitis; significant endocrine or metabolic disease; mental retardation or oligophrenia.
- Co-existing medical conditions known to affect on-road driving performance including uncontrolled epilepsy or convulsions; current clinically significant psychiatric disease, current clinically significant cardiovascular disease; history of drug or alcohol abuse within the last year, or prior prolonged history.
- The participant did not provide written informed consent.

3.2 PARTICIPANT RIGHTS AND CONSENT

Following ethical approval, participants were recruited into the study as described below. The literature indicates that individuals with MCI or early dementia are competent to provide informed consent (Buckles et al., 2003; Fry, 1999; Karlawish & Casarett, 2001; Marson, Dymek & Geyer, 2000; Sachs, 1998).

All participants were informed at recruitment, in both written and oral format, that they were free to refuse to participate in any way, or were free to withdraw from the study at any time, without any prejudice to ongoing assessment, diagnosis, and management received at the Memory Clinic.

3.2.1 Selection and recruitment of participants

Each new assessment at the Memory Clinic routinely required participant attendance on two separate occasions. On the first Memory Clinic visit, participant medical and social history, medical examination, blood testing and neuroimaging was conducted/ordered by a consultant geriatrician, and the MMSE was administered to all

participants by a psychologist or nurse. Thus, all information required to determine whether participants met inclusion or exclusion criteria were recorded as part of the standard work-up at this first visit.

Clinical circumstances determined that some, but not all, participants were also cognitively assessed at the first Memory Clinic visit using the Alzheimer's Disease Assessment Scale-Cognitive Subscale (ADAS-Cog; Rosen, Mohs & Davis, 1984), the Animal Verbal Fluency test (AVF; Tombaugh, Kozak & Rees, 1999), or the Executive Interview (EXIT-25; Royall, Mahurin & Gray, 1992; Royall, 2000). Each is briefly described in turn. The ADAS-Cog was designed to evaluate the severity of cognitive dysfunctions characteristic of individuals with AD, and includes components of memory, language, and praxis. It has become the gold standard of cognitive scales used in pharmaceutical trials. Composite scores range from 0 to 70, with scores ranging from 11 to 14 representing MCI, and 15 to 25 representing mild to moderate AD. The AVF test evaluates the spontaneous production of words of a given class within a limited amount of time. Cognitively intact older people name around 13 to 16 animals. Word repetitions or words from an incorrect class indicate errors. The EXIT-25 includes items which relate to specific executive functions of perseveration, disinhibition, frontal lobe release signs, verbal intrusions, imitation, loss of spontaneity, environmental dependence, sequencing and self-monitoring. It is not purported to measure executive functions of planning and foresight. Scores from 0 to 50 are possible with higher scores correlating with greater executive dyscontrol. The Digit Symbol (WAIS-R, 1981) and the CDT (Brodaty & Moore, 1997; Shulman et al., 1986) were also administered to some participants. These tests have been described previously in this report. Any available test scores from this first Memory Clinic visit were recorded in participant files.

On the second Memory Clinic visit, a week following the first, participants met with a consultant geriatrician to discuss their diagnosis, prognosis, and treatment options. Participants with incident MCI or dementia who met inclusion criteria had their files flagged by the researcher, and were invited by the consultant geriatrician at this second visit to meet with the researcher, who explained and provided written information about the project for participants to read and retain, and answered relevant questions. A study appointment was scheduled within 10 working days of the second Memory Clinic visit, and given to participants in writing. At the study appointment, a short introduction was provided by the researcher, designed to ensure consistency of approach and maximize response. Each participant proceeded to read the information sheet, before being invited to sign a consent form.

3.2.2   Participant Assessment
Participant assessment had three elements as follows:

The Maze Task. The researcher developed the Maze Task, a pencil and paper test of attention, visuoconstructional ability, and executive functions of planning and foresight. Administration of the Maze Task on an earlier development sample of 10 Memory Clinic patients indicated that it was acceptable for use. Study participants completed a simple demonstration maze first, in order to establish the rule set. Demonstration tasks are commonly utilised in neuropsychological assessment, and are generally not scored (Lezak, 1995; Spreen & Strauss, 1998). Participants then completed the Maze Task. Performance was scored according to time (in seconds) to complete the test measured by a stopwatch, and total number of errors. Errors were determined by counting the number of times a participant entered a dead-end alley or failed to stay within the lines.

A structured interview. Relevant participant demographic details including gender, age, country of birth, postcode of residence, highest educational attainment, occupational status (1=unskilled, 2=trade/service/clerk, 3=manager, professional), self-rated health (1=excellent, 2=very good, 3=good, 4=fair, 4=poor), health trajectory (1=much better, 2=somewhat better, 3=about the same, 4=somewhat worse, 5=much worse), number of years as a licensed driver, average number of driving days per week in the last three months, and average number of kilometres (kms) driven per week in the last three months, and usual method of travel to shops, medical appointments, and social/recreational events were collected via interview format.

An on-road driving assessment. The driving assessment comprised a 45-minute in-traffic road test along a predetermined route, using current Licensing Authority (Transport SA) vehicle on road test (VORT) criteria. The assessment was given to all participants in a standard manual or automatic 1998 Toyota Corolla (according to the participants' preferences) with power steering, electronically operated windows, an engine cut-off switch, and dual braking systems. All tests were conducted at approximately the same time of day, and in light road and clear weather conditions, in order to ensure consistency and maximize safety. An assessor, authorized and accredited to conduct driving assessments for Transport SA, and with specific expertise in the assessment of fitness to drive of people with a range of medical conditions and physical disabilities, including dementia, was seated in the front next to the participant.

The on-road driving assessment was conducted in traffic around both business and residential areas, and assessed typical driving skills including maintaining speed, obeying traffic signs, signaling, turning, yielding right of way, changing lanes, anticipating and reacting to traffic conditions, negotiating intersections, and parallel parking. The assessor scored, along the route, errors in these skills and maneuvers using a Transport SA VORT scoring sheet, yielding quantitative scores for left turn errors (%), right turn errors (%), and general drive errors (%), from which an overall result (%) was calculated. Inter-item reliability was very high (Cronbach's alpha = .87). In order to additionally describe the on-road driving performance of participants, total number of law breaks (e.g. failure to adhere to speed limits or failure to stop at stop signs) was scored. Total number of physical interventions provided by the assessor was also scored. Physical interventions included taking control of the steering wheel, or applying the brakes, and were utilised to ensure the safety of participants and other road users, by preventing car crashes.

The driving assessment was intended to reveal the driving errors that are associated with cognitive decline while excluding those errors shown to be "bad habits" of experienced competent drivers. Such a habit may include failing to indicate for 5 seconds before changing lanes or entering traffic. For this reason a lowered overall result of 70% or above was selected to entitle the participant to a "pass" and 69% or below a "fail". With learner drivers, Transport SA requires an overall result of 85% or above for a "pass". The singular advantage of this pass/fail criterion is that it has obvious practical relevance. Failure genuinely carries the implication of "not fit to drive".

Two assessors were utilised across the course of the study. They were unaware of the cognitive status of all participants. Both assessors scored participant competency for a sub-sample (n=32) of on-road driving assessments. One assessor was seated next to the driver and gave instructions; the other was seated on the back seat. The inter-rater reliability was assessed by way of the intraclass correlation coefficient (ICC) using a two-way mixed model as suggested by Bravo and Potvin (1991), McGraw and Wong (1996), and Shrout and Fleiss (1979). The inter-rater reliability for all aspects of the on-road driving assessment was moderate to high. There was complete agreement between the assessors regarding the overall result as a pass or fail (please see Table 3.1).

Table 3.1
Inter-rater reliability for the on-road driving assessment

Criteria	ICC Value	95% CI	$F(31)$
Left turn faults	.64	.25-.82	2.74*
Right turn faults	.64	.25-.82	2.74*
General drive faults	.81	.61-.91	5.22**
Overall result as a percentage	.84	.67-.92	6.28**
Number of law breaks	.92	.85-.96	13.70**
Number of interventions	.98	.92-1.00	17.76**
Overall result as pass or fail	1.00	1.00-1.00	-

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Note. ICC=Intraclass correlation coefficient
　　　*p<.01, **p<.001

3.3 DATA COLLECTION PROCEDURE

All consenting participants met licensing and vision requirements. The researcher administered the participant assessments in the order of the Maze Task and structured interview. These were immediately followed by the on-road driving test, conducted by one or both authorized and accredited assessors. The researcher collected the results of the on-road assessment from the assessor/s at completion. Participants were given verbal feedback regarding their on-road assessment result by the assessor/s. The researcher recorded the feedback in writing. All participants who failed the on-road driving assessments were counseled immediately by the researcher to cease driving, and again in writing within 1 week of the assessment. A copy of the letter advising driving cessation was also sent to the participants' referring GPs and RGH case notes. In total, the duration of this procedure averaged 2 hours for each participant, of which the administration and scoring of the Maze Task averaged a total of 2 minutes.

3.4 ESTIMATED SAMPLE SIZE AND DATA ANALYSES

A screening test is unquestionably a valid indicator of a condition if it has high sensitivity and high specificity. To estimate a sensitivity of 85% within ten percentage points of the true value and with 95% confidence, a sample size of 49 participants was required. To estimate a specificity of 85% within ten percentage points and with 95% confidence, another sample size of 49 participants was needed, leading to a total sample size requirement of 98 participants (Lwanga and Lemeshow, 1991).

Data were coded and entered into an IBM compatible system using SPSS for Windows, version 11.5 statistical software package (2002). Edit checks were applied to ensure that the data entry was syntactically correct, and that all fields requiring a code had one allocated. Sample characteristics, on-road driving performances, and Maze Task characteristics were described.

As Maze Task time and error scores did not approximate to normal distributions, Spearman's Rank-Order Correlation coefficients or Chi-Square tests were used to examine the freedom of Maze Task scores from the influence of sociodemographic variables of age, educational attainment, gender, and country of birth. Spearman's Rank-Order Correlation coefficients were also computed between Maze Task time and error scores and available total scores from the Memory Clinic's neuropsychological protocol: MMSE, ADAS-Cog, AVF, AVF errors, EXIT-25, Digit Symbol, Digit Symbol errors, and CDT.

Logistic regression analysis using the enter procedure was utilised to develop an equation for prediction of on-road assessment outcome based on Maze Task time and error scores. Three models were presented. The Wald Chi-Square test assessed the significance of the variables in the models. The fit of the models was assessed by the Hosmer and Lemeshow test (Hosmer and Lemeshow, 1989). A p value of <0.05 was considered to indicate statistical significance. A regression equation was developed from the model that most parsimoniously fit the data.

To select the optimal Maze Task cut-point to discriminate on-road driving assessment passes from fails, receiver operating characteristic (ROC) curves were constructed (DeLong, DeLong & Clarke-Pearson, 1988; Hanley & McNeil, 1982; 1983; Swets & Pickett, 1982). Epi Info 6, Version 6.04d (2001) was then utilised for calculation of the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the Maze Task. Prevalence of on-road driving failure was also calculated.

4. RESULTS

4.1 SAMPLE CHARACTERISTICS

154 consecutive participants who met inclusion criteria were invited to participate in this study. Thirty-nine (25.3%) refused to participate. Reasons for refusal, when offered, are shown in Table 4.1. Notably, of the 26 participants who kindly offered a reason for refusal, 10 (38%) indicated a willingness to relinquish their driver's license rather than take an on-road test.

As the age, gender, and general cognitive status of all participants of the Memory Clinic were recorded, participants were compared with non-consenters on these variables. The age of non-consenters (mean=76.94, SD=7.0 years) was not significantly different from those who consented (mean=76.96, SD=5.87 years), ($t(150) = 0.00$, ns). There was a weak trend towards a higher refusal rate for males than females (54.3% and 45.7% respectively), although this difference was not statistically significant ($\chi^2(1)$=0.84, ns). The general cognitive status of non-consenters (mean MMSE score 24.08, SD=3.06) was not significantly different from consenters (mean MMSE score=24.21, SD=2.77), ($t(141)$=0.20, ns). Therefore the obtained sample did not differ from those who declined to participate in terms of age, gender, and general cognitive status.

Table 4.1

Self-reported reasons for refusal to participate (n=39)

Reason	*n*	%
Will relinquish driver's license rather than take a driving test	10	25.6
Will take a Transport SA driving test rather than participation	5	12.8
So confident in driving ability that a test is considered unnecessary	4	10.3
A driving test is just too stressful, and best avoided	2	5.1
Already have a lot to deal with, having just received a diagnosis	1	2.5
Only driver in the family, and thus don't want to risk losing license	1	2.5
There is no legal requirement to undertake a driving test	1	2.5
Inconvenient to travel from rural region to the RGH	1	2.5
Can't be bothered	1	2.5
No reason offered	13	33.7

The participants were 115 community dwelling older drivers (73 males of mean age 77.1 years [SD=6.4, range=65-91 years], 42 females of mean age 76.8 years [SD=4.9, range=65-88 years]). The sociodemographic characteristics of the participants were categorised by age group (65-74 years, 75-84 years, 85+ years), and are shown in Table 4.2. A number of features of the sample are notable. Participants across age categories were predominantly male. This is unsurprising for older drivers (e.g. Raitanen, Tormakangas, Mollenkopf & Marcellini, 2003; Siren & Hakamies-Blomqvist, 2004; Stacey & Kendig, 1997). Three quarters of the sample were born in Australia, located in the inner metropolitan area, and residing in a house. Two thirds of participants were married. The majority of participants had received at least some formal secondary (high school) education. Most participants were not working. These participant sociodemographic characteristics approximate those of the older Australian population drawn from 2001 census data and reported in the *Census of Population and Housing: Ageing in Australia 2001* (ABS, 2003c), and *Older Australia at a Glance* (AIHW, 2002).

The cognitive and self-reported health status of the participant group, categorised by the same age groups, is presented in Table 4.3. Notably, most participants reported their health to be good or better, and unchanged from the previous year. This pattern is similar to that described in the *1997 National Survey of Mental Health and Wellbeing of Adults* conducted by the Australian Bureau of Statistics (AIHW, 2002). Large proportions of participants reported a brief history of memory impairment (2 years or less). Three quarters of participants reported no history of confusion. Self-reported cognitive status was consistent with the objective measure of general cognitive functioning administered to all participants. That is, the mean MMSE score of 24.6 (SD=2.9) for the sample was in the mild range of general cognitive impairment, and at the suggested cutoff score for cognitively intact versus mildly demented individuals (Tombaugh & McIntyre, 1992; Tombaugh, McDowell, Krisjansson & Hubley, 1996). A larger proportion of the sample had received a diagnosis of early dementia than of MCI. The age of participants with MCI (mean=76.43, SD=6.4 years) was not significantly different from

those with early dementia (mean=77.09, SD=5.76), (t(113) = 0.48, ns). There was no significant difference in the gender composition of the MCI and early dementia groups ($\chi^2(1)$=0.6, ns). As expected the general cognitive status of participants with MCI (mean MMSE score=26.52, SD=1.59) was significantly higher than those with early dementia (mean MMSE score=23.63, SD=2.70), (t(113) = 4.90, p<.001). Of participants with early dementia, the most common diagnosis was of Alzheimer's disease (n=60, 65.2%), followed by vascular dementia (n=18, 19.5%), frontotemporal dementia (n=12, 13.0%), and dementia with Lewy bodies (n=2, 2.1%). These distributions are consistent with available epidemiological information regarding MCI and dementia (e.g. Johansson & Lundberg, 1997; Leifer, 2003; Lichtenberg et al., 2003).

The self-reported driving patterns of the sample, categorised by age, are presented in Table 4.4. Most participants had driving experience spanning half a century. Participants relied heavily on their own driving ability for travel to shops, medical appointments, and social or recreational events. These data are consistent with the literature pertaining to the driving patterns of older people (e.g. Raitanen, et al., 2003; Siren & Hakamies-Blomqvist, 2004; Sommer, Falkmer, Bekiaris & Panou, 2004; Stacey & Kendig, 1997; Tuokko et al., 1995).

Table 4.2

Sociodemographic characteristics of the study participants by age group (N = 115)

| | Age group (years) | | | |
	65-74	75-84	85+	Total, (%)
Age group n, (%)	35 (30.4)	67 (58.3)	13 (11.3)	115 (100)
Gender n, (% within gender)				
Male	23 (31.5)	39 (53.4)	11 (15.1)	73 (63.5)
Female	12 (28.6)	28 (66.7)	2 (4.8)	42 (36.5)
Country of birth n, (% country)				
Australia	21 (24.4)	53 (61.6)	12 (14.0)	86 (74.8)
Outside Australia	14 (48.3)	14 (48.3)	1 (3.4)	29 (25.2)
Postcode of residence n, (% within stratum)				
Inner metropolitan	24 (26.4)	54 (59.3)	13 (14.3)	91 (79.1)
Outer metropolitan	8 (47.1)	9 (52.9)	0	17 (14.8)
Rural	3 (42.9)	4 (57.1)	0	7 (6.1)
Type of residence n, (% within residence type)				
House	31 (36.0)	47 (54.7)	8 (9.3)	86 (74.8)
Unit/Flat/Apartment	4 (13.8)	20 (69.0)	5 (17.2)	29 (25.2)
Marital status n, (% within marital status)				
Married/defacto	22 (28.9)	47 (61.8)	7 (9.2)	76 (66.1)
Separated/widowed	10 (28.6)	19 (54.3)	6 (17.1)	35 (30.4)
Single/never married	3 (75.0)	1 (25.0)	0	4 (3.5)
Educational attainment n, (% within educational levels)				
Primary school	4 (20.0)	11 (55.0)	5 (25.0)	20 (17.4)
Secondary school	21 (34.4)	37 (60.7)	3 (4.9)	61 (53.0)
Trade certificate	5 (26.3)	13 (68.4)	1 (5.3)	19 (16.5)
University degree	5 (33.3)	6 (40.0)	4 (26.7)	15 (13.0)
Current/previous type of employment n, (% within employment type)				
Unskilled	3 (33.3)	4 (44.4)	2 (22.2)	9 (7.8)
Trade/service/clerk	16 (30.2)	33 (62.3)	4 (7.5)	53 (46.1)
Manager/professional	16 (30.2)	30 (56.6)	7 (13.2)	53 (46.1)
Employment status n, (% within employment status)				
Paid work	3 (75.0)	1 (25.0)	0	4 (3.5)
Voluntary work	9 (47.4)	10 (52.6)	0	19 (16.5)
Not working	23 (25.0)	56 (60.9)	13 (14.1)	92 (80.0)

Table 4.3

Self-reported health and objective cognitive status of the study participants by age group (N=115)

	Age group (years)			
	65-74	75-84	85+	Total (%)
Age group n, (%)	35 (30.4)	67 (58.3)	13 (11.3)	115 (100)
Self-rated health n, (% within health category)				
Excellent	8 (29.6)	16 (59.3)	3 (11.1)	27 (23.5)
Very good	11 (24.4)	29 (64.4)	5 (11.1)	45 (39.1)
Good	11 (39.3)	15 (53.6)	2 (7.1)	28 (24.3)
Fair	5 (38.5)	6 (46.2)	2 (15.4)	13 (11.3)
Poor	0	1 (50.0)	1 (50.0)	2 (1.7)
Health trajectory from previous year n, (% within health trajectory)				
Much better	3 (60.0)	1 (20.0)	1 (20.0)	5 (4.3)
Somewhat better	0	5 (100)	0	5 (4.3)
About the same	27 (32.1)	49 (58.3)	8 (9.5)	84 (73)
Somewhat worse	5 (26.3)	10 (52.6)	4 (21.1)	19 (16.4)
Much worse	0	2 (100)	0	2 (1.7)
Years since onset of memory impairment n, (% within year)				
0	5 (13.9)	25 (69.4)	6 (16.7)	36 (31.3)
1	13 (36.1)	18 (50.0)	5 (13.9)	36 (31.3)
2	8 (38.1)	12 (57.1)	1 (4.8)	21 (18.3)
3	4 (50.0)	4 (50.0)	0	8 (7.0)
4	2 (40.0)	3 (60.0)	0	5 (4.3)
5	2 (40.0)	2 (40.0)	1 (20.0)	5 (4.3)
7	0	2 (100)	0	2 (1.7)
10	1 (50.0)	1 (50.0)	0 (0.0)	2 (1.7)
Years since onset of confusion n,(% within year)				
0	22 (30.1)	40 (54.8)	11 (15.1)	73 (63.5)
1	3 (16.7)	14 (77.8)	1 (5.6)	18 (15.7)
2	6 (40.0)	9 (60.0)	0	15 (13.0)
3	1 (25.0)	3 (75.0)	0	4 (3.5)
4	1 (50.0)	1 (50.0)	0	2 (1.7)
5	1 (50.0)	0	1 (50.0)	2 (1.7)
8	1 (100)	0	0	1 (0.9)
Objective cognitive status				
MMSE Mean	24.60	24.15	23.46	24.21
SD	2.93	2.85	1.76	2.77
Range	18-29	18-29	19-26	18-29
Diagnosis n, (% within diagnosis)				
MCI	9 (39.1)	12 (52.2)	2 (8.7)	23 (20.0)
Early dementia	26 (28.3)	55 (59.8)	11 (12.0)	92 (80.0)

Table 4.4
Self-reported driving patterns of the study participants by age group (N=115)

	Age group (years)			
	65-74	75-84	85+	Total (%)
Age group n, (%)	35 (30.4)	67 (58.3)	13 (11.3)	115 (100)
Years as licensed driver				
Mean	47.40	53.85	68.62	53.56
SD	8.58	8.89	4.15	10.35
Range	22-60	30-68	60-75	22-75
Average days/week driving in last 3 months				
Mean	5.42	4.90	4.39	5.00
SD	1.79	1.98	2.06	1.94
Range	2-7	1-7	2-7	1-7
Average kms/week driving in last 3 months				
Mean	107.46	90.50	57.92	92.29
SD	93.04	102.79	44.59	95.68
Range	20-400	3-400	10-150	3-400
Usually travel to the shops by n,(% within mode of travel)				
Don't go to shops	0	3 (100)	0	3 (2.6)
Public transport	0	0	0	0
Taxi	0	0	0	0
Passenger in car	2 (66.7)	1 (33.3)	0	3 (2.6)
Drive car	28(29.2)	56(58.3)	12 (12.5)	96 (83.5)
Walk	5 (38.5)	7 (53.8)	1 (7.7)	13 (11.3)
Usually travel to medical appointments by n, (% within mode of travel)				
Don't go to Dr	0	0	0	0
Public transport	0	0	0	0
Taxi	0	3 (75)	1 (25)	4 (3.5)
Passenger in car	2 (18.2)	8 (72.7)	1 (9.1)	11 (9.6)
Drive car	29 (30.9)	55 (58.5)	10 (10.6)	94 (81.7)
Walk	4 (66.7)	1 (16.5)	1 (7.7)	6 (5.2)
Usually travel to social/recreational events by n, (% within mode of travel)				
Don't go out	0	1 (100)	0	1 (0.9)
Public transport	0	1 (50.0)	1 (50.0)	2 (1.7)
Taxi	0	1 (100)	0	1 (0.9)
Passenger in car	4 (33.3)	7 (58.3)	1 (7.7)	12 (10.4)
Drive car	29 (29.9)	57 (58.8)	11 (11.3)	97 (84.3)
Walk	2 (100)	0	0	2 (1.7)

4.2   ON-ROAD DRIVING ASSESSMENT PERFORMANCES

Most participants completed the on-road assessment (*n* = 112, 97.5%). The assessors discontinued the on-road test for 3 participants (2.5%), at approximately the 35 minute mark of the 45 minute route, as their driving performances posed a serious traffic hazard. It was considered that such discontinuation did not compromise the proportional scores for these participants (relative to other participants), from which their overall results were calculated. These data were, therefore, included in analyses.

Participants (*N*=115) were scored on a number of aspects of their driving. The distributions for left turn faults (%), right turn faults (%), general drive faults (%), overall result (%), and law breaks were approximately normal (Table 4.5). However, it can be seen that the distribution for physical interventions was substantially positively skewed and leptokurtic.

Table 4.5
Distribution of on-road assessment scores (N=115)

	Skewness	SE of Skewness	Kurtosis	SE of Kurtosis	Lilliefors
Left turn faults (%)	.60	.22	-.37	.44	.11 (p=.003)
Right turn faults (%)	.33	.22	-.61	.44	.07 (p>.20)
General drive faults (%)	.50	.22	-.05	.44	.06 (p>.20)
Overall result (%)	-.42	.22	-.43	.44	.05 (p>.20)
No. of law breaks	.29	.22	-.35	.45	.07 (p=.06)
Physical interventions	1.99	.22	4.20	.45	.31 (p=.000)

Histograms for on-road driving assessment left turn faults (%), right turn faults (%), and general drive faults (%) are given in Figures 4.1 to 4.3 respectively. The mean percentage of right turn faults (mean=44.27, *SD*=23.74, range=0-100%) was significantly higher than the mean percentage of left turn faults (mean= 38.53, *SD*=25.56, range=0-100%), (t(114)=3.56, p<.001), and the mean percentage of general driving faults (mean= 39.06, *SD*=21.51, range=0-100%), (t(114)=3.16, p<.05).
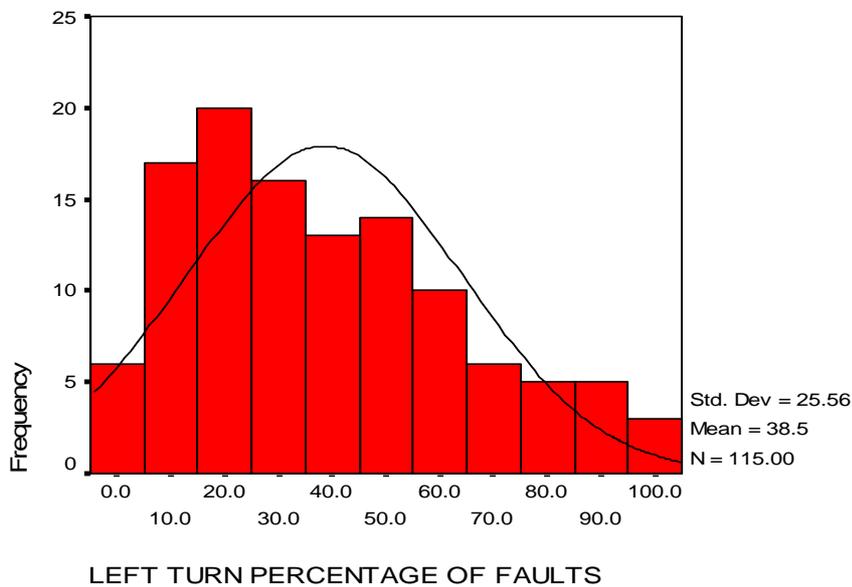

Figure 4.1   *Histogram of on-road driving assessment left turn faults (%)*
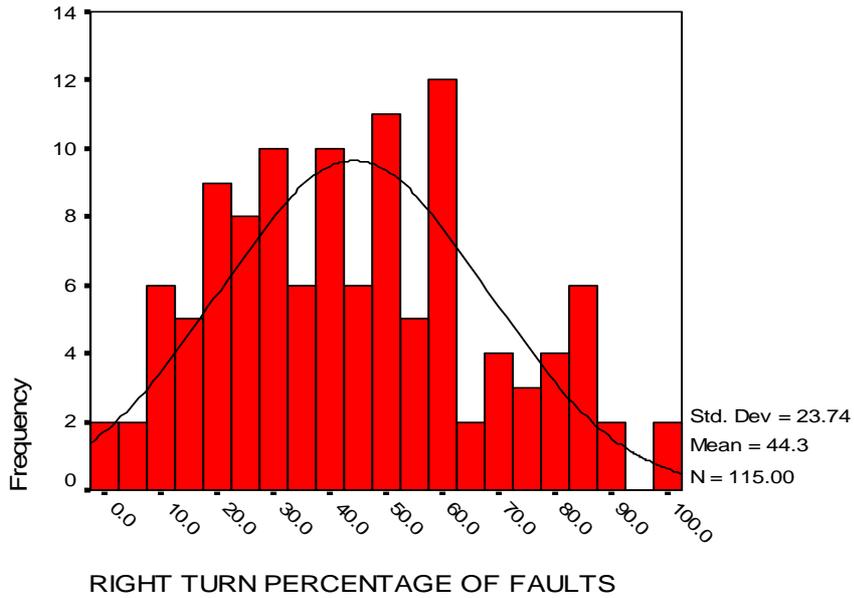
Figure 4.2   *Histogram of on-road driving assessment right turn faults (%)*
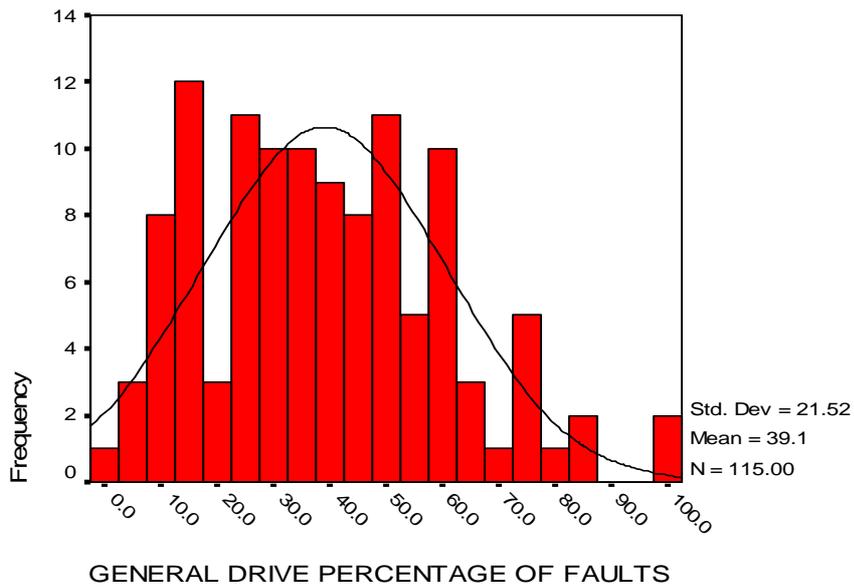

Figure 4.3   *Histogram of on-road assessment general drive faults (%)*

Histograms for on-road assessment overall result (%), and law breaks are presented below in Figures 4.4 to 4.5 respectively. The mean overall result was 55.4% (*SD*=20.89, range=0-94%). Most participants (*n*=109, 94.8%) broke at least one road law (range=0-18).
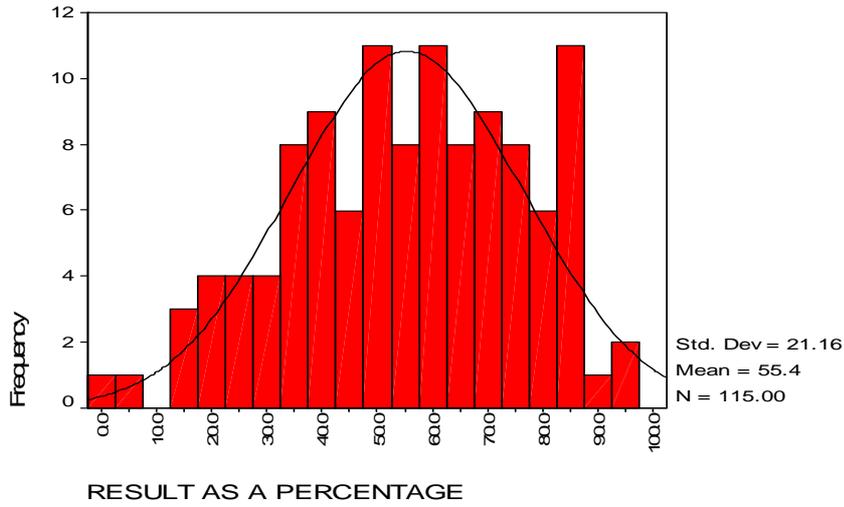
Figure 4.4   *Histogram of overall on-road driving assessment result (%)*
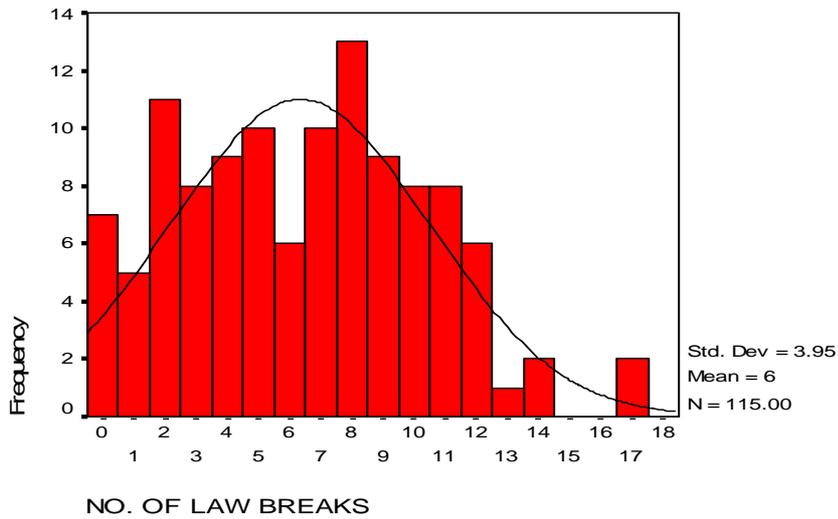

Figure 4.5   *Histogram of on-road driving assessment law breaks*

A Box and Whisker Plot for the number of driving assessor physical interventions is given in Figure 4.6. The median number of physical interventions was zero (range=0-8). A substantial proportion of participants (n=50, 43.4%) required physical intervention at least once during the on-road assessment.
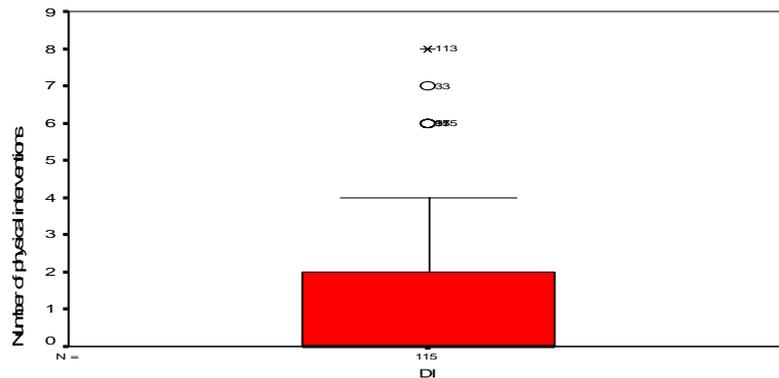
Figure 4.6   *Box and Whisker Plot of on-road driving assessment physical interventions*

According to the verbal feedback of the driving assessors, which was recorded in writing by the researcher, participant driving faults were related to poor scanning and observation of other vehicles on the road or parked on the curb, poor scanning and observation of road signs and signals, an inability to monitor and control car speed (both high and low speeds), poor positioning of the car on the road and in the car park, confusion with pedals and gear selection (both manual and automatic cars), and a lack of anticipatory or defensive driving. Faults became obvious when driving tasks became more complex, and/or the road traffic was heavier. Participants tended to lack awareness of their driving faults.

Crosstabulations for the on-road driving assessment result as a pass or fail for the total sample, and by diagnosis of MCI or early dementia, are presented in Table 4.6. Notably, 81 (70.4%) participants failed the on-road test. The remaining participants (*n*=34, 29.6%) passed. Of the participants with MCI, 52.2% passed the on-road driving assessment, while only 23.9% of the participants with early dementia passed the same assessment. This represented a significant difference ($\chi^2(1)=7.06$, *p*<.01).

Table 4.6

Crosstabulation of diagnosis (MCI/early dementia) by on-road driving assessment (pass/fail)

		Fail	Pass	Total
MCI	*n*	11	12	23
	% within driving assessment	13.6	35.3	20
	% within diagnosis	47.8	52.2	100
	% of total	9.6	10.4	20
Dementia	*n*	70	22	92
	% within driving assessment	86.4	64.7	80
	% within diagnosis	76.1	23.9	100
	% of total	60.9	19.1	80
Total	*n*	81	34	115
	% within driving assessment	100	100	100
	% within diagnosis	70.4	29.6	100
	% of total	70.4	29.6	100

4.3   MAZE TASK PERFORMANCES

Participants were invited, using standardized instructions for administration, to complete the simpler demonstration maze first. All participants (*N*=115, 100%) completed the demonstration task, which was not scored.

All participants were able to engage with and complete the Maze Task, administered immediately following the demonstration task, using standardized instructions (*N*=115, 100%). The Maze Task may therefore be considered safe and acceptable to participants.

Responses for both Maze Task time and Maze Task error scores were substantially positively skewed and peaked (leptokurtic), as shown in Table 4.7. Non-parametric statistical techniques were therefore selected for analyses using Maze Task scores.

Table 4.7

Distribution of Maze Task time and error scores (115)

| | Maze Task | |
	Time scores	Error scores
Skewness	2.08	2.32
SE of Skew	0.23	0.23
Kurtosis	6.16	7.12
SE of Kurtosis	0.45	0.45
Lilliefors	0.17 (p=.000)	0.22 (p=.000)

Box and Whisker Plots of Maze Task time (Figure 4.7) and Maze Task error (Figure 4.8) scores are given below. The median response time was 60 seconds (range=11-300 seconds), and the median number of errors was 1 (range=0-10 errors), reflecting the brevity of the task.
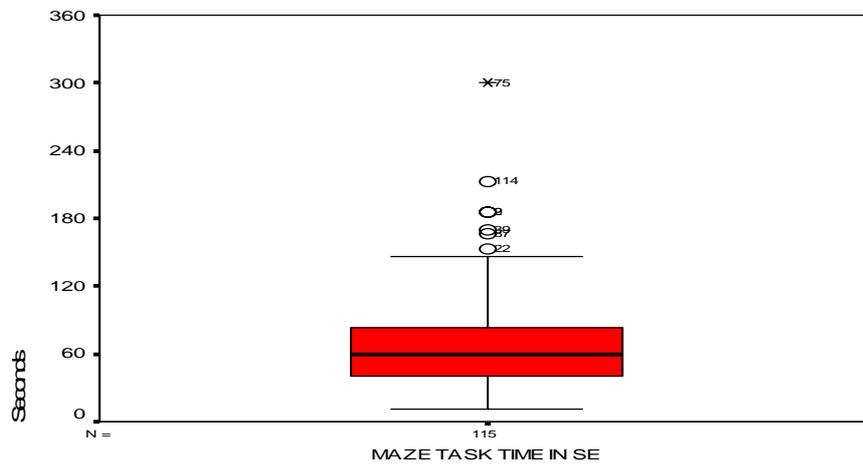

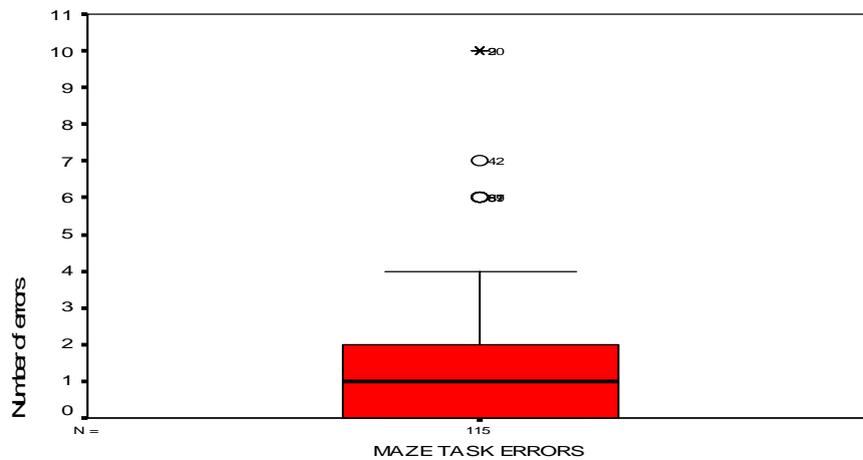Figure 4.7   *Box and Whisker Plot of Maze Task time scores*

Figure 4.8   *Box and Whisker Plot of Maze Task error scores*

4.4   INFLUENCE OF SOCIODEMOGRAPHIC VARIABLES ON MAZE TASK SCORES

Age of participants was unrelated to the time taken to complete the Maze Task or the number of errors (Spearman's rho=.05, rho=.06 respectively). Similarly, Maze Task time and error scores were unrelated to participant educational attainment (Spearman's rho=-.13, rho=-.01 respectively). No significant gender differences in Maze Task time scores (U=1447.5, ns) or Maze Task error scores (U=1444.5, ns) were evident. Nor were there significant differences for country of birth in Maze Task time scores (U=1045.0, ns) or Maze Task error scores (U=1202.5, ns). Maze Task scores may therefore be considered relatively free of the influence of participant age, educational attainment, gender, and country of birth.

4.5   CONCURRENT VALIDITY OF THE MAZE TASK

Participants were cognitively assessed at their first Memory Clinic visit using the MMSE, ADAS-Cog, AVF, Digit Symbol, CDT, and EXIT-25. Spearman's Rank-Order Correlation coefficients among scores for these cognitive tests and time and error scores for the Maze Task are presented in Table 4.8. Convergent validity was evident. A moderate significant inverse relationship was found between Maze Task time scores and Digit Symbol scores (primarily a measure of attention). A moderate significant relationship was found between Maze Task error scores and Digit Symbol error scores (primarily a measure of executive dysfunction associated with establishing and maintaining set). Moderate and highly significant positive relationships were found between CDT scores (primarily a measure of visuoconstructional skill and the executive function of planning) and both Maze Task time and error scores. Finally, a modest significant relationship between the Maze Task time and error scores was revealed. This pattern of correlations suggests that the Maze Task may indeed provide a measure of the cognitive domains of attention, visuoconstructional ability and the executive function of planning and foresight.

Divergent validity of the Maze Task was also apparent. No significant relationships were found between the Maze Task scores and the cognitive tests that do not pertain specifically to attention or visuoconstructional ability (Table 4.8). The EXIT-25, although a measure of executive functioning was not developed to capture discrete functions of planning and foresight, and thus also did not significantly correlate with Maze Task scores. Moreover, the MMSE, ADAS-Cog, AVF, and EXIT-25 are all language based tests. The Maze Task may therefore be considered free of the effects of language.

Table 4.8

Spearman's rho (two-tailed) among the cognitive measures

	Maze Task Time		Maze Task Errors	
	rho	(*n*)	*rho*	(*n*)
MMSE	-.09	(115)	-.01	(115)
ADAS-Cog	.09	(64)	.14	(64)
AVF	-.04	(27)	-.26	(27)
AVF Errors	-.03	(27)	.27	(27)
DSS	-.41*	(25)	-.37	(25)
DSS Errors	.02	(25)	.49*	(25)
CDT	.41**	(76)	.36**	(76)
EXIT-25	.08	(28)	-.06	(28)
Maze Task Time			.21*	(115)

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Note.   * p<.05, ** p<.001
MMSE=Mini-Mental State Examination, ADAS-Cog=Alzheimer's Disease Assessment Scale-Cognitive Subscale, AVF=Animal Verbal Fluency, DSS= Digit Symbol, CDT=Clock Drawing Test, EXIT-25=Executive Interview.

4.6   PREDICTIVE VALIDITY OF THE MAZE TASK

Box and Whisker Plots for Maze Task time scores and Maze Task error scores by on-road assessment pass or fail are presented in Figures 4.9 and 4.10 respectively. A broader range of scores were evident for those who failed the on-road assessment. Those participants tended to take longer than 60 seconds to complete the Maze Task, and made one or more errors. Conversely, the distributions of Maze time and error scores for those who passed

the on-road test were more compressed. Those participants tended to complete the Maze Task in up to 60 seconds and made zero or only one error.
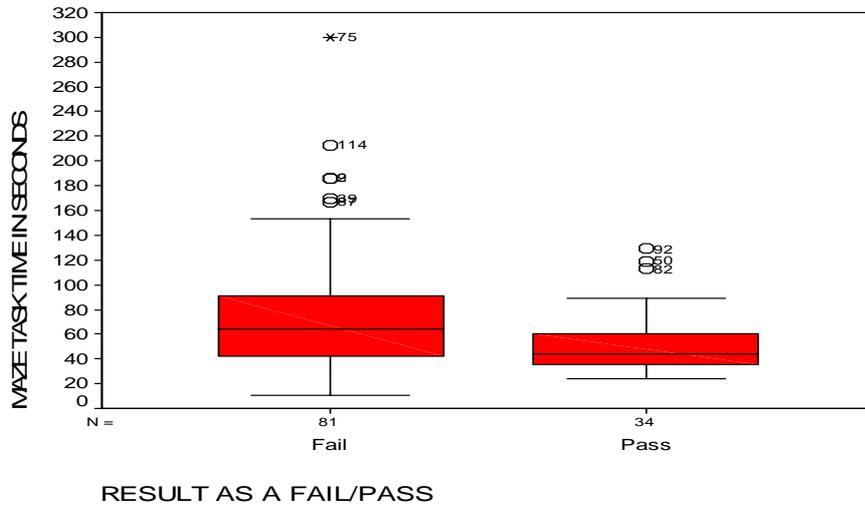

Figure 4.9   *Box and Whisker Plot of Maze Task time distributions by on-road assessment pass/fail*
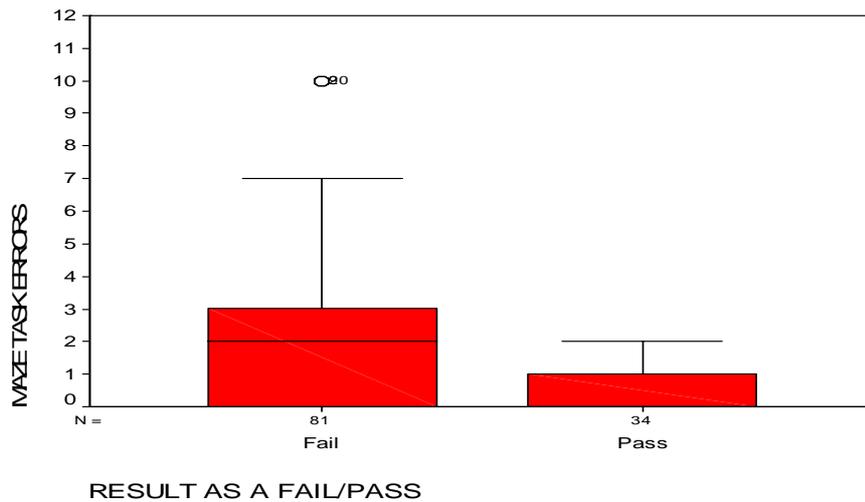

Figure 4.10   *Box and Whisker Plot of Maze Task error distributions by on-road assessment pass/fail*

Results for the logistic regression analyses using the enter procedure are given in Table 4.9. Three models are presented. The dependent variable in each was the on-road driving assessment result. The first model included only Maze Task time as the independent variable. The second model included only Maze Task errors as the independent variable. The third model included a block of Maze Task time and error scores, in order to determine if these scores, in combination, were related to on-road driving assessment outcome.

Table 4.9

Logistic regression results (Dependent variable = on-road driving assessment pass)

Variable	Model 1			Model 2			Model 3		
	Coefficient	SE	Wald	Coefficient	SE	Wald	Coefficient	SE	Wald
Constant	.22	.46	.24	.15	.28	...27	1.01	.56	3.24
Maze Task time	-.018	.01	5.87**	-	-	-	-.02*	.01	3.84*
Maze Task errors	-	-	-	-1.16	.29	15.51***	-1.13	.29	14.73***
Model Chi-Square (*df*)	8.16 (1)**			27.89 (1)***			31.68 (2)***		
Block Chi-Square (*df*)	-			-			23.47 (1)***		
% Correct predictions#	69.6			71.3			77.4		
-2 Log Likelihood+	131.48			111.75			108.01		
Hosmer & Lemeshow (*df*)	17.09 (7)*			1.21 (3) *p*=.75			8.70 (8) *p*=.37		

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Note.   *p<.05,   **p<.01,   ***p<.001
Predictive criterion=0.5
+ Constant only -2 Log Likelihood=139.64

The results from Model 1 indicate that as Maze Task time increased, participants were less likely to pass the on-road assessment. The coefficient on the Maze Task time variable had a significant Wald statistic (*df*=1). The Model Chi-square statistic was significant. Maze Task time identified 98.8% of fails, but zero passes were correctly classified. The overall classification was 69.6%. The change in -2 Log Likelihood from the constant only model was significant (χ^2(1)=8.16, *p*<.01). The Hosmer and Lemeshow goodness of fit test was significant, which demonstrates that the number of passes and fails predicted from the model were different from the observed passes and fails across the whole spectrum of predicted scores.

The results from Model 2 indicate that as Maze Task errors increased, participants were less likely to pass the on-road assessment. The coefficient on the Maze Task error variable had a significant Wald statistic (*df*=1). The Model Chi-Square statistic was highly significant, and Maze Errors identified 67.6% of passes and 72.8% of fails, with overall accuracy of 71.3%. The change in the -2 Log Likelihood from the constant only model was highly significant (χ^2(1)=27.89, *p*<.001). The Hosmer and Lemeshow goodness of fit statistic was not significant, demonstrating that the number of passes and fails predicted from the model were not different from observed passes and fails across the range of predicted scores.

Results from Model 3 indicated that as Maze Task time and error scores both increased, participant likelihood of passing the on-road driving assessment decreased. The Maze Task time and error variables had significant Wald statistics (*df*=1). The Model Chi-square (*df*=2) and the Block Chi-Square (*df*=1) were highly significant. Model 3 correctly classified 84% of fails and 61.8% of passes, with overall accuracy of 77.4%. The change in the –2 Log Likelihood from the constant only model was highly significant (χ^2(2)=31.63, *p*<.001). The Hosmer and Lemeshow test was not significant.

According to statistical performance, Model 3 is substantially superior to Model 1. The percentage of overall accuracy increased by 7.8%. The change in –2 LogLikelihhod was highly significant (χ^2(1)=23.47, *p*<.001). The superiority of Model 3 over Model 2 is marginal. The percentage of overall accuracy increased by 6.1%. The change in –2 Log Likelihood closely approached significance (χ^2(1)=3.74, *p*<.055). A Chi-Square value of 3.84 is required for *p*=.05. Overall, Model 3, which includes both Maze Task time and error variables, is considered the most parsimonious.

The interpretation of any fitted model requires that practical inferences are able to be drawn from the estimated coefficients for the continuous independent variables in the model. A logistic regression equation to screen for on-road driving assessment performance (pass/fail) was developed by the application of the formula suggested by Hosmer and Lemeshow (1989). Table 4.9 gives these logistic regression parameters for Model 3 as:

LOGODDS = 1.01 - 0.02xTIME – 1.13xERRORS
and so:
ODDS = exp (LOGODDS)
and hence:
PROBABILITY = ODDS / (1 + ODDS).

Thus, the estimated odds for a meaningful increase in time taken to complete the Maze Task of, say, 30 seconds is 1.82 (95% CI=1.65-2.01). This indicates that for every 30 second increase, the odds of passing the on-road assessment decreases 1.82 times, and the probability of passing decreases by 64.5%. Similarly, the estimated odds ratio for each error on the Maze Task is 3.09 (95% CI=2.30-4.14). For one increase in error, the odds of passing the on-road assessment decreases 3.09 times, and the probability of passing decreases by 75.5%.

A Receiver Operating Characteristic (ROC) curve was plotted to examine the distributions of on-road assessment passes or fails for the Maze time and error scores (please see Fig. 4.11). A ROC curve is an exploration of what happens to the true positives and the false positives of the test as the cut-off level is varied. The more steeply the curve moves up and then (only later) across, the better the test. A more precise way of characterising the curve is to look at the area under the ROC curve (AUC). The AUCs were significant for the Maze Task time scores (Area=.67, 95%CI=.56-.77, SE=.05, p<.01) and the Maze Task error scores (Area=.77, 95%CI=.67-.86, SE=.04, p<.001). The closer the area is to 1.0, the better the performance of the screening test. A diagonal reference line (AUC = 0.50) defines points where the screening test is no better than chance in identifying individuals who pass the on-road driving assessment.
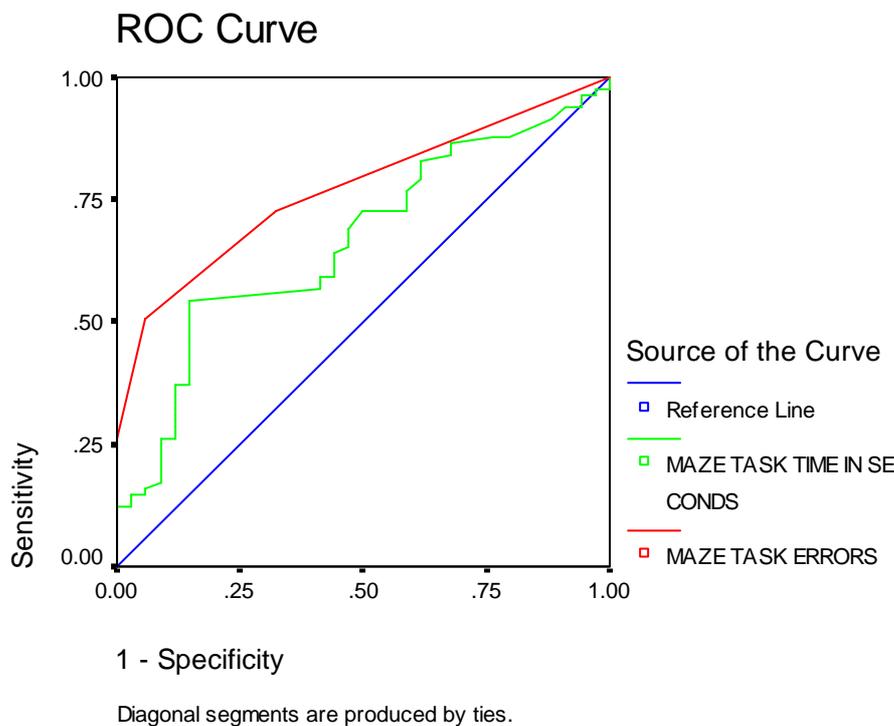

Figure 4.11   *ROC curves for Maze Task time and Maze Task error scores.*

A decision regarding optimal levels of sensitivity and specificity involved weighting the consequences of leaving unfit drivers undetected and classifying fit drivers as unfit. A combination of Maze Task time and error cut-point scores was selected, by inspection of the coordinates of the ROC curve. This procedure led to three risk categories, which are given in Table 4.10. The classification of the Maze Task results according to these risk categories are presented in Table 4.11 below.

Table 4.10

Maze Task risk categories

Maze Task completed in 61 seconds or longer, with or without errors, then the person is not cognitively fit to drive safely
Maze Task completed in up to 60 seconds, but with two or more errors, then the person is not cognitively fit to drive safely
Maze Task completed in up to 60 seconds, with zero or one error, then the person is cognitively fit to drive safely

Table 4.11

Classification of Maze Task results (N=115)

	Condition according to on-road driving assessment	
Screening result	Present (fail driving test)	Absent (pass driving test)
Positive (unfit to drive)	True positives=63	False positives=6
Negative (fit to drive)	False negatives=18	True negatives=28

The sensitivity, specificity, PPV, NPV, with 95% confidence intervals, for the risk categories are shown in Table 4.12. Some 77.8% of participants who failed the on road driving assessment were classified at risk (sensitivity); 82.4% of participants who passed the on road driving assessment were classified as not at risk (specificity); 91.3% of participants who were classified at risk failed the on road driving assessment (PPV); and 60.9% of drivers who were classified as not at risk passed the driving test (NPV). The prevalence of on-road driving test failure was 70.4%. The Maze Task was able to discriminate on-road driving performance in this group of participants with MCI or early dementia.

Table 4.12

Validity of the Maze Task as a predictor of on-road driving assessment (pass/fail)

Sensitivity (95%CI)	Specificity (95%CI)	PPV (95%CI)	NPV (95%CI)
77.8% (66.9-86.0%)	82.4% (64.8-92.6%)	91.3% (81.4-96.4%)	60.9% (45.4-74.5%)

…….
Note. PPV=Positive Predictive Value, NPV=Negative Predictive Value, CI=Confidence Interval

5   DISCUSSION

5.1   AIMS OF THE PROJECT AND SUMMARY OF THE FINDINGS

The first aim of this study was to describe the on-road driving performance of older people with MCI or early dementia. The findings raise concern about the safe driving competence of this group. Seventy percent of the study participants failed the standardized on-road driving assessment, most broke an important road law, and nearly one-half required physical intervention at least once during the assessment. Right turns, which presumably involve a greater cognitive load, were more problematic than left turns and general driving. Of the study participants with MCI, almost half failed the on-road test, while three-quarters of those with early dementia failed the same test.

These proportions of on-road assessment failures were higher than those suggested by the few previous prospective studies which also used on-the-road tests as the outcome variable of interest with participants suffering MCI or early dementia (Duchek et al, 2003; Fitten et al, 1995; Hunt et al, 1993; Hunt et al, 1997). This may be accounted for by methodological disparity on several fronts. First, previous studies used small sample sizes, a primary limiting factor from the standpoint of replicability. Second, unlike the present study, which sourced participants from a specialist, Memory Clinic following GP referral for assessment of cognitive dysfunction, previous studies tended to source participants from the community by advertisement. Third, previous studies restricted participant inclusion to those with AD. The present study included participants with VaD, FTD, and dementia with Lewy bodies. Each of these dementia types is characterised by pronounced impairment in the specific cognitive domains required for safe driving (de Jager et al., 2003). Finally, driving assessments may vary from one centre to the next. Nouri and Lincoln (1992) cited this as a reason for the very different pass/fail rates on-road between their original study and the validation study of the Stroke Drivers' Screening Test (Nouri, Tinson & Lincoln, 1987). The on-road assessment in the present study was designed to reveal the competence-defining errors of cognitively impaired drivers, while excluding those errors shown to be bad habits of experienced competent drivers. Participants were challenged to make active and informed decisions.

The driving faults of the study participants were reported to be related to poor scanning and observation of traffic and road signals, an inability to monitor and control car speed, poor positioning of the car on the road, confusion with pedals, and a lack of anticipatory or defensive driving. Such errors are frequently cited mishaps for the driver with moderate AD (e.g., Bieliauskas et al., 1998; Bloedow & Adler, 1992; Kasniak et al., 1991; Lucas-Blaustein, Filipp, Dungan & Tune, 1988; Logsdon, Teri & Larson, 1992), but have not previously been cited in MCI, and only recently been cited in early dementia (Uc et al, 2004). The exact probability of such errors resulting in motor vehicle accidents is not known. Retrospective studies suggest a higher accident risk for those with dementia than age-matched controls (Adler et al., 1996; Bieliauskas et al, 1998; Cooper et al, 1993; Dubinksy et al, 1992; Tuokko et al, 1995; Zuin, Oritz, Boromei & Lopez, 2002). Moreover, neuropathological examinations on a large sample of older drivers killed in motor accidents revealed that 33% had dementia, while 53% had MCI (Johansson et al., 1997). The crashes of older people tend to involve multiple vehicles (Dobbs, 1997). Thus, older drivers with MCI or early dementia who are at risk for a crash endanger not only themselves but others as well. Driving with MCI or early dementia would appear to carry a high burden of risk. The need to find methods of assessing current driving abilities and predicting future compromise of safe driving in older people with early cognitive decline is highlighted.

The second aim of this study was to examine the performance characteristics and estimate the criterion-referenced (concurrent and predictive) validity of the Maze Task, a new cognitive screening instrument developed to predict the on-road driving competence (pass/fail) of older people with MCI or early dementia.

Administration and scoring of the Maze Task was standardized, simple, and brief, generally consuming up to 2 minutes in total. Materials required, that is, a copy of the Maze Task, a pen, and a stopwatch, were minimal and inexpensive. The pencil and paper "puzzle" presented in large print, was completed quickly by all study participants. Poor participant performances were not harshly exposed, and the Maze Task may be considered safe and acceptable. The Maze Task may be administered by all health professionals, including GPs. It's use is not restricted to psychologists.

Another important feature of the Maze Task was its independency of sociodemographic variables; age, gender, educational attainment, and country of birth. Ensuring that screening measures are free of bias so that more culture-fair classifications will result is important in epidemiological research and practice in Australia, where

the number of overseas born older people, from culturally and linguistically diverse backgrounds, will increase over the next 20 years (AIHW, 2002).

The Maze Task correlated significantly with only those measures of cognitive domains considered critical to the ability to move a car in space and to negotiate traffic and road situations. Although it is difficult to distinguish clearly between cognitive abilities required for driving tasks, research to date has indicated that combinations of cognitive skills are likely to be important for safe driving among people with dementia (Reger et al., 2004, Ott et al., 2003). The association, or not, between the Maze Task and known measures of attention, visuoconstructional skills and executive functions may explain the Maze Task's predictive validity for driving competence.

The Maze Task predicted the on-road driving ability a group of older people with MCI and early dementia recruited from a specialist Memory Clinic. Across the sample, it accurately identified 79% of the drivers in terms of whether they would pass or fail the road test. The Maze Task was both sensitive and specific. Highly specific tests minimize the number of false-positive results but increase the number of false-negative results. MCI and early dementia are often slowly progressive. Individuals with initial false-negative screening tests would be identified on rescreening. Also, false-positive screening tests may require further assessments that are inconvenient, expensive, and time-consuming. Screening may never be perfectly sensitive and specific, but it would be inefficient and costly to administer extensive neuropsychological assessments or on-road driving tests to every older person who may be unfit to drive as a result of cognitive impairment. The potential of the Maze Task, therefore, is that the most competent and the most dangerous drivers can be identified without a road test.

5.2   IMPLICATIONS OF THE FINDINGS

Our society demands mobility. Decentralisation and suburban living have helped make the car the sole means of transportation for many individuals. Driving is considered a necessity, a right, and a symbol of independence (Maratolli, et al, 2000; Hopkins et al, 2004). Kostynuik and Shope's (1998) focus group study found that older people in general do not anticipate ceasing driving. Becoming unable to drive may represent one of the first losses experienced by an older person with a dementing disorder (Cotrell & Wild, 1999; Odenheimer, 1993; O'Neill, 1996,1997); a loss also related to increasing isolation and depression (Fildes et al., 1997; Fonda, et al., 2001; Johnson, 2002; Kostynuik & Shope, 2003; Marottoli et al., 2000; Odenheimer, 1993; Siren & Hakamies-Blomqvist, 2004; Stacey & Kendig, 1997). However, driving a car is a privilege and not a right. Individual liberties must always be balanced appropriately against the maintenance of public road safety (Freedman & Freedman, 1996; Lipski, 1997, 2000, 2001; Pettit, 2000; Post, 2000).

Given the poor driving performance displayed by this sample, further consideration by policy makers in Australia of the Clinical Guidelines proposed by the American Academy of Neurology (Dubinsky, Stein & Lyons, 2000) is suggested. The Academy Guidelines recommend that individuals with early dementia be precluded from driving as they represent an unacceptable risk, while those individuals with MCI undergo close supervision and driving evaluation as they pose a significant driving hazard.

A gap in the literature has been filled by the development and validation of the Maze Task. However, several questions must be considered carefully before any implementation of the Maze Task as a screening programme. First, should all older people be screened or only those reporting symptoms of cognitive and/or driving impairment? In the present study participants were recruited from a specialist Memory Clinic following GP referral on the basis of complaints of cognitive decline. These participants would not necessarily be the focus of screening. The prevalence of on-road driving assessment failure in this group was 70%. It is unknown if this prevalence would hold for older people in primary care, who may more appropriately be considered the focus for screening. A report on the self-regulation of driving behaviours of a group 90 older people (aged 60 years or more) recruited from Senior Citizens' clubs and Australian Retired Person Association clubs in metropolitan Adelaide (Baldock, 2004), suggested an on-road driving assessment failure prevalence of approximately 25%. If this lower prevalence is adopted, then by calculation the PPV of the Maze Task would fall to 72%, while the NPV would rise to 89%. The sensitivity and specificity of the Maze Task would remain unchanged. Any individual with a positive result on the Maze Task would retain a satisfactory probability of failing an on-road driving assessment, while any individual with a negative result on the Maze Task would have a very high probability of passing the same driving assessment. The Maze Task could have better predictive validity in the primary care setting. Therefore, population screening may be considered appropriate, given the other conditions for acceptable screening are satisfied.

The question of who should conduct the screening is unresolved. GPs seem the natural choice because they are local, accessible, trusted, and play a pivotal role in the ongoing medical management of older people (Brodaty et

al, 1998; Mitchell et al., 1995). A more active approach in recognizing individuals at risk has frequently been called for, as GPs represent the last line of public protection from older drivers who are cognitively impaired by the dementing process (Boustani et al., 2003; Duchek et al., 1997; Hecker & Snellgrove, 2003; Hopkins et al., 2004; Hunt et al, 1993; Lipski, 1997; Lopponen, Raiha, Isoaho, Vahlberg, & Kivela, 2003; Lundberg et al., 2003; McKenna, 1998; Mitchell et al., 1995; O'Neill, 2000; Reger et al, 2004; Valcour, 2001).

Licensing rules vary between the States and Territories of Australia. In South Australia GPs are required to make annual judgments regarding the driving capacity of individuals aged 70 years or older via the Transport SA License Renewal Form. The Maze Task could serve as an adjunctive screening measure for license renewal, where currently only physical and visual acuity screening tests are requested. Maze Task time and error scores could also be reported on the License Renewal Form. Once introduced as part of the license renewal process, individuals would be rescreened annually by their GPs. It is unlikely that individuals with cognitive impairment could "prepare" for the Maze Task. Moreover, equivalent versions of the Maze Task could readily be developed.

5.3   QUALIFICATIONS OF THE FINDINGS

Before the above findings are adopted, several limitations of the study should be noted. The convenience sample was recruited from a small sector of the community. Selection bias was therefore unavoidable. The data should be seen as relating to community-dwelling older drivers with MCI or early dementia at first presentation to a specialist Memory Clinic. The data are not generalisable to other select older populations. For example, new patient referrals constitute only a part of the total case load of the Memory Clinic, and those already in treatment for cognitive decline might be found more impaired than the study group on some of the variables examined. Alternatively, the impairments seen in patients newly referred to the Memory Clinic can realistically be expected to be higher than in the older driving population seen in general practice, the likely target of a screening programme. The implication of this for the predictive validity of the Maze Task was discussed above. Unfortunately, random sampling was neither possible nor practical for this study.

The choice and administration of criterion cognitive tests in this evaluation was constrained by clinical considerations. None of the validation tests (ADAS-Cog, AVF, EXIT-25, Digit Symbol, and CDT) were in themselves pure measures of discrete cognitive domains of attention, visuoconstructional skills, and executive functions of planning and foresight. However, the patterns of significant correlations observed, although not high, were logical and supported by the literature (Reger et al., 2004; Ott et al., 2003; Duchek et al., 1997). The convergent and divergent validity can be established only insofar as any cognitive ability can be accurately assessed.

The issue of identifying a gold standard for a criterion measure of driving competence is central to studies attempting to predict future driving problems. An on-road test which challenges the participant to make active and informed driving decisions is acclaimed as the gold standard of driving ability in cognitive impairment (Akinwuntan et al, 2003; Bieliauskas et al, 1996; Dobbs, 2004; Reger et al, 2004). The limitations of all road tests include the inability to control variables such as traffic flow and road conditions. In this study road tests were single trial assessments and the participants may have been on their "best behaviour" knowing that they were being observed and evaluated. Conversely, older people find it hard to adapt to an unfamiliar car or route (McKenna, et al., 2004). Thus, participants may have been so anxious during these formal assessments that their driving ability was compromised and restricted inappropriately. The fairness or the appropriateness of the on-road test remains an open question. In the present study verification and review biases can be excluded, as all participants were tested using the same on-road assessment route, and different examiners administered the screening test and driving assessment. Also, the inter-rater reliability of the on-road assessment was very high.

5.4   SUGGESTIONS FOR FUTURE RESEARCH

Given these limitations, the present findings must be viewed as preliminary. For example, no attempt was made to estimate the test-retest reliability of the Maze Task, which assesses a potentially highly variable cognitive quality in participants over time. Methodological problems of determining such reliability deterred the researcher. However, test-retest reliability is necessary to show that not only is there a tendency for Maze Task time and error scores to remain the same if severity of cognitive impairment in the domains of attention, visuoconstructional skills, and planning and foresight does not alter, but also that Maze Task time and error scores increase or decrease should an individual's cognitive impairment exacerbate or remit. The shorter-term reliability of the Maze Task might be examined by twice administering the test to a large (200 or more) heterogeneous group of community dwelling older drivers, with a time interval of two weeks. Similarly, the

longer term reliability of the Maze Task might be examined over a time interval of 12 months, which would reflect the reality of the current license renewal process in SA.

Data pertaining to the performance characteristics and validity of the Maze Task, when administered by GPs to older drivers in primary care, are needed. In brief, a convenience sample of approximately 80 GPs could be selected through all of the regional Divisions of General Practice in SA, reflecting a broad socioeconomic cross-section. About 400 driving patients could be recruited by these GPs. This represents about 5 patients per GP. Community-dwelling licensed drivers included should be aged 65 years or older, and have presented to their GP for license renewal. GPs could administer the Maze Task to consecutive eligible and consenting patients, and refer the patients within ten working days for an on-road driving assessment as utilised in the present study. Care must be taken to ensure that the Maze Task and on-road assessment are conducted close together in time. GP and patient satisfaction could be evaluated using self-report questionnaires.

The Maze Task was developed to target cognitive domains most critical for driving skill and safety. Thus, it may be non-specific to particular diagnostic subgroups that implicate cerebral functioning. Progress in medical technology has increased the survival rates of people recovering from an acquired brain injury, many of whom want to return to driving once the acute phase of their injury has passed. Similarly, extended longevity has increased the number of people who develop degenerative brain pathology, most of whom wish to continue driving for as long as possible (McKenna et al, 2004). For comparison purposes it would be beneficial to recruit samples from other select groups within the driving population as a whole. Such homogeneous groups might include participants with acquired brain injury, right or left sided cerebral vascular accidents (CVAs) or tumours, Parkinson's disease, Huntington's disease, multiple sclerosis, anoxia, generalized cerebral infections such as meningitis or encephalitis, Asperger's syndrome, attention deficit hyperactivity disorder (ADHD), alcoholism, and depression. Two major questions could be addressed. First, is the Maze Task sufficiently powerful to predict those who fail and those who pass an on-road driving assessment, regardless of the nature or location of cerebral pathology? Second, do different diagnostic groups produce differing results on the Maze Task or on-road driving assessment?

5.5   CONCLUSION

The quantity and the quality of the on-road faults made by this group of older drivers with MCI or early dementia may realistically be described as "hazardous or potentially catastrophic" (Dobbs, 1997, 2004). It is likely that the basic skills necessary for maneuvering a car are well automised and represent procedural knowledge that is relatively spared in early cognitive decline. However, in the event of changes in traffic conditions these drivers seem unable to rapidly process new stimuli, and make active and informed driving decisions. For reasons of individual and public road safety, a recommendation to preclude all individuals with dementia, even in its early stage, from driving both commercial and private vehicles may well be appropriate. Frequent supervision and evaluation of older drivers with MCI may also be in order.

With high criterion-referenced validity for on-road driving competence in this group of older people with MCI and early dementia, easy administration, and independency of sociodemographic factors, the Maze Task fulfils all essential criteria for a cognitive screening instrument that could be used by a range of professionals, including GPs. Current Australian drivers license renewal practices of physical and visual screening do not tap into those cognitive skills deemed necessary for safe driving; cognitive skills that are likely to be impaired in the expanding population of older people. It is hoped that the Maze Task may eventually serve as an adjunctive screening measure in the license renewal process of older drivers. Such practical implementation of the Maze Task requires further investigation.

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